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The Basic Needs in Games Scale (BANGS): A new tool for investigating positive and negative video game experiences

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ABSTRACT

Players' basic psychological needs for autonomy, competence, and relatedness are among the most commonly used constructs used in research on what makes video games so engaging, and how they might support or undermine user wellbeing. However, existing measures of basic psychological needs in games have important limitations—they either do not measure need frustration, or measure it in a way that may not be appropriate for the video games domain, they struggle to capture feelings of relatedness in both single- and multiplayer contexts, and they often lack validity evidence for certain contexts (e.g., playtesting vs experience with games as a whole). In this paper, we report on the design and validation of a new measure, the Basic Needs in Games Scale (BANGS), whose 6 subscales cover satisfaction and frustration of each basic psychological need in gaming contexts. The scale was validated and evaluated over five studies with a total of 1246 unique participants. Results supported the theorized structure of the scale and provided evidence for discriminant, convergent and criterion validity. Results also show that the scale performs well over different contexts (including evaluating experiences in a single game session or across various sessions) and over time, supporting measurement invariance. Further improvements to the scale are warranted, as results indicated lower reliability in the autonomy frustration subscale, and a surprising non-significant correlation between relatedness satisfaction and frustration. Despite these minor limitations, BANGS is a reliable and theoretically sound tool for researchers to measure basic needs satisfaction and frustration with a degree of domain validity not previously available.

1. Introduction

One of the primary goals of research on video games is to explain, predict, and measure player experience and engagement. Using constructs such as immersion (Jennett et al., 2008), curiosity (Brockmyer et al., 2009), challenge (Denisova et al., 2020), and many others, researchers in both academia and industry settings attempt to evaluate gaming experiences of a given group of players. These findings can then inform game development processes, our understanding of the positive and negative effects of games on players' lives, and responsible policy-making.

One theory that has been widely applied in this area is self-determination theory (SDT; Ryan and Deci, 2017) and its notion of basic psychological needs. SDT argues that humans have three basic psychological needs for *autonomy* (the need to feel in control over one's life and volitional in one's actions), *competence* (the need to act effectively and exert mastery in the world), and *relatedness* (the need to feel that one is connected to and valued by others). Needs are named as such because they are theorized to be nutriments vital for a person to live a fully functional life.

SDT's basic needs have been fruitfully applied to the study of both interactive and non-interactive media (Tamborini et al., 2011). Across a variety of domains, evidence shows that media experiences that better satisfy the three basic needs are more enjoyable and engaging (e.g., virtual reality applications Reer et al., 2022; television Adachi et al., 2018; esports viewership Qian et al., 2022; and social media Sheldon et al., 2011).

These psychological needs have been especially widely studied in games research (Tyack and Mekler, 2020), dating back to influential

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papers by Ryan et al. (2006) and Przybylski et al. (2010). Satisfaction of basic needs in games is associated with greater intrinsic motivation and engagement across genres (e.g., Tamborini et al., 2011; Oliver et al., 2016; Adinolf and Türkay, 2019) as well as to positive well-being effects (Kowert, 2020; Formosa et al., 2022; Vella et al., 2013).

To relate basic needs to outcomes such as enjoyment, engagement, and well-being, researchers often make use of surveys tapping SDT's basic needs. However, we will argue below that the existing questionnaires used to assess basic needs in games have important limitations, which together motivate our development of a new scale, the Basic Needs in Games Scale (BANGS).

2. Background

We identified three desirable ways that a measure of basic psychological needs in games can advance upon prior scales: (1) the inclusion of domain-appropriate need frustration items, (2) items that can assess relatedness in both single-player and multiplayer contexts, and (3) good evidence psychometric validity across multiple levels of generality. We discuss each desirable property in turn, before reviewing existing measures in this space and the extent to which they fulfill these.

2.1. Need frustration

One of the key recent advances in research on games and self-determination theory has been need frustration as a distinct construct (Tyack and Wyeth, 2017; Ballou and Deterding, 2023). Recent work in self-determination theory has developed a distinction between *satisfaction* of basic needs and their active *frustration*. Need frustration is not simply the absence of need satisfaction (Bartholomew et al., 2011; Warburton et al., 2020), but a separate construct referring to feelings of being controlled or coerced *(autonomy frustration)*, failure and self-doubt *(competence frustration)*, or loneliness and exclusion *(relatedness frustration)*. Evidence suggests that need satisfaction and need frustration are separate experiences that can coexist to a degree in both games (Allen and Anderson, 2018) and daily life (Vansteenkiste et al., 2020).

Need frustration has been the focus of growing attention in media use studies, with researchers proposing it as an explanatory mechanism for negative experiences, disengagement, and adverse effects of media engagement. Evidence suggests that need frustration is a salient experience in games (Pusey et al., 2021) with impacts that are separate and distinct to those of need satisfaction (Kosa and Uysal, 2021). Ballou and Deterding (2023) found that players could readily recall diverse experiences of game-related need frustration, and that these experiences – and the change in expectations for future experiences that resulted from them – were important determinants of ongoing engagement. Need frustration in games may have negative consequences beyond games as well, having been linked to strong negative affective reactions including aggression (Przybylski et al., 2014) and dysregulated gaming (Allen and Anderson, 2018; Kosa and Uysal, 2021).

Despite the emergence of need frustration as a valuable target of study, there currently exists no measure of need frustration that has been developed for use in a video games context. One measure that captures need frustration, the Basic Psychological Need Satisfaction and Frustration scale (Chen et al., 2015), has been adapted for a gaming context, but this comes with its own limitations, discussed below. To facilitate work on disengagement and churn, potential negative effects of gaming on well-being, and more, we argue that a need frustration scale targeted specifically for gaming experiences is needed.

