

Chapter 13

Development of the Video Game Demand Scale

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ABSTRACT: One of most unique elements of video games often attributed to their critical and economic success is their interactivity—the requirement of video games to actively engage the player into the on-screen actions of the digital world. Scholars have focused on interactivity as a core variable to understand a variety of uses and effects of gaming, but conceptualizations vary and are often non-specific. This chapter proposes a multidimensional construct of interactivity based around the notion of demand (the extent to which a video game requires or “makes” a player engage), specifying potential cognitive, emotional, social, and physical demands common to video games. A Video Game Demand Scale is validated on a sample of gamers ($N = 660$) that uncovers latent factors associated with each of these dimensions of demand (also bifurcating physical into device and exertion dimensions). Exploratory structural equation modeling is used to demonstrate predictive, concurrent, and convergent validity with other variables critical to understanding the experience of video game play.

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Development of the Video Game Demand Scale

The middle 20th Century saw the development and growth of an entertainment technology that allows users to actively interface with on-screen content. Video games, developed originally to demonstrate creative and unique properties of early computing systems (Graetz, 1981), quickly grew to a cultural and economic force, which was not unnoticed by media psychologists and other scholars curious about the motivations and consequences of their use. Video games are intriguing due to their interactivity: they are “a series of interesting decisions” (Meier, 2012) cast as lean-forward entertainment media (Jansz, 2005) that allow users to alter the form and content of on-screen portrayals (Steuer, 1992). Notably, while this interactivity is assumed critical to understanding gaming uses and effects, current understandings tend to be non-specific (see Weber, Behr, & DeMartino, 2014), and assume by proxy that increased interactivity necessarily leads to more positive entertainment outcomes. This is not always the case, however. For instance, media flow states (Sherry, 2004) are disrupted when games over-tax a user’s attentional resources (Lang, 2000; Bowman & Tamborini, 2012; 2015), and Bucy (2004) describes the expected curvilinear relationship between a desire for increased interactivity and eventual negative consequences (such as irritation and information overload). That is, interactivity can be enjoyable, but (as outlined throughout this volume) it is also *demanding*—a requirement is placed on the user to actively and constantly respond to on-screen displays in order to continue the digital experience (e.g., demanding of the user’s attentional, emotional, or other resources).¹

Importantly, however, these various demands tend to be examined broadly (rather than as part of a comprehensive suite of tensioned demands, as we argue is appropriate), and there

¹ These theses are elaborated on in the preceding chapters of this volume, with a detailed discussion in Bowman (2015) as well as Chapter 1 of this volume.

currently exists no comprehensive metric to capture the experienced demands of video game play. To address this gap, this chapter reports a study that (a) organizes the extant literature on interactivity and demand around four central themes—cognitive, emotional, physical, and social demands—in order to (b) explicate each and (c) propose a new, validated self-report metric to assess how they are experienced: the Video Game Demand Scale (VGDS). Using exploratory factor analysis (EFA) with oblique geomin rotation, a five-factor model reflecting cognitive, emotional, physical (controller and exertional), and social demand was retained. The predictive, convergent, and concurrent validity of this set of five VGDS factors were evaluated with exploratory structural equation modeling (ESEM), which incorporates EFA into a general latent variable modeling framework (Marsh, Morin, Parker, & Kaur, 2014). The implications of VGDS for video game scholarship are discussed.

Interactivity and Demand

Among myriad definitions that we can offer for digital media interactivity, perhaps the simplest is that of Steuer (1992) characterizing the end user's ability to alter the form and content of what is shown on screen. Such an approach tends to consider interactivity as an attribute of the medium—an objective affordance of a system. Other scholars (Sundar, 2004; Sundar, Jia, Waddell, & Huang, 2015) have argued that such an approach is superior to user-centered models in that it focuses our attention on objective properties of a given system. In particular, Sundar (2004) argues that:

“If we were to theorize about the psychological effects of interactivity using such a technologically independent conception of interactivity, then we would be building knowledge about people (i.e., theories of psychology) rather than about media” (p. 386).

Sundar's point is a critical one, as in most studies of human-computer systems (including studies of video games), the technological affordances are usually objective and constant properties of the system while the human users vary on several dimensions (such as skill and motivations for engagement). However, such an approach also assumes that all users necessarily experience these interactive affordances in the same way, which seems unlikely given the natural variance in user's abilities to handle various elements of interactivity—a central point raised by Bucy (2004).

We can borrow from discussions of telepresence in human-computer systems to guide our assumptions here, and perhaps draw attention to considering interactivity as a two-way dialogue between a user and the machine (see Haraway, 1991). Take, for instance, the phenomenon of experiencing presence (the illusion of non-mediation during a media experience; Lombard & Ditton, 1997). The affordances of particular technologies are likely to encourage a sense of presence in their users (Westerman & Skalski, 2010), for example wearing head-mounted displays and using naturally mapped controllers may intensify the sense of being inside a digital space (Bowman, Pietschmann, & Leibold, 2017). On the surface, it makes sense that technological affordances are the chief driver of telepresence, yet evidence shows that users' perceptions of the technologies, independent of their design, can have a major impact on how they are experienced—both Bowman et al. (2017) and Rogers, Bowman, & Oliver (2015) found naturally mapped controllers to be perceived as *less* natural than their abstract counterparts (i.e., gamepads).

In short, both the interface and the user discretely contribute to the nature and experience of unfolding interactivity. Thus, and perhaps as best argued by Stromer-Galley (2004), we might suggest that an *interactivity-as-process* rather than *interactivity-as-product* approach is useful for

understanding the phenomenology of—and demands associated with—gaming. Such a perspective somewhat privileges the player's perceptions of demand over the technological affordances themselves and thus, their perceptions of other aspects of the gaming experience. As outlined in Chapter 1 of this volume, perceptions of demand may be most elegantly considered according to four principle requirements of game play: cognitive, emotional, physical, and social.

