**A German-language version of the Video Game Demand Scale (VGDS-G): Development, measurement invariance, and (replicated) factorial validity**

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**Abstract:** The Video Game Demand Scale (VGDS) is a 26-item, five-factor scale designed to assess the cognitive, emotional, physical and social demands experienced by video game players. Given the popularity of video games, as well as game studies research in Germany, the current study introduces a German-language VGDS (VGDS-G). The translated scale replicated the original version with exception of a single item, demonstrating configural and partial metric measurement invariance when compared with freely available data from the VGDS. Moreover, predictive, convergent, and concurrent validity tests between the VGDS-G and common measures of task load, entertainment, need satisfaction, and game ratings (replications of the original VGDS validity tests) provide further evidence of (a) the translated scale’s quality and (b) further validation of an interactivity-as-demand approach to studying video games. For scholars interested in how video game players experience interactivity in video games on multiple dimensions, as well as how these demand perceptions influence myriad gaming outcomes, VGDS and VGDS-G emerge as useful and reliable self-report metrics.

*Keywords: Video Game Demand Scale, scale translation, scale validation, media entertainment*

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Video games are often characterized as lean-forward media (Jansz, 2005) in which users are chiefly responsible for co-creating the on-screen experience (Wellenreiter, 2015). While previous research suggested that perceived interactivity might be key to explain both positive and negative effects resulting from playing (Weber, Behr, & DeMartino, 2014), more recent approaches instead examine how players perceive more nuanced demands of this interactive co-creation (Bowman, 2018). Proposed as an *interactivity-as-demand* framework, a player’s experiences of the demands associated with interactivity, rather than interactivity itself, are thought to mediate associations between on-screen content and the effects of that content. Bowman (2018) suggested four dimensions in which these co-created interactions can be understood in video games (cognitive, emotional, physical, and social demand) and a self-report measurement model was proposed: the Video Game Demand Scale (VGDS; Bowman, Wasserman, & Banks, 2018).

Although current video game market analyses show that English-language markets still have a large share in global game revenues, other language regions in East Asia (e.g., China, Japan, and South Korea) and Western Europe (e.g., Germany, UK, and France) have also emerged as core gaming markets (Newzoo, 2018). Likewise, game scholars have intensified their work on translating and validating extant measurements into languages besides English—such as Kahn et al.’s (2015) expansion into Chinese-language markets or de Grove et al.’s (2017) and Banks et al.’s (2019) multi-language expansions. In addition to being a language regions with growing game revenues, Germany might be particularly interesting as German scholars represent a large group of contributors in the global communication science and media psychology community (second only to US researchers in co-authorship at the annual meetings of the International Communication Association; Jiang & Barnett, 2017). Given this twin popularity of video games and games scholarship in Germany, our first goal was to develop a German version of the VGDS (VGDS-G) and test for measurement invariance with respect to the original scale’s five-factor structure using data made freely available by Bowman et al. (2018). As a second goal, we replicated the validation procedures from the original scale by examining how the VGDS-G correlates with other established measures of task demand (for convergent validity), perceived effort (for predictive validity), as well as entertainment experience, need satisfaction and ratings of game features (for concurrent validity).

**Demand Dimensions and Validation Analyses**

According to extant work by Bowman and colleagues (Bowman, 2018; Bowman et al., 2018), players’ perceived demands in video game can be differentiated into four domains—each of which serving as critical intermediary variables between game content and outcomes of play. Cognitive demands referred to the extent to which a video game requires users to implicitly or explicitly rationalize the system, borrowing from Gee’s (2003) assertion that gaming provides *de facto* learning experiences through their challenge structures. Emotional demands were defined as the extent to which a video game triggers an implicit or explicit affective response in the player, owning to Oliver et al.’s (2015) work hedonic and eudaimonic reactions to gaming as well as the role of video games as both emotion elicitors and emotion regulators (Hemenover & Bowman, 2018). Physical demands consider how gameplay requires users to exert discrete or holistic effort on the system through some control apparatus, referring to both the handheld devices themselves as well as whole-body physical exertion (Liebold, Bowman, & Pietschmann, 2018). Social demands refer to how much a game evokes an implicit or explicit user response to the presence of other social actors, both in terms of social interactions with other human players (Quandt & Kroeger, 2013) as well as non-human characters (Banks, 2015).