2.2. Relatedness in single-player games

There is substantial evidence that players can derive meaningful social benefits from games even without (traditional) multiplayer features. Tyack and Wyeth (2017) describe three such additional sources of relatedness satisfaction: players' relationships with in-game characters/worlds (including both relationships with one's own avatar, and with other non-player characters (NPCs) in the game, Bopp et al., 2019), the shared community and group membership, and with the game as an object.

At present, however, measures of relatedness satisfaction in games struggle to capture these kinds of experiences, either focusing items exclusively on multiplayer games (Ryan et al., 2006), or separating them into two sub-facets of relatedness (Azadvar and Canossa, 2018). By separating them, players who derive high relatedness satisfaction from either other players OR non-player characters – but not both – will have middling scores overall, and the divergence can result in construct validity problems (Ballou et al., 2022).

Theory predicts that relatedness experiences with both human players and non-player characters or worlds would similarly lead to greater engagement and enjoyment in games (Rigby and Ryan, 2011; Tyack and Wyeth, 2017). Measures of relatedness satisfaction and frustration should therefore carefully word items so as to allow players to report feelings of social connectedness either with other human players or non-player characters. This would facilitate research that more comprehensively addresses the variety of social experiences players can derive from their gaming.

2.3. Levels of generality

Games research frequently grapples with, but rarely formally addresses, questions around the level of *generality* of a measure. It is common for player experience questionnaires to be used in multiple contexts: during or after playing a particular gaming session (the *session* level), when recalling experiences with a particular game (the *game* level), or when recalling experiences across all games the person played (the *hobby* level). As the level of generality increases, players are asked to aggregate over longer periods and larger numbers of gaming sessions, and must internally compute an average of these experiences.

Theory and evidence on the hierarchical model of self-determined motivation in SDT (Vallerand and Ratelle, 2002; Guay et al., 2003) suggest that intrinsic motivation manifests at different levels of generality with different degrees of stability and top-down and bottom up influences between levels. Furthermore, these different levels of generality are used to address different research questions. Responses about a recent session are key for playtesting and user research: for example, Peng et al. (2012) found that avatar customization, skill upgrades, and dialogue options supported the need for autonomy during a one-off session of an exergame. Responding about one's experience of need satisfaction and frustration across all games has been used to investigate more global relationships between gaming as a hobby and wellbeing: for example, Allen and Anderson (2018) find that need satisfaction across gaming in general, in combination with high need frustration in daily life, is related to dysregulated play.

Rarely, however, have player experience scales been explicitly tested for validity in each of these contexts. At least one study suggests that the factor structure differs in just-played vs. recalled gaming experiences (Ballou et al., 2021). Given this uncertainty, we argue that questionnaires should explicitly undergo validation across each level of generality, to investigate whether the same questionnaire can work equally well across all three levels, and whether scores can be compared across them.

2.4. Limitations of existing measures

Different combinations of the above limitations are found in the three most commonly-used measures of need satisfaction in video games (Tyack and Mekler, 2020), alongside some other limitations specific to each measure.[1] Below, we review these three measures in light of what we hope to improve upon.

2.4.1. Player Experience of Need Satisfaction Questionnaire (PENS)

The most commonly-used scale for measuring need satisfaction in video games is the Player Experience of Need Satisfaction scale (PENS; Ryan et al., 2006). In PENS, we identified (1) a lack of need frustration and (2) a narrow conceptualization of relatedness as limitations to be addressed by an updated questionnaire.

In relation to the desirable qualities of a measure listed above, PENS was developed prior to the emergence of need frustration as a separate construct, and therefore only includes satisfaction of each basic need. PENS also adopts a narrow view of relatedness satisfaction. While some items are ambiguous with regard to whether they refer to other human players or non-human characters ('I find the relationships I form in this game fulfilling'), one of the three items ('I don't feel close to other players'.) is limited to experiences in multiplayer games.

Other work has pointed out other minor psychometric issues of PENS Johnson et al. (2018). For instance, games researchers have been interested in studying the effect of difficulty balance or 'optimal challenge' (Ryan and Deci, 2017) on competence need satisfaction. Here, the PENS competence subscale presents the issue that it entails an item assessing balance ('My ability to play the game is well matched with the game's challenges'). This risks a jangle fallacy when assessing the impact of difficulty on competence satisfaction using PENS (Deterding and Cutting, 2023).

2.4.2. Ubisoft Perceived Experience Questionnaire (UPEQ)

The Ubisoft Perceived Experience Questionnaire (UPEQ; Azadvar and Canossa, 2018) is a newer measure which has begun to see use. Similar to PENS, UPEQ measures need satisfaction in games, but does not include need frustration.

UPEQ's initial validation had notable strengths, including a large sample and a test of criterion validity through predicting objectively logged behavior among players of *Tom Clancy's The Division*. However, the initial validation was not very extensive—the authors conducted principal components analysis (PCA) on the initial item pool, but retained all 21 items tested, potentially suggesting a lack of experimentation and item diversity. This factor structure was not explicitly tested in the second study of the paper, which instead relied on reliability in the form of Cronbach's α to provide evidence of psychometric validity, which has the well-established limitations that high values may obscure multidimensionality (Stanley and Edwards, 2016). The validation did not include cognitive pretesting, convergent or divergent validity, or measurement invariance analyses. Some UPEQ items do not pass face validity tests: an autonomy subscale item, 'My actions had an impact on the game', does not describe autonomy as theorized in SDT (and in fact is more closely related to competence).