Cognitive demand. Cognitive demand is conceptualized as the consumption of attentional and cognitive resources (Bowman, 2015; see Chapter 1, this volume)—in simplest terms, cognitive demand refers to how much (or how little) the video game made one think. These cognitive resources are limited (Lang, 2000) and, per the cognitive miser approach (Fiske & Taylor, 1991), conserved whenever possible. Notably, while cognitive resources are held in reserve, a critical component of video game play is that it implicitly requires the player to learn since games usually present players with novel experience, which much be rationalized in order to be played effectively (Gee, 2003). That is, players are required to make sense of the digital environment in order to properly engage it. Green (Chapter 2, this volume) overviews extensive literature on the role of video games broadly, and action video games specifically, in strengthening cognitive skills. While understanding a game is therefore a cognitively intensive process, players also tend to resort to resource-conserving heuristics whenever possible (Martinez-Garza & Clark, 2017) in order to avoid overtaxing those resources (to avoid subsequent frustration; Bowman & Tamborini, 2012). More generally, it has been suggested that individuals seek a balance between cognitive ability and cognitive demand as an optimal media flow state (Sherry, 2004), and this demand/ability balance during video game play is experienced as intrinsically rewarding and motivating (Keller, Ringelhan, & Blomann, 2011). If we assume that video games have some requirement to engage the player's cognitive resources as they make

sense of the experience, we can define cognitive demand as *the extent to which a video game requires the player to implicitly or explicitly rationalize the game*.

Emotional demand. Emotional demand is the instigation of an affective response in a player (Bowman, 2015; see Chapter 1, this volume)—at the most basic level, emotional demand refers to how much (or how little) the video game made one feel. Regardless of valence, more emotionally arousing experiences can be understood as more emotionally demanding ones. McGonigal (2011) discusses that during video game play, “we are intensely engaged, and this puts us in precisely the right frame of mind and physical condition to generate all kinds of positive emotions” (p. 28)—sentiments echoed by claims that pleasures of gaming are often associated with emotions such as exhilaration and joy (Grodal, 2000). At the other end of this spectrum are studies on violent video games, which often examine aggression-related emotions such as anger or hostility (Anderson et al., 2010). Yet, more recent research has begun to examine a broader set of emotions, such as fear (Lynch & Martins, 2015) and moral reactions related to guilt emotions (Grizzard, Tamborini, Lewis, Wang, & Prabhu, 2014; also see Grizzard, Chapter 5 this volume)—as well as a broader set of theories of emotion (Hemenover & Bowman, in press). Oliver et al. (2016) found that meaningful video game experiences lead to positive affect (amused, happy, humored, positive) just as much as enjoyable video game play experiences, but lead to more mixed affect (touched, moved, compassionate, inspired) and negative affect (angry, anxious, tense, negative) than more hedonic-based enjoyable video game play experiences. In short, emotional demand refers to *the extent to which a video game causes the user to have an affective response to the game*.

Physical demand. Physical demand is related to physical input into a game via controller (Bowman, 2015; see Chapter 1, this volume), and in its simplest form it refers to how much (or

how little) the video game made one do something physically. Often measured in other contexts as whole-body exertion (DiDomenico & Nussbaum, 2008)—which is critically important to more recent advances in the use of whole-body gaming inputs such as Microsoft’s Kinect and Sony’s PlayStation Move systems, physical demand in video games can also involve fine-motor movements more aligned with handheld and/or button-based gaming inputs (controllers and keyboards, for example). As players physically manipulate controllers, players develop mental models that associate their movements with on-screen actions (Rogers et al., 2015), which might lessen their perceived physical demand. Moreover, more recent “naturally-mapped” controllers—those that most closely mimic the simulated physical equivalent of the game actions (Skalski, Tamborini, Shelton, Buncher, & Lindmark, 2011)—should reduce physical demand by allowing players to apply their pre-existing mental models to gameplay (e.g., a held mental model of bowling with a bowling ball would easily map to use of a naturally-mapped bowling video game controller).

While some studies have shown naturally-mapped controllers that mimic their real-world counterparts are perceived as natural and thereby increase perceptions of realism, immersion, and in-game success (Shafer, Carbonara, & Popova, 2014; McGloin, Farrar, Krcmar, Park, & Fishlock, 2016), others find that these same controllers are cumbersome and hinder performance, reducing feelings of competence (Tamborini, Bowman, Eden, Grizzard, & Organ, 2010) and inducing frustration (Rogers et al., 2015). Bowman et al. (2017) found that experienced gamers preferred traditional controllers over naturally mapped ones, finding the former to be less cumbersome and physically demanding and finding the latter to be imprecise and paradoxically more complicated. An explication of physical demand is *the extent to which a video game requires the player to exert discrete or holistic physical effort(s) when playing the game*.

Social demand. Social demand is related to social interactions and relationships with others (Bowman, 2015; Chapter 1 this volume), and might be understood in its most basic form as how much (or how little) the video game made one react to and/or aware of other avatars, characters, or people. The more social interaction players engage in during gameplay or the more social others of whom they are aware, the greater their social demand, and this demand may emerge explicitly or implicitly. Regarding explicit social demand, players may be actively aware of and respond to other players or characters. Games provide a site for social interaction and relationship formation (Sherry, Lucas, Greenberg, & Lachlan, 2006; Yee, 2006; Cole & Griffiths, 2007), and online games for those individuals who might find face-to-face social interaction difficult or intimidating (Kowert, Domahidi, & Quandt, 2014). Other players also provide both audience and ambient social backdrop to gameplay, even when not directly engaged (Ducheneaut, Yee, Nickell, & Moore, 2006).