For predictive validity tests, we assumed that players’ perceptions of demand would be strongly associated with the self-reported effort (Paas, 1992)—for example, increased perceptions of cognitive demand being strongly associated with higher reports of expended cognitive effort. For convergent validity tests, we considered the extent to which self-reported demand was correlated with perceptions of task load (Hart & Staveland, 1988). In particular, we expected increased cognitive demand and physical exertion to be uniquely and positively associated with increased task demand, given that task load considerations are rooted in user experience design. For concurrent validity tests, we considered the relationships between demand perceptions and both enjoyment and appreciation. Owning to Oliver et al.’s (2016) work on hedonic and eudaimonic gaming reactions, we broadly expected enjoyment to be associated most strongly with cognitive demand, and appreciation to be most strongly associated with emotional demand. Player need satisfaction was also assessed concurrently with VGDS-G in the current study (Ryan, Rigby, & Przybylski, 2006). Informed by Oliver et al. (2016), emotional demands were expected to align with relatedness (feeling closer to in-game action). Controller demands were expected to suppress competence and autonomy scores, representing difficulty engaging on-screen action (Rogers, Bowman, & Oliver, 2015). Likewise given past work establishing relatedness and social presence (Ravaja et al., 2006), relatedness is expected to be positively related to social demand. Finally, we also explored how perceived demands might be associated with how players rate a video game’s distinct qualities, such as gameplay (associated with cognitive demand), and narrative (associated with emotional demand; see Oliver et al, 2016). Notably, the specified validation relationships were all found in prior VGDS validation work (Bowman et al., 2018) and thus, the validation tests here serve to both (a) validate VGDS-G and (b) replicate observations from Bowman et al. (2018).

**Method**

The original VGDS was translated into German using a translation-back translation method[[1]](#footnote-2). The VGDS-G was distributed online to samples of gamers, following the Bowman et al.’ (2018) procedures in asking participants to (a) recall their most recent gaming experience, (b) reply to the VGDS-G, (c) describe the game’s demands in own words, and (d) respond to the validation measures. All study materials and data analysis files are available online: <https://osf.io/dr54t/?view_only=e7520417c83b4170a5d22ddca41ec249>.

**Participants**

Players were recruited at a mid-sized German university via a campus-wide email invitation. Filtering out participants who completed the questionnaire (*N* = 594) but did not give complete answers to the VGDS-G items (*n* = 34), the final sample consisted of *N* = 560 participants (*M* = 24.83 years, *SD* = 4.38, range: 18–63 years) with *n* = 137 identifying themselves as female (24.5%), *n* = 404 as male (72.1%), and *n* = 19 who decided not to specify their biological sex (3.4%). Nearly 200 unique games and franchises were mentioned by participants. Most participants reported playing with keyboard and mouse (*n* = 313, 55.9%) or a standard controller (*n* = 206, 36.8%). On average, the session lasted for *M* = 2.80 hours (*SD* = 2.90). While 56.8% of respondents (*n* = 318) indicated that they had played alone, 40.7% (*n* = 228) indicated some form of online or offline co-playing.

**Measures**

**VGDS.** The original VGDS consisted of 26 items loading onto five factors: cognitive, emotional, physical (broken into controller demands and physical exertion), and social demands. Items were answered on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), in response to the participants most recent gaming experience.

**Convergent validity.**An adapted version of the six-item NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988) was used as an established measure of task demand, customized for application to video games and translated/back-translated for German application. One item measuring perceived success was removed for poor inter-item correlation (see supplemental files), and the resulting five-item scale demonstrated acceptable internal consistency (*M* = 4.12, *SD* = 1.60, α = .750).

**Predictive validity.**Paas’ (1992) single item-measure of mental effort was amended to assess participants’ perception of cognitive (*M* = 6.27, *SD* = 2.67), emotional (*M* = 4.40, *SD* = 3.08), physical (*M* = 2.07, *SD* = 2.50), and social effort (*M* = 3.56, *SD* = 3.26) exerted during their recent game session on a scale ranging from 0 (= extremely low) to 10 (= extremely high).

**Concurrent validity.**Next, we assessed whether participants felt entertained during their recent game session, using a three-item enjoyment scale (*M* = 6.21, *SD* = 0.90, α = .830) and a three-item appreciation scale (*M* = 3.52, *SD* = 1.72, α = .797) proposed by Oliver et al. (2016), with German language translations borrowed from Schneider, Bartsch, & Oliver (2017). Need satisfaction was measured via the player need satisfaction scale (PENS). PENS consists of three-item scales for participants’ basic psychological needs: perceived competence (*M* = 5.48, *SD* = 1.09, α = .817), autonomy (*M* = 5.30, *SD* = 1.33, α = .736) and relatedness (*M* = 3.25, *SD* = 1.84, α = .894); borrowing translations from Rieger et al. (2014). Both scales were answered on 7-point Likert scales (1 = strongly disagree; 7 = strongly agree).