One way in which UPEQ extended PENS was by including relatedness satisfaction items that refer to non-human characters. However, UPEQ elected to have separate items for relatedness from multiplayer experiences (e.g., 'Other players are friendly towards me') and experiences with non-player characters (e.g., 'I was bonding with some of the characters'). These are presented as part of a single subscale; however, in a recent study, Ballou et al. (2022) found that this subscale was not unidimensional—parasocial relationships and multiplayer relationships clearly separated into two separate factors. As a result, players who derive high relatedness satisfaction from only one of these sources would score medium to low on the overall subscale, creating challenges in analysis and interpretation.

To improve upon UPEQ's limitations, therefore, a new measure should include need frustration, attempt to phrase items that allow players to derive relatedness satisfaction from *either* other human players or non-player characters, and undergo a more extensive psychometric validation procedure in line with current best practices.

2.4.3. Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS)

Lacking validated measures for need frustration in games, some researchers have attempted to use domain-general measures of basic needs in a video games context. Two such studies modified the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS; Chen et al., 2015) by either pre-pending 'when I play video games' to each item (Allen and Anderson, 2018), or adding 'in my [current favorite online game]' in the middle (Kosa and Uysal, 2021). Teng et al. (2024) only used the need satisfaction items of the BPNSFS, similarly pre-pending 'When I play this online game'.

In the limited examples of such research, these measures performed reasonably well, but we have reason to suspect that they are nonetheless imperfect solutions for measuring games-related experiences. Kosa and Uysal (2021) needed to remove 3 items due to low factor loadings (e.g., 'I have the impression that people I spend time with dislike me'.), suggesting that certain items are not straightforwardly applicable.

Allen and Anderson (2018) find in their modification almost no correlation between need satisfaction and frustration in games, while theory expects that these should at least be moderately negatively correlated. More generally, Ballou and Deterding (2023) find that certain types of need-frustrating gaming situations are implicitly excluded from modified domain-general scales (e.g., unfair situations, disconnection from game's community).

Teng et al. (2024) report acceptable to good indicator loadings of their items for each basic need (λ between .65 and .92), but did not measure need frustration and therefore do not provide information about the relation between satisfaction and frustration.

More generally, the relatedness items in the BPNSFS implicitly refer only to satisfaction and frustration derived from other human players. We are also not aware of studies testing its validity across levels of generality. Thus, a measure seeking to improve upon the BPNSFS for games research should ensure that items map coherently onto a games context (and should compare the relative predictive validity of games-related outcomes against the BPNSFS), allow a broader conceptualization of relatedness, and undergo more extensive validation than the brief ones done in conjunction with the empirical research presented by Allen and Anderson (2018), Kosa and Uysal (2021), and Teng et al. (2024).

3. Present research

In sum, we have argued that existing measures of basic psychological needs in games miss important constructs (need frustration) and/or adopt narrow views of basic needs (considering only simple forms of relatedness satisfaction); and that the domain-general scales used to solve the former may not be fully appropriate for use in a games context. Together with the prominence of SDT in the games literature and the potential power basic needs hold to explain engagement and the wellbeing impacts of gaming, we believe this warrants the development of an improved instrument.

[1] There are of course other SDT-based scales for games, but these measure other constructs within SDT, such as the six forms of motivation along the spectrum of self-determination (e.g., Lafrenière et al. (2012)). The recently developed and increasingly used Player Experience Inventory (PXI) (Vanden Abeele et al., 2020) contains two subscales (mastery and autonomy) that arguably map onto and show strong cross-loadings with competence and autonomy satisfaction in PENS, but was explicitly developed as a trans-theoretical general player experience instrument, and does not entail a relatedness equivalent, nor equivalents of need frustration.

Table 1
Items in the final version of the BANGS.

Construct	Label	Wording	CFA factor loading		
			Study 1	Study 2	Study 3
Autonomy satisfaction	bangs_01	I could make choices regarding how to play [X].	.84	.80	.76
	bangs_02	I could play [X] in the way I wanted.	.90	.83	.73
	bangs_03	I could direct my own play experience in [X].	.85	.84	.81
Autonomy frustration	bangs_04	I felt forced to take certain actions in [X].	.68	.72	.78
	bangs_05	Many actions in [X] were boring.	.72	.62	.44
	bangs_06	I often found myself wishing I could do something else within [X].	.72	.69	.54
Competence satisfaction	bangs_07	I felt I was getting better at playing [X].	.81	.77	.73
	bangs_08	I felt that I made progress while playing [X].	.86	.84	.69
	bangs_09	I felt a sense of achievement while playing [X].	.81	.79	.72
Competence frustration	bangs_10	I often felt that I lacked the skills necessary for [X].	.78	.69	.70
	bangs_11	I kept failing to accomplish what I wanted to while playing [X].	.61	.72	.69
	bangs_12	I felt disappointed with my performance in [X].	.87	.76	.85
Relatedness satisfaction	bangs_13	I felt I formed relationships with other players and/or characters in [X].	.85	.81	.78
	bangs_14	Engaging with [X], I felt a connection to others, virtual or real.	.84	.81	.75
	bangs_15	I felt that other players and/or characters in [X] cared about me.	.66	.79	.70
Relatedness frustration	bangs_16	Interactions with other players and/or characters in [X] felt toxic to me.	.81	.85	.82
	bangs_17	The community or virtual world in [X] made me feel unwelcome.	.72	.75	.75
	bangs_18	Others in [X] were unfriendly towards me.	.77	.83	.83

Note: [X] is a placeholder, which was filled in with 'the game' in Study 1 to refer to a single session; 'the games I played' in Study 2 to refer to gaming in general, and the name of a game entered by the participant using piped text in Study 3 to refer to one game over time. For downloadable files with final items and usage guidelines for all of these variants, please see https://nickballou.com/docs/bangs.