Regarding implicit social demand, players may be influenced by the presence of other players or characters without actively devoting attentional resources to them. Building on extant work on social facilitation effects, Bowman, Weber, Tamborini, and Sherry (2013) found that the presence of others while playing can significantly boost arousal, which can impact both performance and enjoyment by triggering natural reactions to the mere presence of other social actors. Research finds that media users often engage computers and displayed content as social actors (Reeves & Nass, 1996), which might make more salient certain social norms (such as politeness), suggest that social demand may be experienced in video games, even in the physical absence of other humans (Banks & Carr, in press). An explication of social demand is *the extent to which a video game triggers an implicit or explicit response in the player to the presence of other social actors*.

Research Goals

In the absence of a comprehensive metric to capture these phenomena, we sought to develop and offer initial validations for measuring demand in video games: the Video Game Demand Scale (VGDS). VGDS is designed to assess four sub-dimensions of demand (hypothesized to be cognitive, emotional, physical, and social) as a self-report survey metric for use either immediately following or in recollection of a focal video game experience (the latter done for the current study, in order to ensure a variety of play experiences via online survey). In developing this scale, we (a) explored the latent factor structure of the proposed items using an oblique geomin rotation method and (b) examined the newly created scale's predictive validity (with measures of effort exerted), concurrent validity (with respect to an established measure of task demand), and convergent validity (with measures of entertainment, ratings of video game experiences, and need satisfaction) using individual ESEM for each of the three validity types.

Method

Participants were solicited via social media platforms (Facebook, Reddit, and Twitter) and email (to student accounts at the host university, as well as past research participants in other video game studies who had agreed to receive future research invitations via email) to participate in a survey on "how players engage video games on cognitive, emotional, physical, and social dimensions." The 80 survey questions related to Video Game Demand Scale (VGDS) were embedded into a larger bank of open- and closed-ended items (used to conduct predictive, concurrent, and convergent validity tests); only closed-ended data are used for the validation analyses presented here.

Before addressing the closed-ended question bank containing the proposed VGDS items, participants were first asked to specify and describe their most recent video gaming session (in

order to ground responses in an ostensibly salient experience), and the title of the game played was automatically inserted into the directions for all scales for the remainder of the survey—this was done to focus the respondents’ attention on that one experience playing that one game. Participants were entered into a drawing for one of three \$100 gift cards, with odds of winning fixed at no less than 1:500. The survey could be completed in 20 to 30 minutes (based on pilot-testing).

Several methodology and analysis files, including a full copy of the survey given to participants, data analysis file (which includes all quantitative data used in this scale validation), Mplus syntax, and other files have been made available using a public Open Science Foundation project file, which can be assessed at <https://osf.io/x5jch/>.

Participants

Of an initial survey response of 1,068, a total of $N = 660$ participants gave complete answers to the 80 VGDS pool items and thus were retained for analysis. Among these, $n = 640$ voluntarily answered a series of self-report demographic measures. The sample had an average age of $M = 23.07$ ($SD = 5.98$, range 18 to 62) with 70% of the sample ($n = 464$) reporting as male and 3.5% of the sample ($n = 23$) reporting a non-binary gender. Considering race, 84% of the sample ($n = 538$) self-identified as White or Caucasian, with the next-most represented ethnicity being Asian (2%). About 46% of the sample was currently enrolled in college or technical school ($n = 304$) with 23% ($n = 152$) as college graduates. The most popular genres of video game reported were shooters ($n = 149$, 22.6%), action RPGs ($n = 94$, 14.2%), sports ($n = 80$, 12.1%), and turn-based RPGs ($n = 67$, 10.2%), and 26 different genres were listed overall. Over 97% of the sample ($n = 642$) reported playing with a standard gaming controller or keyboard and mouse, and respondent’s most recent gaming session (which they were reporting on) was an average of

$M = 1.92$ hours long ($SD = 1.50$). Just over half of the sample ($n = 352$, or 53% of respondents) indicated that they had played this game alone, with the other respondents indicating a variety of co-playing experiences (both online and offline); as an open-ended question, not all participants specified or elaborated on what they meant by “others” in their replies.

Measures

VGDS. The primary focus of this study was to develop a multi-dimensional survey metric for assessing video game demand in terms of cognitive, emotional, physical, and social dimensions. To do this, we developed 80 total items—20 for each different type of demand—by consulting the literatures reviewed earlier in this manuscript, consulting existing open-ended data from past data collections to cull players’ natural language about demand, and through deliberation within the research team. This 80-item bank was randomized and presented to participants, with items written in Likert-style with seven response options from “Strongly Disagree” to “Strongly Agree” (see OSF project space for survey metric). Table 1 of the Results section contains the finalized scale.

Validation measures. We conducted several construct and predictive validity tests by analyzing the associations between the proposed VGDS sub-dimensions and other established measures of both demand (construct validity) and gaming outcomes (predictive validity).

For predictive validity tests, we adapted Paas’ (1992) single item mental effort measure to assess—on a scale of 1 “very, very low” to 9 “very, very high”—perceptions of cognitive ($M = 4.84$, $SD = 2.04$), emotional ($M = 4.86$, $SD = 2.84$), physical ($M = 3.64$, $SD = 1.95$), and social effort ($M = 5.29$, $SD = 2.26$) exerted during play. Each effort item was expected to predict most substantially its respective VGDS dimension (e.g., cognitive demand was expected to predict cognitive effort). We note here that as a cross-sectional study design, causality via time-ordering

is not observable. However, the logic here is that the demands of a system should drive the amount of effort that we invest to manage those demands.².

To evaluate VGDS's convergent validity, we used a version of the NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988) adapted for video game use (Bowman & Tamborini, 2012). Commonly used to measure subjective perceptions of workload, NASA-TLX consists of six items related to mental demand, physical demand, perceived success, and temporal considerations (i.e., feeling hurried or rushed). As in Bowman & Tamborini (2012), removal of perceived success resulted in a five-item solution of global demand, $M = 4.36$, $SD = 1.46$, although with a lower-than-expected $\alpha = .669$ ($\alpha = .811$ in Bowman & Tamborini, 2012). We expected VGDS cognitive and physical demand dimensions to be positively related to the overall NASA-TLX index, as these dimensions are most similar to the task load construct.