Lastly, in borrowing from Oliver et al. (2016), participants rated their video game from 0 (= lowest) to 10 (= highest) regarding its story/narrative (*M* = 5.83, *SD* = 3.43), gameplay (*M* = 8.40, *SD* = 1.57), controller scheme (*M* = 8.08, *SD* = 1.68), sound (*M* = 7.76, *SD* = 2.29), graphics (*M* = 7.53, *SD* = 2.20), as well as provided an overall game rating (*M* = 8.43, *SD* = 1.34).

**Results**

**Factor analysis**

Observed data were tested against the five-factor structure reported in Bowman et al. (2018). Confirmatory factor analysis with maximum likelihood estimation with robust standard error (MLR) showed that the observed data was an adequate fit for the specified model, χ2(289) = 668.34, *p* <. 001, TLI = .910, CFI = .920, RMSEA = .048 (90% CI .044–.053), SRMR = .065. Within each dimension, the regression weights for all 26 items were significantly associated with their respective latent dimension at the .001 level. With the exception of a single item, all items had factor loadings of between .535 and .880, see Table 1. Removal of the poor-loading item had a nominal impact on fit, χ2(265) = 622.65, *p* <. 001, TLI = .914, CFI = .924, RMSEA = .049 (90% CI .044–.054), SRMR = .066. Local fit testing indicates negligible correlations among most items’ residuals with some exceptions (45 out of 325 [15%] with *r* > .1 and 5 out of 325 [1.66%] with *r* > .2), with residual correlations only within the social demand dimension (see supplemental files).

[insert Table 1 about here]

[insert Table 2 about here]

**Measurement invariance tests**

In order to further investigate whether the latent VGDS-G variables can be compared with those of the original VGDS, we examined measurement invariance across both samples using the *lavaan* package (version 0.6-3) in R (Rosseel, 2012); data from Bowman et al. (2018) was freely available at <https://osf.io/x5jch/>. Unstandardized factor loadings, intercepts, and residual variances for both samples as well as fit indices for each invariance model are shown in Table 3 and Table 4. Configural invariance model validated the same factor structure to be valid in both groups, χ2(530) =1192.81, *p* <.001, TLI = .937, CFI = .944, RMSEA = .045 (90% CI .042–.049), SRMR = .057. Further analyses demonstrated partial metric invariance in item loadings across both samples, χ2(548) = 1219.3, *p* <.001, TLI = .938, CFI = .944, RMSEA = .045 (90% CI .042–.048), SRMR = .058, suggesting that VGDS items were understood similarly across language groups and thus, comparisons of regression coefficients can be considered valid with only a minor bias. However, due to non-invariance in latent variables’ residuals variance and intercepts, comparisons of both manifest and latent means should be avoided[[2]](#footnote-3).

[insert Table 4 about here]

**Validation tests**

***Convergent validity.*** As a test of convergent validity, we regressed the five VGDS-G latent variables onto the NASA-TLX latent variable via MLR. Global model indices showed marginally good fit (see Table 5), and most critically, NASA-TLX scores were significantly and positively associated with both cognitive demand and physical exertion (bolded in Table 5).

[insert Table 5 about here]

***Predictive validity.*** The VGDS-G latent variables were regressed onto single-item indicators of how much mental, emotional, physical, and social effort participants reported to have put into gameplay via MLR. Global model fit was good (see Table 6). With the exception of controller demand not being related to physical effort, each dimension of perceived demand was significantly predicted by recalled effort exerted for that dimension (see Table 6).

[insert Table 6 about here]

***Concurrent validity.*** We explored the concurrent validity with regressing the VGDS-G latent variables onto latent variables for both entertainment outcomes (i.e., enjoyment and appreciation) and need satisfaction metrics (i.e., autonomy, competence, relatedness) as well as game ratings (i.e., story, gameplay, control, sound, graphics, and overall rating) using MLR. Again, global indices demonstrated acceptable fit (see Table 7).

For entertainment outcomes, both enjoymentand appreciation were significantly associated with demand dimensions, variance explained in the appreciation model being substantially larger than the enjoyment model (94.5% vs. 18.5%; see Table 7). Most critically as a test of concurrent validity (bolded in Table 7), while enjoyment scores did not sort as expected, there is a clear connection between emotional demand and appreciation, significantly higher than all other associations and replicating prior work on VGDS. Considering PENS, the most striking data (marked in bold in Table 7) were the strong influences of emotional and social demand on increased relatedness, and the suppression effect of controller demand on competence scores. Unexpectedly (although sensical), self-reports of increased physical exertion were associated with decreased scores for all three need satisfaction measures. Lastly, with respect to players’ game ratings, several regression coefficients were significant. Most critically as a test of concurrent validity (bolded in Table 7), those most notable for scale validation included the strong association between emotional demand and ratings of a game’s storyline, and the substantial negative impact of increased controller demand on ratings of a game’s control mechanisms.