Table 2
Study details.

	Design details			Demographics			
	Context	Population	n	Mean age (SD)	Men	Women	Non-binary
Study 1: EFA	Session	Adult video game players	383	26.0 (6.3)	288	80	15
Study 2: CFA	Games in general	Adult US/UK Xbox users	1891[a]	32.8 (8.4)	236	50	11
Study 3: CFA	Particular game	Adult players (50% Xbox)	449	30.4 (8.1)	297	139	13
Study 4: Measurement Invariance	All of the above	All of the above	2723	30.2 (8.3)	821	230	79
Study 5: Conv./Disc./Pred. Validity	All of the above	All of the above	2723	30.2 (8.3)	821	230	79

[a] Composed of six waves of a longitudinal study with 414 unique participants.

This was our undertaking in the current paper. We present the development the Basic Needs in Games Scale (BANGS) and demonstrate its validity in several contexts. The final item list is presented in Table 1. Below, we describe each stage of development and validation process.

Following best practice guidelines for measure development (DeVellis and Thorpe, 2022), we adopted a multi-study, multi-sample approach to creating our scale (Table 2). We took particular inspiration from the development of the Player Experience Inventory (Vanden Abeele et al., 2020), one of the most well-validated player experience measures.

After generating a list of 78 candidate items, we first conducted an exploratory factor analysis study in which players recalled a recent play experience (study 1). EFA results allowed us to discard 26 items that did not perform adequately. We then used domain expertise to select among the remaining items and reach a measure of an appropriate length (18 items). In study 2, we validated the 18-item measure in a different context, namely with players' experiences of gaming in general over the previous 2 weeks. CFA analyses demonstrated excellent construct validity, with strong model fit and high item loadings in the intended 6-factor structure. In study 3, we conducted CFA analysis in a third context, this time using piped text so that items referred to a player's experience with one particular game over time. We extended the CFA analysis by further assessing convergent validity with existing basic needs questionnaires, and criterion validity by correlating need satisfaction and frustration with intrinsic motivation. Finally, in study 4 we combined the samples from each previous study to assess measurement invariance. Results show that the factor structure is similar for each context, but that there are minor differences in factor loadings and item intercepts.

3.1. Context

Our goal was to develop a questionnaire valid for use with all digital games. Throughout the following studies, players could respond to the survey with reference to any and all games that they had recently been playing. These were wide-ranging, including games that were both online and offline, single- or multiplayer, and so on (for a list of games, please see the supplementary materials). This means that some players responded to relatedness items with a single-player game in mind, while others had a multiplayer game in mind—thereby assessing the potential validity of the relatedness subscales for use in both contexts. Data further spans a wide range of genres, including but not limited to MOBAs, FPSs, sports games, action RPGs, walking simulators, and so forth.

3.2. Data and materials

All underlying data, analysis code, and materials for the below studies are available on the OSF (https://osf.io/uq8mp/). A basic user guide to deploying the questionnaire is available at https://nickballou.com/docs/bangs.

3.3. Survey design

All surveys were built in Qualtrics. In all studies, the order of measures, and of items within each measures, was randomized.

3.4. Scale format

Throughout the below studies, the BANGS was administered using a 7-pt Likert scale with anchors '1 - Strongly disagree', '4 - Neither agree nor disagree', and '7 - Strongly agree'.

The instructions for the measure read 'Below, we ask you about experiences of [X]. In [X]...', where [X] could be 'the gaming session you described' (Study 1), 'gaming in general over the past 2 weeks' (Study 2), or the name of a game listed by a participant in a previous question (Study 3).

3.5. Analysis

We performed a series of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) models to validate the questionnaire. All EFA models were fit using maximum likelihood and promax rotation, allowing for correlated factors. All CFA models used robust maximum likelihood estimation, and fit indices refer to their robust variants. Responses were required in most studies, so there are minimal missing data; where present, missing data are dropped pairwise.

Throughout, we do not use typical 'rules of thumb' cut-offs (e.g., those of Hu and Bentler, 1999), which are not universally applicable to all factor models, and instead adopt dynamic cutoffs to understand the magnitude of the misfit based on specific model and characteristics of the data (McNeish and Wolf, 2021).

3.6. Ethics

Ethical approval for the following studies was provided by Queen Mary University of London [QMERC20.565 DSEECS22.117]. In all studies, participants provided informed consent via Qualtrics before participating. The data originating in the separate longitudinal study (Study 2 and part of Study 3) contained identifiable information in the form of Xbox IDs and received separate ethics approval [QMERC20.383] including extensive procedures for maintaining confidentiality of personal data.

4. Item generation

4.1. Method

We adopted a mixed deductive and inductive approach to item generation, both considering the top-down theory, and the bottom-up qualitative research describing need-related experiences. To support this, we developed a 'primer' for item generators, consisting of key top-down theoretical definitions of basic psychological need satisfaction and frustration, as well as summaries of studies uncovered in a literature review of qualitative research describing when and how needs could be satisfied or frustrated during gaming (n = 16 papers). We particularly drew from an interview study whose intention was specifically to support the development of future need frustration in games measures (Ballou and Deterding, 2023). We further assembled a list of items from similar gaming-specific or domain-general need satisfaction and frustration measures. This primer is available in the supplementary materials (osf.io/uq8mp).

Four authors then proceeded to generate items separately, using the primer as a guide. Between them, these authors had expertise in questionnaire development, SDT (in games), and qualitative research. Broadly, our intention was not to measure every possible 'subfacet' of each need experience, which were numerous, but rather to minimize the implicit exclusion of these experiences (e.g., writing about relationships with other players that are not relevant for single-player games).