For concurrent validity tests, we used an adapted version of the Affect Grid (Bowman & Tamborini, 2012) in which participants could mouse-click an on-screen grid with “affect” as the x-axis (from unpleasant to pleasant feelings, $M = 338.19$, $SD = 62.67$, and higher scores representing more pleasant feelings) and “arousal” as the y-axis (from low to high arousal, with lower scores representing less arousal, $M = 146.94$, $SD = 77.21$); scores for “affect” were able to range from 92 to 464, and scores for “arousal” were able to range from 35 to 376 (measuring pixels from the top-left of the image, recorded by the survey system using a specialized cursor). We expected emotional demand to be associated with increased affect (replicating Oliver et al., 2016) and physical demand to induce frustration as negative affect (replicating Bowman & Tamborini, 2012); that same study found nonspecific effects on increased arousal from increasing game difficulty.

² We are grateful to an anonymous reviewer for this suggestion.

A three-item enjoyment measure ($M = 6.40$, $SD = .827$, $\alpha = .914$), six-item appreciation measure ($M = 3.98$, $SD = 1.46$, $\alpha = .903$), and single-item ratings of the game's story/narrative ($M = 54.66$, $SD = 35.20$), gameplay mechanics ($M = 84.20$, $SD = 17.17$), controller scheme ($M = 78.82$, $SD = 21.63$), and overall game rating ($M = 86.72$, $SD = 12.63$; all on 100-point scales) were used from Oliver et al. (2016). We expected cognitive and physical demands to be associated with gameplay assessments, while emotional demands to be associated with story/narrative assessments, as in Oliver et al. 2016. Overall game assessments were explored, without a strong *a priori* expectation. Notably, given that over 95% of our sample reported enjoyment scores above 5.00 (the median score was 6.67 and the modal score was 7.00, $n = 298$ or 45% of our sample), participants in our study seem to have heavily biased themselves to report on recollections of highly enjoyable experiences.

Finally, the player need satisfaction measure (Ryan, Rigby, & Przybylski, 2006) was used that included three items each for assessing felt autonomy ($M = 5.39$, $SD = 1.27$, $\alpha = .759$), competence ($M = 5.69$, $SD = 1.02$, $\alpha = .746$), and relatedness ($M = 3.70$, $SD = 1.71$, $\alpha = .883$). Based on Tamborini et al. (2010), we expected competence to be positively associated with cognitive demands (gamers focused on in-game challenges), physical demands (gamers developing their play skills), and emotional demands (exhilaration from successful in-game performance, Bowman et al., 2013). Because Ravaja et al. (2006) suggest that feelings of relatedness are associated with social presence, we expected relatedness to be associated with social demands (for gamers interacting with other gamers).

Results

VDGS Factor Analysis

The primary purpose of this study was to develop the VGDS, (a) exploring its factor structure to test the plausibility of its predicted four-factor structure and (b) reducing the initial 80-item pool to the best-performing items that both load strongly on a single primary factor and weakly on all other factors for the derived factor structure. Rather than use a confirmatory factor analysis to force a presumed four factor structure³ and to identify poor-performing items *post hoc* with modification indices, the initial pool was instead subjected to an exploratory factor analysis (EFA) using maximum likelihood (ML) estimation with oblique geomin rotation. This approach allowed for the possibility that this item pool reflected more constructs than the four expected dimensions of demand. Because nothing was presumed *a priori* about relationships among demand dimensions, an oblique rotation method was used to allow factors to correlate. More specifically, geomin rotation was used because simulation studies suggest that geomin outperforms other alternative oblique rotation strategies in accurately estimating cross-loadings and factor correlations, especially when little is known in advance about the factor structure (Aksoy, 2017; Asparouhov & Muthén, 2009). Accurately estimating cross-loadings is especially important given this study's goal of eliminating items with substantial cross-loadings. Additionally, ML estimation afforded the inspection of several indices for choosing the appropriate number of factors to extract: parallel analysis identifying the number of factors with eigenvalues greater than the 95th percentile of random-data eigenvalues, the smallest Bayesian information criterion (BIC), the fewest-factor solution with root mean square error of approximation (RMSEA) $\leq .05$, and the fewest-factor solution with the lower-bound 90%

³ Although extant literature coalesces around the four expected dimensions, within our research team (as a result of various arguments) we determined that some manifestations of some demand categories could coalesce with some manifestations of others. For instance, feeling empathy for a doomed character could elicit perceptions of both social and emotional demand, ostensibly breaking down the four-factor structure. Likewise, it is plausible that some demand dimensions might have more than one factor related to them.

confidence interval of $RMSEA \leq .05$ (Cota, Longman, Holden, Fekken, & Xinaris, 1993; Eijk & Rose, 2015; Preacher, Zhang, Kim, & Mels, 2013). Additionally, factor solutions were examined for interpretability, rejecting solutions including factors with exclusively low ($< .5$) standardized rotated loadings. Neither Akaike information criterion (AIC) nor sequential chi-square model comparisons were used to evaluate number of factors to extract, as in this study they consistently appeared to over-extract numerous uninterpretable factors with exclusively weak primary loadings (see Preacher et al., 2013).

These indices suggested the extraction of between five and seven factors at each step of the iterative analysis. Therefore, the ostensible four-factor structure was rejected. To reduce the item pool to only items that reflected their primary dimension of demand and not others (i.e., those best-performing items with high discriminant validity), poorly-performing items were iteratively eliminated. Because indices suggested extracting between five and seven factors, items were eliminated by examining standardized rotated factor loadings across all of these factor solutions. Increasingly strict criteria for primary loadings and cross-loadings were applied to these items to eliminate weakly-loading and cross-loading items, beginning with eliminating items with no loadings $\geq .32$ primary loadings across all solutions and increasing ultimately to eliminating items without $\geq .6$ primary loadings across two or more solutions or with $\geq .15$ cross-loadings. We used this strict cross-loading cut-off rather than more common and more liberal cross-loading cut-offs (i.e., $\geq .3$ or $\geq .4$), because in this study even cross-loadings as small as .15 were significant at $p < .01$. In the final iteration, one item with $< .6$ primary loading was retained so that every factor would contain four or more items. Four items per factor reduces potential issues with model estimation, including empirical under-identification (Kline, 2016).