[insert Table 7 about here]

**Discussion**

Interactivity is at the heart of video games as it is considered to have a key role in the medium’s appeal and its effects (AUTHORS). By focusing on whether players recognize the interactivity given within video games (Weber et al., 2014), previous theoretical work overlooked the experience of interactivity itself, as players are constantly required to co-create their game experience—an involvement that taxes players’ resources in different ways (i.e., cognitively, emotionally, physically, and socially), all of which likely mediating the relationship between game content and its outcomes (Bowman, 2018). The current study was designed to extend research into the cognitive, emotional, physical, and social demands of video games by (a) developing a German version of the five-factor VGDS by Bowman et al. (2018) and testing for measurement invariance and (b) validating the VGDS-G with well-established measures of task demand, perceived effort, and pivotal game outcomes.

The observed data replicated that original model as well as demonstrated partial metric invariance with the original VGDS. The observed data from the VGDS-G was an acceptable fit for the five-factor structure, suggesting these sources of demand to be valid (with extended replication and extension still required). Beyond that, German- and English-speaking respondents do not seem to interpret the underlying dimensions differently from each other, which indicates that an interactivity-as-demand perspective might be culturally invariant on a metric level. Only two slight deviations to the original were found in this data and both were related to controller demand. First, the item “The game controls tripped me up” had to be dropped for poor factor loading (.574, while having a loading of .860 in the US sample). Second, the controller demand dimension of VGDS-G did not share a significant correlation with other scale dimensions, whereas in the original VGDS it did share a small-albeit-significant correlation with physical exertion, *r*(660)= .173, *p* = .001. It is unclear why the samples differ as both data sets shared low means and similar variances on this dimension (*M* = 2.43, *SD* = 1.24 vs. *M* = 2.60, *SD* = 1.18) and participants reported having playing with standard input devices in similar numbers (97.3% vs. 94.2%). Replications that focus on other core gaming markets and take differences in gamer culture into consideration (e.g., Banks et al., 2019; de Grove et al., 2017; Kahn et al., 2015) are necessary to provide definitive evidence about measurement invariance.

Convergent, predictive, and concurrent validity measures closely mirrored previous research on video game effects, as well as validation work on VGDS from Bowman et al. (2018). All demand factors had strong positive correlation with focal single-item self-reports of effort exerted. However, controller demand was unrelated to any effort, most notably physical effort. Along with the suggestions that controller demand might not be salient enough to register as demand as players are unlikely to have had a recent play experience with an unfamiliar controller, future examinations of this construct will require more direct manipulation of novel or challenging control schemes. Cognitive demand and physical exertion were the only two dimensions that were related to perceptions of increased task load. These findings suggest that perceptions of these demands are more aligned with how to physically and mentally negotiate the game and reflect a focus on ludic rather than narrative dimensions of games (Oliver et al. ,2016). Rather weak relations were observed between enjoyment and any demand type—suggesting that while some demands might facilitate enjoyment (such as when players engage in the ludic and narrative dimensions of games), other demands might hinder enjoyment sometimes creating a unique sense of frustration or lacking feelings of competence (such as when the input devices require too much of us; in line with Liebold et al., 2018 or Rogers et al., 2015). An observed strong association between emotional demand and increased appreciation scores (which was corroborated by strong relations to game features that are linked with the game atmosphere like story, sound, and graphics), suggesting emotional demand to be a critical element of eudaimonia during gaming (Oliver et al., 2016); these findings were reinforced by strong correlations between relatedness and both social and emotional demand. Extensions of this work should retest the scale with specific and focal gaming events (such as administering the scale immediately after play), with attention to games known (or manipulated) to vary on specific demand dimensions. Similar to the original scale, the VGDS-G demonstrated both reliability and validity indicating its utility to assess perceived demands in video games and to promote an interactivity-as-demand approach to examine video game uses and effects.

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1. The scale translation was carried out by the first author and two German native speakers with English language fluency, experience in conducting behavioral research, as well as varying expertise in video games. The two translations were done separately, and then discussed among all three translators until they agreed on a final wording. Another German native speaker with English language fluency (and without any knowledge of the original scale) translated the German items back to English (see Table 1). [↑](#footnote-ref-2)
2. Detailed measurement invariance analyses illustrating model comparisons and procedures for estimating partially invariant models are available in the supplemental OSF space. [↑](#footnote-ref-3)