From the initial 168-item pool, we proceeded to reduce the item list so as to filter out less face valid items and minimize participant burden in Study 2. To achieve this, two authors with extensive experience in SDT and UX research (RR and SR) reviewed the item pool, providing feedback, edits, and comments to help select items that match theory and measurement best practices. The remaining authors reviewed all comments and feedback, and selected items for removal via discussion. This resulted in a list of 78 items with which we proceeded to Study 1. Stages of the pruning process and brief rationale for item inclusion/exclusion are available in the Materials folder of the supplementary materials.

Table 3
CFA model fit in each primary data study.

Study	χ^2 (df)	p	CFI	RMSEA [90% CI]	SRMR
Study 1	192.203 (120)	<.001	.978	.041 [.029, .052]	.050
Study 2	946.126 (720)	<.001	.978	.034 [.028, .040]	.043
Study 3	194.427 (120)	<.001	.947	.054 [.041, .066]	.058

5. Study 1: Exploratory factor analysis (Session-level)

In study 1, our goal was to prune the large candidate item list into a scale that is manageable in length and composed of only items that performed well in EFA analyses, as well as in a follow-up CFA. For this purpose, we elected to study the session-specific context.

5.1. Method

We recruited 422 participants on Prolific.co, a recruitment platform tailored to social science research. Manual inspection of responses, including comparing scores of 2 repeated items, found that 39 participants were potential careless responders; these participants were dropped from further analysis, yielding a final sample of 383.[2]

In Study 1, participants responded with reference to a recent gaming session, with placeholder [X]s replaced by the words 'the game'. To induce a degree of variation in need satisfaction and frustration in the data, we randomized participants to recall one of three different kinds of sessions: a recent session of a game they enjoyed (n = 87), did not enjoy (n = 106), or simply their most recent experience without any specification of its valence (n = 190). All participants were asked to briefly describe the session in writing and respond to all items in the pruned item pool with reference to this experience.

Participants were paid £1.30 for the survey, which had a median completion time of 12 min.

5.2. Results

With a KMO index of 0.955 and a significant Bartlett's test of sphericity ($\chi^2(4186) = 249\,218.2$, $p < .001$), sampling adequacy was considered excellent and the data suitable for factor analysis. There was no evidence for meaningful floor or ceiling effects across items. We therefore proceeded to conduct exploratory factor analysis.

Various factor retention analyses including parallel analysis converged on an optimal number of factors to retain between 5 and 7, which we confirmed via inspection of the scree plot. Given our strong theoretical rationale for a 6-factor structure, we fixed extraction to 6 factors. The 6-factor EFA model of all 78 items fit the data very well (see efa1_full_table.html in the supplementary materials for details).

We adopted an iterative approach to item pruning: after fitting an EFA model, we would remove any poor-performing items, then fit a new model with those items removed, and repeat this process until

[2] Participants in study 1 were recruited in 2 waves; the first wave completed 92 candidate items, of which 14 showed clear signs of poor performance and were dropped for the second sub-sample. For clarity, we describe the Study 1 results with reference only to the 78 items shown to all participants.

all remaining items met our quality criteria. Poor-performing items were defined as those that (1) load most strongly onto an unintended factor, (2) load onto more than 1 factor with nearly equal strength (within .1), (3) load weakly onto their intended factor (<.3), and/or (4) load strongly onto their intended factor (>.45), but also cross-load moderately onto one or more other factors (>.3).

After 3 rounds of iterative pruning, our final EFA model included 53 items (Table A.1). This was longer than our intended scale length, so we then proceeded to select among the remaining moderate- to high-performing items.

5.3. Item selection and cognitive pretesting

From the list of 53 candidate items that performed sufficiently well in Study 1, we used domain expertise to select a smaller subset for further validation. Our goals were to (1) retain equal-length subscales of no more than 4 items, (2) ensure that items in each subscale together holistically assessed the construct, and (3) ensure that the selected items had adequate reliability and factor fit when analyzed on their own.

Ultimately, we selected 3 items per subscale for a total of 18 items.[3] All authors reviewed the item list and the rationale for each item's selection, which are available in the supplementary materials.

5.4. Confirmatory factor analysis

A confirmatory factor analysis model on the 18 selected items using the data from Study 1 indicated excellent fit (Table 3), with all items loading strongly onto their intended factor (all loadings ≥ .60; Table 1). Dynamic fit index cut-offs showed that the degree of misfit was similar in magnitude to 2 cross-loadings of .4 each that are present in the population model but not our factor model, which would be considered minor misfit.

5.5. Cognitive pretesting

To supplement the item selection process, we conducted a cognitive pretest with 3 participants (1 native English speaker, 2 non-native speakers; all three were regular video game players). Cognitive pretesting allows researchers to establish whether (1) respondents can understand the question concept or task, (2) they do so in a consistent way, and (3) they do so in a way the researcher intended. We used a think-aloud method (Collins, 2003). On a Zoom video call with the first author, participants shared their screen while completing the questionnaire and described their decision-making process aloud. Where participants less freely voiced their thoughts, we used follow-up probes such as 'How did you go about answering that question?' and 'I noticed you hesitated before you answered, what were you thinking about?' The three cognitive pretests largely supported that the items were easily understood and understood in the intended way. Feedback from participants led to minor wording changes, such as removing the word 'tasks' from item cf05 and replacing 'actions' with 'activities' in item af16.