The final 7-factor solution was obtained after dropping 47 items, the final 6-factor solution after dropping 50, and the final 5-factor solution after dropping 54. Notably for all solutions, items had their strongest primary factor loadings with the demand dimension they were initially developed to represent. To select between the final 5-factor, 6-factor, and 7-factor solutions, their rotated loading structures were compared for interpretability. The 7-factor structure was rejected for over-factoring emotional demand into two dimensions that reflected positive- and negative-item wording rather than conceptual differences, $\chi^2(318, n = 660) = 463.411, p < .0001$, RMSEA = .026 (90% CI: .021, .031), CFI = .987, TLI = .979, SRMR = .014, BIC = 75788.884. The 6-factor structure was rejected for over-factoring physical demand into three dimensions reflecting controller demand, amount of physical movement, and physical tiredness, the latter two of which were deemed too conceptually similar to merit this level of complexity, $\chi^2(270, n = 660) = 390.905, p < .0001$, RMSEA = .026 (90% CI: .020, .032), CFI = .989, TLI = .981, SRMR = .014, BIC = 68630.149. Therefore, we retained the most parsimonious 5-factor solution, in which cognitive, emotional, and social demand factored in line with reviewed literature, and physical demand was factored into only two dimensions reflecting controller demand and physical exertion, respectively. See Table 1 for the retained 5-factor EFA solution, which was obtained after 11 iterations of the aforementioned procedure, at which point BIC, RMSEA, RMSEA 90% CI, and parallel analysis all suggested retaining five factors. Although the hypothesis of exact fit was tentatively rejected, most global fit indices suggested acceptable global fit, $\chi^2(205, n = 660) = 303.473, p < .0001$, RMSEA = .027 (90% CI: .020, .033), CFI = .989, TLI = .982, SRMR = .015, BIC = 59914.294.⁴

⁴ Comparing fit indices among these nested models indicate minimal loss of fit, and in some cases improvement, when proceeding from the most complex 7-factor model to the most parsimonious model. Exact chi-square model comparisons, which are highly sensitive to sample size are as follows: 7 vs 6 $\Delta\chi^2 = 72.506, \Delta df = 48, p = .012$; 6 vs 5: $\Delta\chi^2 = 87.432, \Delta df = 65, p = .033$.

Table 1. *Final VGDS sub-dimensions and standardized rotated factor loadings*

Factor description	Item text	Factor				
		1	2	3	4	5
1. Cognitive demand – $M = 4.10$, $SD = 1.43$, $\alpha = .90$						
	The game was cognitively demanding.	0.807*	-0.070*	-0.060*	0.008	-0.005
	I had to think very hard when playing the game.	0.804*	-0.049	0.038	0.014	-0.020
	The game required a lot of mental gymnastics.	0.759*	0.007	0.022	0.063*	0.025
	This game doesn't require a lot of mental effort. (R)	0.766*	-0.018	0.001	-0.090*	-0.046
	The game made me draw on all of my mental resources.	0.703*	0.127*	0.003	0.059	-0.014
	The mental challenges in this game had an impact on how I played.	0.646*	0.138*	0.034	0.009	0.080*
	The game stimulated my brain.	0.622*	0.121*	-0.106*	-0.057	0.044
2. Emotional demand – $M = 3.38$, $SD = 1.60$, $\alpha = .89$						
	The game tugged at my heartstrings.	-0.035	0.886*	0.045*	-0.011	-0.032
	The game gave me the feels.	-0.015	0.810*	-0.011	-0.017	-0.011
	I was moved by the game.	0.067*	0.766*	-0.027	0.032	-0.019
	I had a strong emotional bond with the game content.	0.022	0.761*	-0.110*	-0.024	0.026
	I had a lot of unexpected feelings during gameplay.	0.019	0.632*	0.055	0.110*	0.069*
3. Controller demand – $M = 2.43$, $SD = 1.24$, $\alpha = .87$						
	The controls were very natural to me. (R)	-0.042*	0.004	0.897*	-0.053*	0.043*
	The game's controls were like second nature to me. (R)	-0.109*	-0.013	0.811*	-0.049*	-0.032
	The game controls were easy to handle for me. (R)	0.059*	-0.031	0.800*	0.050*	-0.013
	The game controls tripped me up.	0.067*	0.042	0.686*	0.136*	-0.010
4. Exertional demand – $M = 2.12$, $SD = 1.14$, $\alpha = .84$						
	I was physically exhausted after playing.	-0.069*	-0.013	-0.044*	0.895*	-0.019
	I felt strained after playing.	0.063*	-0.049	0.083*	0.666*	0.082*
	My body felt drained after gameplay.	0.025	0.055*	-0.033	0.821*	-0.046*
	The game was physically demanding.	-0.004	0.030	0.041	0.583*	0.091*

5. Social demand – $M = 3.69$, $SD = 1.58$, $\alpha = .88$

Socializing was an important part of playing this game.	-0.009	-0.017	0.018	-0.031	0.799*
While playing, I was aware of others in the game.	-0.027	-0.059*	-0.065*	-0.047	0.780*
I was compelled to interact with others in the game.	-0.046	0.099*	-0.040	-0.009	0.777*
I felt obligated to others, while playing.	0.064*	0.005	0.054*	0.050	0.715*
Being around others in the game had an impact on how I played.	0.035	-0.022	-0.031	0.032	0.676*
This game was socially demanding.	0.047	0.043	0.045	0.071*	0.652*
Eigenvalues	6.711	3.335	3.089	2.465	1.799

Note. Standardized rotated geomin loadings. Primary loadings are bolded. The item loading at 0.583 on factor four was retained so that this factor would contain four items. * $p < .05$.