6. Study 2: Confirmatory factor analysis (Gaming in general)

In study 2, our goal was to validate the structure of the measure using CFA, and to do so at a different level of generality—rather than players responding with reference to a recent gaming session, we were interested in players' experiences with gaming in general (i.e., across potentially many different games).

[3] In the first instance, we selected 4 items per subscale (24 total), recognizing that further data collection may identify weak items among these, and thus giving us leeway to drop one item per subscale without dropping below the 3-item minimum. This was indeed the case, and we dropped 1 item per subscale after Study 3 (see supplementary materials for details). For clarity, we report results across all studies for the 18 items retained in the final version.

6.1. Method

We collected 2036 responses via participants in a separate unpublished project in which we investigated the relationship between objectively-tracked Xbox playtime and well-being. In this study, participants completed the pruned item list to in up to 6 bi-weekly surveys. Participants were paid £1.50 for each survey (which included several other measures and took on average 8 min to complete). More details about the design of this study are available on its OSF page (https://osf.io/edtwn/).

The study had 414 eligible participants at Time 1; due to attrition, waves 2–6 contained between 308 and 355 responses each. Of these, 145 responses were flagged as potentially careless due to implausibly fast survey completion or no variance in answers, leaving us with final sample of 1891 responses from 414 unique participants.

In Study 2, placeholder [X]s in the BANGS items were replaced with 'the games I played', thus adapting items to refer to one's experiences with gaming in general (i.e., across potentially many different games).

6.2. Results

6.2.1. Model fit

We conducted a multigroup CFA model, with each survey wave coded as a separate group. Results indicated excellent construct validity with model fit indices well above traditional cut-offs (Table 3). Dynamic cut-offs are not currently available for multigroup CFA.

6.2.2. Reliability

Reliability in this context was moderate (Table 4): three subscales had $\omega > .80$, though autonomy frustration ($\omega = .68$), competence satisfaction ($\omega = .75$) and competence frustration ($\omega = .75$), had somewhat lower reliability. As in the session-level data, autonomy frustration was the least internally consistent.

7. Study 3: Confirmatory factor analysis (Particular game)

7.1. Method

We recruited a total of 449 participants. 210 participants derived from Prolific.co, and 283 came from the aforementioned longitudinal Xbox study, where in the 6th and final wave only participants could optionally choose to respond to this variant of the questionnaire. 23 Prolific participants and 21 Xbox participants were flagged as potential careless responders, leaving a total of 187 + 262 = 449 responses.

In both surveys, participants were asked to provide the name of a game they had been playing recently, and then to briefly describe their experiences playing it. We then used piped text to insert the name of the game they provided into each of the items, replacing 'the game' with, for example, 'One Step from Eden'.

Participants from Prolific completed three related measures, to allow us to test convergent and criterion validity. The specific items of all measures are available in the supplementary materials. Participants from the Xbox study were paid £1.50 as above, while Prolific participants were paid £1.25 for a survey with a median completion time of 9 min.

7.2. Measures

7.2.1. Autonomy and mastery

To measure autonomy and competence satisfaction using a measure that was developed specifically for a games context, participants completed the autonomy and mastery (akin to competence) subscales of the Player Experience Inventory (PXI; Vanden Abeele et al., 2020). The mastery construct in the PXI is very closely related to competence satisfaction (correlating at $r = .88$ in their sample with a competence satisfaction measure), and therefore serves as a suitable construct for assessing criterion validity. Reliability of each PXI subscale was high ($\omega_{aut} = .83$, $\omega_{mas} = .89$).

Table 4
Sub-scale reliability in each primary data study.

Study	Reliability (Omega) [95% CI][a]					
	Autonomy satisfaction	Autonomy frustration	Competence satisfaction	Competence frustration	Relatedness satisfaction	Relatedness frustration
Study 1	.90 [.88, .92]	.75 [.70, .80]	.87 [.84, .90]	.80 [.77, .84]	.83 [.80, .87]	.81 [.78, .85]
Study 2	.80 [.78, .82]	.68 [.65, .71]	.75 [.73, .78]	.75 [.72, .77]	.81 [.80, .83]	.82 [.80, .84]
Study 3	.84 [.81, .87]	.69 [.63, .75]	.78 [.74, .83]	.80 [.76, .84]	.83 [.80, .86]	.86 [.83, .89]

[a] Reliability refers to coefficient omega as recommended by Kelley and Cheng (2012), which can be interpreted similarly to Cronbach's α but does not assume equal factor loadings. Confidence intervals calculated using 1000 bootstrap replicates.