Most VGDS factors shared small-to-moderate significant partial correlations with each other, with the exception of controller demand, which was only significantly correlated with exertional demand, as reported in Table 2.

Table 2. *Partial correlation matrix of VGDS latent factors*

Factor	1	2	3	4
1. Cognitive	—			
2. Emotional	.321 <.001	—		
3. Controller	.003 .945	-.074 .063	—	
4. Exertion	.392 <.001	.235 <.001	.173 <.001	—
5. Social	.261 <.001	.167 <.001	-.072 .077	.235 <.001

Note. First lines report partial correlation coefficients of latent factors (controlling for other VGDS latent factors), followed by p -values.

Predictive Validity

To assess the degree to which VGDS dimensions were predicted by perceived effort, the set of VGDS EFA factors was regressed on all four single-item effort assessments using

maximum likelihood estimation with robust standard errors (MLR). Although predictions were complicated by the emergence of two physical demand factors, as predicted each dimension of VGDS was most substantially predicted by its respective effort item (see Table 3), and the overall model demonstrated acceptable fit, $\chi^2(289, n = 660) = 514.578, p < .001$, RMSEA = .034 (90% CI: .030, .039), CFI = .976, TLI = .964, SRMR = .020. The lone exception was controller demand, which was unrelated to any effort dimension (we might have expected an association with physical effort, although the high prevalence of traditional controllers in this data may have suppressed any such association). Surprisingly, emotional effort and exertional demand shared a slight positive association, which might be indicative of an arousal transfer effect.

Table 3. Self-reported effort as a function of VGDS dimensions

Outcome	Demand Dimension					R^2
	Cognitive	Emotional	Controller	Exertional	Social	
Mental Effort	.817 <.001	.000 .990	-.026 .367	-.036 .314	.043 .123	.666
Emotional Effort	.080 .025	.627 <.001	.014 .670	.088 .028	.146 <.001	.535
Physical Effort	-.025 .581	-.039 .309	.003 .945	.500 <.001	.082 .065	.258
Social Effort	.035 .304	.116 <.001	.066 .016	-.051 .118	.772 <.001	.631

Note. Standardized regression coefficients followed by p -values are reported. Largest coefficients within each row are bolded; the 95% confidence intervals around all coefficients above are +/- .11 or more narrow for all estimates.

Convergent Validity

To evaluate VGDS's convergent validity with an existing measure of perceived demand, the set of VGDS EFA factors was regressed on the NASA-TLX using MLR, yielding marginally acceptable model fit $\chi^2(335, n = 660) = 855.097, p < .001$, RMSEA = .049 (90% CI: .044, .053), CFI = .943, TLI = .920, SRMR = .050 that could be improved by including NASA-TLX items as indicators of VGDS dimensions (which is not surprising given that both instruments are intended

to measure similar constructs). As predicted, NASA-TLX was significantly associated with cognitive ($\beta = .927, p < .001, R^2 = .86$) and exertional ($\beta = .557, p < .001, R^2 = .31$) demand. To a smaller degree, NASA-TLX was also associated with both emotional ($\beta = .318, p < .001, R^2 = .10$) and social ($\beta = .412, p < .001, R^2 = .17$)—but not controller ($\beta = -.004, p = .950, R^2 < .001$)—demand.

Concurrent Validity

We also wanted to explore concurrent relationships of VGDS dimensions with measures associated with assessments of video games, such as affect and arousal, game ratings (discrete ratings of a game's story, gameplay mechanics, controller scheme, and overall rating), entertainment outcomes (enjoyment and appreciation), and self-reported need satisfaction from play. As such, these measures were regressed on the set of VGDS EFA factors using MLR, yielding an overall model with acceptable fit $\chi^2 (977, n = 660) = 1874.422, p < .001, RMSEA = .037$ (90% CI: .035, .040), CFI = .946, TLI = .932, SRMR = .038 (see Table 4).

As expected, emotional demand had a significant positive association with affect, while both controller and exertional demand were significantly and negatively associated with affect. For arousal, increased cognitive demand corresponded with an increase in overall arousal levels, similar to research on the increased attention that television viewers give arousing (versus calm) content (Koruth, Lang, Potter, & Bailey, 2015).

With respect to game ratings, controller demand was negatively associated with control rating, and emotional demand was positively associated with story ratings, in line with Oliver et al. (2016). In terms of overall game ratings, emotional demand was positively associated with game ratings and controller demands were negatively associated, partially replicating findings by Bowman, Liebold, and Pietschmann (2017). Likewise, enjoyment scores were increased by

cognitive and emotional demands, and decreased by both types of physical demand—controller and exertional. As expected, emotional demand was strongly associated with appreciation, although cognitive demand had a smaller-albeit-significant association with appreciation as well. Overall, these findings are copacetic with Oliver et al. (2016) and Bowman et al. (2017).

In terms of need satisfaction, as expected, cognitive demand was a significant and substantial positive predictor of competence. Although controller demand was not part of our original predictions, it is not surprising that it substantially and negatively predicted competence. Also as predicted, social demand was a substantial positive predictor of relatedness, as was emotional demand. Finally, cognitive and emotional demand were substantial positive predictors of autonomy, while controller demand was a substantial negative predictor.

Table 4. Concurrent validity measures as a function of VGDS dimensions.

Outcome	Demand Dimension					R^2
	Cognitive	Emotional	Controller	Exertional	Social	
Appreciation	0.260 <.001	0.686 <.001	-0.129 <.001	-0.043 .240	0.071 .030	.695
Enjoyment	0.179 <.001	0.166 <.001	-0.414 <.001	-0.170 .001	0.009 .821	.277
Competence	0.196 <.001	0.143 .001	-0.538 <.001	-0.116 .024	0.065 .171	.401
Autonomy	0.190 <.001	0.375 <.001	-0.224 <.001	-0.086 .098	0.124 .007	.313
Relatedness	0.001 .969	0.432 <.001	-0.094 .003	-0.082 .035	0.585 <.001	.605
Story rating	-0.068 .109	0.605 <.001	-0.003 .927	-0.191 <.001	-0.061 .109	.337
Gameplay rating	0.126 .005	0.043 .271	-0.245 <.001	-0.057 .327	0.072 .083	.095
Controls rating	0.142 .001	-0.030 .432	-0.351 <.001	-0.029 .556	0.122 .001	.168
Overall rating	0.097 .098	0.213 <.001	-0.356 <.001	-0.030 .452	0.042 .337	.214
Affect	-0.015 .753	0.176 <.001	-0.276 <.001	-0.207 <.001	-0.050 .266	.164
Arousal	0.262	0.018	-0.044	0.143	0.152	.179

<.001	.684	.306	.001	<.001
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Note. Standardized regression coefficients followed by *p*-values are reported; coefficients larger than .16 bolded to ease interpretation.

Discussion

The present study developed and validated a metric for assessing self-reports of perceived demands upon videogame players during a specific instance of gameplay—specifically, demands associated with being cognitively, emotionally, physically (via controller devices and via physical exertion), and socially engaged with the game. The final Video Game Demand Scale (VGDS) contained 26 items that assessed these demand dimensions and demonstrated expected associations with theoretically related assessments of gaming experiences. Given the exploratory nature of the measure, it is worthwhile to further interpret the constructs reflected by the retained items.

The cognitive demand dimension items are principally about directed and purposeful thinking—perhaps most directly capturing the mental and rational aspects of video game play. While many of our initial discussions centered around creating items to measure meaning-making (e.g., *was easy to comprehend* and *challenges were clear to me* from the original item pool, see Appendix A), the retained items are more closely aligned with the extent to which a game engages the player’s mental faculties—similar to the notion of attentional demand (Bowman & Tamborini, 2012; 2015; as well as the extensive research of Green and colleagues overviewed in Chapter 2 of this volume). Cognitive demand items shared significant positive associations with arousal, as well as with autonomy and competence (one might expect these relationships to be more curvilinear, although this was not examined in the current dataset), echoing findings that (a) gameplay mechanics are strongly aligned with enjoyment (Oliver et al., 2016) and (b) a core motivation of gameplay is challenge and competition (Sherry et al., 2006).

Games that are highly enjoyable (as were those reported in this study, with 95% of respondents reporting enjoyment scores higher than 5.00 on a seven-point scale) are those that are comparatively high in cognitive demand.

Regarding emotional demand, the high factor loadings of items with colloquial references to game-induced affect are notable: the game *tugged on heartstrings* and *gave me the feels*. These items coalesced with items reflecting perceived player-centered emotions (being *emotionally invested*, *moved*, and having *emotional responses*) and context-centered emotions (in that *emotions ran high* and that emotions were *unexpected*). Emotional demand was strongly associated both with ratings of game story/narrative, ratings of in-game autonomy and relatedness, as well as feelings of appreciation, suggesting that non-hedonic appreciation of video games (Oliver et al., 2016) may be largely due to their emotional demands. Given the renewed focus on emotions in gaming both by industry (in terms of programming emotional experiences, see Schell, 2013) and researchers (in terms of understanding the motivational and appraisal-based emotional systems involved in gaming, see Hemenover & Bowman, in press), the ability to measure emotional demand promises to advance understandings of the role of emotion in gaming—especially if these data were paired with discrete measure of emotion (See Grizzard & Francemone, Chapter 5 this volume).

Two different types of physical demand emerged in our data, with *game controls* being *very natural*, *second nature*, and *easy to handle* being more associated with the discrete controller device (controller demand) and being *physically exhausted* and feeling *drained after gameplay* that seem to focus more holistically on involving the entire body in physical activity (exertional demand). Unsurprisingly, increases in either type of physical demand were negatively associated with most validation metrics—in particular, decreased enjoyment and increased

negative affect—which makes sense given that these physical demand items seem to tap into generally undesired experiences, such as physical exhaustion and poorly mapped control systems. Indeed, difficulty with controller schemes appears to be substantially autonomy-thwarting. Given that 97% of our sample reported on gameplay experience involving traditional handheld controllers, one conclusion is that disrupting a player’s possible expectations regarding physical engagement with the controller will likely lead to a negative experience, as has been found in past literature in which gamers are given naturally mapped rather than traditional controllers, and they paradoxically self-report *increased* naturalness with the more traditional (i.e., familiar) device (cf. Tamborini et al., 2010; Rogers et al., 2015; Bowman et al., 2017).

Finally, the social demand factor similarly comprised items indicating a convergence of items representing both game-induced sociality (it was an *important part of the game*) and player-initiated sociality (feeling *obligated to others*), as well as items suggestive of both explicit awareness of and response to others through concrete influences (they *had an impact on how I played*) and more heuristic assessments of their influence that may suggest more implicit social demand (being *aware of others*); . Importantly, in the present study the wording of the candidate social demand items requested that participants were asked to consider generalized “others” without articulating what type of others—humans (whether co-present or online, whether actively collaborating or merely observing) or non-humans (whether a controlled player-character, other player-character, or non-player character); this was done due to the fact that respondents would be reporting on a very broad set of gaming experiences. That the factor emerged in spite of this reference speaks to the flexibility of the metric; however, since all of these “others” could differently influence a player’s experience of social demand (see Banks &

Carr, in press) and since practical application is likely to focus on one type, validations of the metric should consider variations among relational agents.