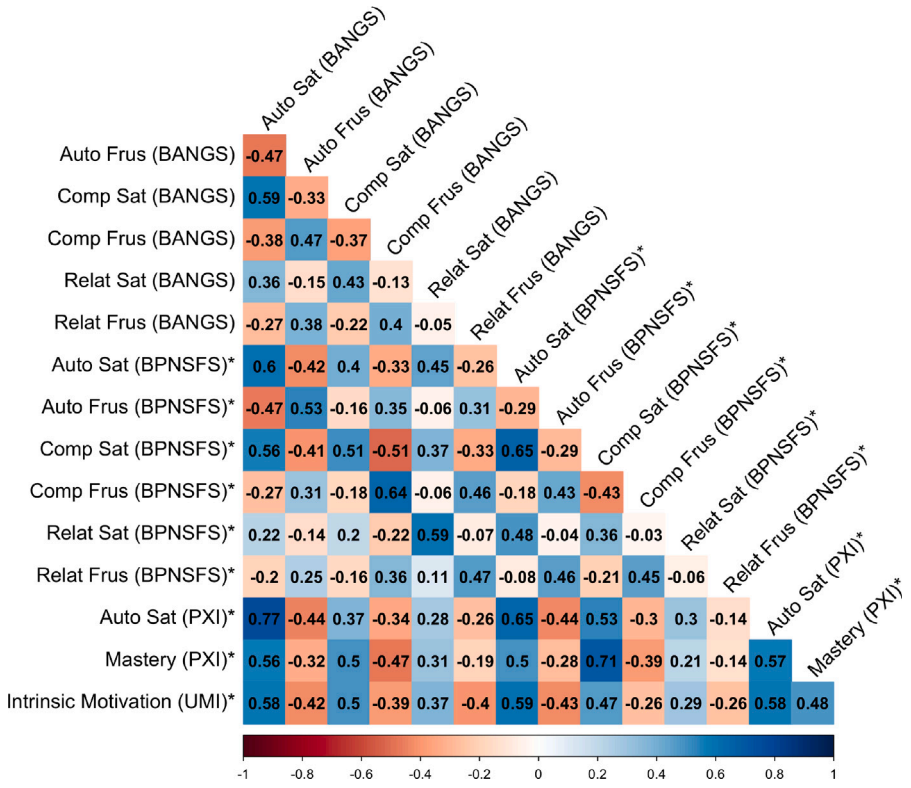


Fig. 1. Pearson correlations between each construct in the data, using mean scores. Constructs marked with an asterisk reflect data from 178 participants (the Prolific subgroup of study 3), while the remainder utilize the entire dataset (n = 2723).

7.2.2. Need satisfaction and frustration

To measure satisfaction and frustration of all three needs, participants completed the modified version of the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2015), as implemented by Allen and Anderson (2018). In this version, all items are preceded by 'When I play [game]' using the same piped text format as above. The BPNSFS uses a 5-pt Likert scale from '1 - Not at all true' to '5 - Completely true'. Reliability of each subscale was high (all $\omega \geq .78$).

7.2.3. Intrinsic motivation

To measure intrinsic motivation, participants completed the intrinsic motivation subscale of the User Motivation Inventory (Brühlmann et al., 2018). As above, piped text was used to insert the name of the game into each item. The UMI uses a 7-pt Likert scale from 'Strongly disagree' to 'Strongly agree'. Reliability was high ($\omega = .88$).

7.3. Results

Model fit Results showed generally good model fit (Table 3). Dynamic cut-offs indicated that the degree of misfit is similar in magnitude to two cross-loadings of .45 that are present in the population but absent in our model. The slightly higher misfit compared to studies 1 and 2 was driven primarily by the autonomy frustration subscale, where two items loaded only weakly onto their intended autonomy frustration factor (λs = .54 and .42, respectively; Table 1). Follow-up diagnostics using EFA indicated that one contributing factor was that 'Many actions in [X] were boring' also cross-loaded negatively onto competence satisfaction, while 'I felt forced to take certain actions in [X]' cross-loaded negatively onto autonomy satisfaction. These results indicate that the autonomy frustration subscale should be used with caution particularly in the game-level context; we return to this limitation in the discussion.

Reliability Results showed good reliability (Table 4), with 5 of 6 subscales having a coefficient omega of .78 or higher. As in Studies 1 and 2, reliability for autonomy frustration was lower at .69, but still within an acceptable range.

8. Study 4: Measurement invariance

8.1. Method

To assess whether the questionnaire functions similarly in each of the three contexts in which we tested it (one session, particular game, and games in general), we combined the data from studies 1, 2, and 3 (n = 2723).

Separately, we tested longitudinal invariance by comparing the two survey waves present in Study 2. These are only 2 weeks separated, so we would not expect any major differences in factor structure, but this

Table 5
Measurement invariance across different contexts (session, one game, gaming in general) and across two different surveys waves.

	CFI	RMSEA	BIC	$\Delta\chi^2$	p	ΔCFI	ΔRMSEA	ΔBIC
Context invariance								
Configural	.974	.040	169 456					
Metric	.971	.040	169 337	68	<.001	−.002	.000	−119
Scalar	.964	.044	169 306	229	<.001	−.007	.003	−30
Longitudinal invariance								
Configural	.978	.034	115 583					
Metric	.977	.034	115 213	73	.80	−.001	.000	−370
Scalar	.967	.039	114 932	207	.98	−.010	.005	−280

nonetheless allowed us to do a basic assessment of whether participants responded to the measure consistently and with similar means across multiple measurement occasions.

8.2. Results

8.2.1. Context invariance

Results showed that the measure is not invariant across contexts (Table 5). While the configural model fits well, indicating that the factor structure is invariant across contexts, constraining the factor loadings (metric invariance) led to a significant reduction in model fit. Similarly, constraining the intercepts (scalar invariance) led to a further significant worsening of model fit. However, even the scalar invariance model fit the data reasonably well (dynamic cut-off indices were not available for invariance models, but fit indices are higher than most conventional cut-offs), and the BIC selected the scalar model as the model that best balanced model fit and parsimony. This indicates that although the measure is not fully invariant, it is likely justifiable to use it in each of the above contexts and to, under certain circumstances, compare results across these. We return to the idea of invariance across gaming contexts in the discussion.

8.2.2. Longitudinal invariance

Results were similar for longitudinal invariance. Although constraining the factor loadings (metric invariance) and intercepts (scalar invariance) across the 6 survey waves led to statistically significant changes in model fit, these were relatively minor (Table 5). The scalar invariance model continued to show strong fit, and was favored by the BIC, indicating that the slightly worse model fit is counterbalanced by the benefits of a simpler model. Broadly, we interpret this as evidence that the factor structure, loadings, and item-level intercepts were largely consistent over a period of 3 months and can readily be compared.