Implications and Utility of VGDS

Notably for the current study, players generally reported on the remembered play experiences with an incredibly high level of fondness (as evidenced by high enjoyment and overall game rating scores). One conclusion we can draw is that the VGDS sub-dimensions seem to have linear relationships with positive game assessments (positive linear associations in the case of emotional, social, and cognitive demand; negative linear associations in the case of physical demand). Thus, the question as to whether or not we can conceptualize demand as a phenomenologically engaging experience or draining one (positive and negative, respectively) remains somewhat unanswered. It could be the case that emotional, social, and cognitive demands are experienced more as thresholds—that is, players are energized by (and somewhat expect) these aspects of an experience to be engaged “to a point,” similar to the logic of flow theory (Sherry, 2004). Perhaps these three demands are more tied to the player’s active agency—choosing to engage the emotions of an experience, or the social actors in the experience, or purposefully thinking through and rationalizing the game’s environment—and as such, players expect and anticipate these demands. Such a logic would align well with understanding video games as a lean forward medium (Jansz, 2005). Conversely, players in the current sample seem to approach the notion of physical demand as resource depletion under non-negotiable conditions (that is, we cannot change the controller itself in the same way we can change content on-screen) such that increasing physical demand has a net negative experience on gaming. Such arguments might align well with other studies reporting that advances in motion-sensor and other full-body controllers are not necessarily experienced as benefits to the gaming experience, as they both

violate mental models of the gaming experience (Rogers et al., 2015; Bowman et al., 2017) while also inducing frustration and hindering performance (Tamborini et al., 2010; Rogers et al., 2015).

Limitations and Future Research

In order to attempt to get a variety of gaming experiences, participants in our study were asked to recall “their most recent gaming experience” rather than “their most memorable or enjoyable gaming experience” (as used in Oliver et al., 2016). However, respondents reported on overwhelmingly positive gaming experiences, which restricts the range of phenomenological experiences of gamers in our study (i.e., we have very few gamers reporting on negative experiences) and thus restricts our ability to (a) test for associations of our demand measures with enjoyment (due to a restriction of range in that variable) and (b) look for possible thresholds of demand (given that the associations between demand and gaming experiences with highly enjoyable experiences seem more linear). Thus, future research might look to more specifically induce a variety of negative and positive gaming outcomes (perhaps by manipulating relative levels of demand along multiple dimensions) via experimental design, perhaps replicating and extending studies such as Bowman and Tamborini (2012), in which attentional demand—by way of cognitive and device demand—was induced at low, medium, and high levels to predict performance and enjoyment outcomes (medium levels of demand resulted in the highest levels of both).

In addition to using experimental methods to look for specific content and experience correlates with VGDS—we broadly expect demands to mediate the direct effects of content and effect—gameplay situations, VGDS should be further validated with other measures, such as open-ended qualitative data from players, observational metrics (both of demand levels and of demand outcomes, such as frustration or boredom), and psychophysiological indicators (such as

hemodynamic indicators or other measures of arousal, attention, and emotion). Such data would be critical in establishing and extending the construct validity of the nascent VGDS metric.

Given that physical demand items seem to conceptually cluster around understandings of both input devices or full body experiences, more attention should be given to this metric to further refine the concept to pick up on nuances associated with different controller schemes (such as comparisons between a two-button NES controller and an eight-button PlayStation controller; or games that use more or less button inputs). At the same time, the increased availability and popularity of augmented and virtual reality (AR/VR) platforms such as the HTC Vive and PlayStation VR might suggest that a focus on full body immersion and the ensuing exertional demands that such experiences bring with them might become increasingly relevant for game studies. Such a focus seems more conceptually aligned with Sundar's (2004) focus on *interactivity-as-product* while also allowing for a consideration of the users' variable perceptions of those technological affordances provided by various input methods—be they a held device or the body itself. Physical demand is discussed here as a special case given recent developments in augmented and virtual reality technologies that focus on the player's embodied experiences in the digital worlds, but other demand dimensions are also critical here. For example, Lin (2017) found that playing a horror survival game wearing a head-mounted virtual reality display (the HTC Vive) led to significantly higher fear reactions, some with residual effects recalled as long as 24 hours after playing—such an effect might be explained by the immersive content triggering intense basic emotional reactions in the player (see Lynch & Martins, 2015). AR/VR technologies might also challenge player's cognitive resources by immersing them in experiences in which details of a game's environment that could normally be ignored might draw specific attention (that should be otherwise allocated for solving in-game goals), for example the

textures of a pathway that a player is traversing or background conversations between other players (which might or might not be relevant for achieving in-game goals). Such orientation effects could be explained through the moderate discrepancy hypothesis, in which we are inclined to attend to and understand stimuli that are familiar enough to have a basic comparison, but unique enough to draw attention (McCall & McGhee, 1977), but might be seen as disruptive from a cognitive demand perspective by overloading the player's already limited cognitive capacity to process the game environment.

Finally, the current analyses do not consider the potential of VGDS dimensions to vary as a function of the relationships between players and their avatars—as has been established by Banks and Bowman (2015). It is plausible that game genre conventions might favor or feature some demand characteristics over others and that players of some genres might see demand characteristics as a benefit to some games, but a disruption in others (one might expect high cognitive and physical demands in an action-based shooter, but not expect high emotional demand such as feelings of guilt for on-screen actions; Grizzard et al, 2014). Likewise, players adopting a more functional orientation towards their avatars in which the on-screen avatar is an asocial game piece might be more likely to engage cognitively with the game, whereas players embracing a more social and affective orientation (in which they see their avatar as an authentic and autonomous social agent) are more likely to experience and expect emotional and social demands (see Banks & Bowman, 2015).

Conclusion

This study proposed a 26-item, five-factor Video Game Demand Scale, conceptualized as the implicit or explicit, interactivity-driven game requirements for players to affectively, cognitively, socially, and physically (controller and exertion) engage with game content. The

metric's validity (as evidenced by convergence with other demand/arousal measures), reliability (as evidenced by the factors' internal consistency), and utility (as evidenced by its theoretically consistent associations with video game experience variables) were supported. Thus, the scale promises to be useful to advance empirical understandings of gaming uses, experiences, and effects.

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