9. Study 5: Discriminant/convergent/criterion validity

In the final study, we were interested in assessing the discriminant validity (are the subscales in BANGS sufficiently distinct?), convergent validity (do BANGS subscales perform similarly to other scales designed to measure the same construct?), and criterion validity (do BANGS subscales predict other constructs are predicted theoretically?). As in study 4, data from Studies 1–3 were combined. Analyses of discriminant validity and Average Variance Extracted therefore reflect the full sample size of 2723, while analyses of how BANGS correlated with other measures reflect just the subsample of Study 3 who completed these (n = 187).

9.1. Method

To assess each of these forms of validity, we inspected correlations among the different BANGS subscales, as well as between the BANGS subscales and the related existing measures included in Study 3: mastery and autonomy from the PXI, intrinsic motivation from the UMI, and need satisfaction and frustration from the modified BPNSFS. The full correlation matrix is shown in Fig. 1. For simplicity, we present this table with Pearson's r correlation coefficients on mean subscale scores; results, however, are highly similar when looking at latent factor correlations.

9.2. Results

9.2.1. Discriminant validity

We found that satisfaction and frustration of each need were negatively correlated. For autonomy and competence, satisfaction and frustration were moderately negatively correlated ($r = -.47$ and $r = -.37$, respectively), while relatedness satisfaction and frustration were only weakly negatively correlated ($r = -.05$, p = .02). This suggests that relatedness satisfaction and frustration, as operationalized in our scale, are almost entirely independent, a finding that we return to in the discussion.

Across needs, we found strong relations between autonomy satisfaction and competence satisfaction ($r = .66$, 95% CI [.62, .69]), and moderate relationships for each other pair ($-.18 \leq rs \leq .48$). These were safely below previous recommendations that two latent factors can be accepted as sufficiently distinct when factor correlations have a 95% confidence interval upper bound does not exceed .8 (Rönkkö and Cho, 2020).

Overall, discriminant validity was supported—satisfaction and frustration of each need are distinct in measurement but co-vary in ways that align with SDT predictions.

9.2.2. Convergent validity

We found moderate to weak correlations between the BANGS subscales and their BPNSFS counterparts ($.47 < rs < .64$, Fig. 1). Correlations between the BANGS and corresponding PXI subscales were similar or slightly higher ($r_{aut} = .77$, $r_{comp} = .50$). Broadly, this supported that the BANGS is measuring similar, but not identical constructs as previous measures, and that there is greater correspondence among measures developed specifically for a games context. We explore possible sources of divergence in the discussion.

Some researchers (e.g., Vanden Abeele et al., 2020) have adopted a different definition of convergent validity based on Average Variance Extracted (AVE), or the proportion of variance in the indicators explained by the latent factor—a metric related to reliability. We tested this as well, finding that AVE was well above the conventional .5 cut-off for all subscales except for autonomy frustration, which was slightly below (.45). This is in line with its lower reliability in Studies 1–3.

9.2.3. Predictive validity

To assess predictive validity, we used BANGS scores to predict both intrinsic motivation (Prolific subsample of study 3) and objectively logged playtime (Xbox sample from study 2).

As expected, people who reported higher satisfaction also reported significantly more intrinsic motivation to play ($.37 < rs < .58$), while those who reported greater frustration also reported less intrinsic motivation ($-.39 < rs < -.42$). We fit two linear regression models

where intrinsic motivation scores were predicted by the mean scores of either (1) all 6 BANGS subscales or (2) all 6 BPNSFS subscales. Notably, the BANGS accounted for significantly more variance in intrinsic motivation than the BPNSFS (R^2 = .50 vs. .42). This increased our confidence that although the BPNSFS does seem to measure stable constructs similarly to the BANGS, the BANGS is more relevant and predictive for games contexts.

For objectively logged playtime, we fit a generalized multilevel linear model using the tweedie link function, where the outcome variable was objectively logged playtime during the 2 weeks leading up to survey completion, and all within- and between-person centered versions of all 6 BANGS subscales were entered as predictors. This model accounted for 8.4% of the variance in logged playtime (comparable to a single variable correlated at r = .3). Given the numerous factors that influence playtime over a two week period beyond need satisfaction, we considered this a moderate effect, and interpret this as modest evidence in favor of the scale's predictive validity. Due to a near complete lack of studies investigating playtime across an entire platform, however, variation in objectively-logged playtime over time (and the factors that influence it) are poorly understood—we therefore leave more in-depth assessments of predictive validity for behavioral outcomes to future research.

10. Discussion

Above, we described the development of the BANGS and provided evidence to support many aspects of its validity. We demonstrated high construct validity across three studies and contexts (recent recalled play session, experiences with a particular game over time, and experiences of gaming in general over the previous 2 weeks). The measure was largely invariant across these three contexts, suggesting that the measure can be used in each, and that results can be compared across contexts—with a degree of caution. The BANGS subscales were sufficiently distinct to be measured and understood separately, but correlated with each other in theoretically-predicted ways (e.g., satisfaction of each need is correlated with satisfaction of the others, and negatively correlated with frustration of that need). Finally, we showed that both need satisfaction and frustration were predictive of intrinsic motivation for play—even more strongly than a previous, non-gaming-specific measure in the form of the modified BPNSFS.

Together, we believe these results demonstrate that BANGS is suitable for use in a range of game user research settings, and can thereby contribute to research rigor, theory development, and understanding of player experiences. As described in the introduction, we believe the measure improves upon previous scales used to assess basic needs in games in several ways: by capturing need frustration in a form that is specific to gaming, by being extensively validated for multiple levels of generality, and by adopting a broad conception of relatedness with both human and non-human characters.

10.1. Player experience research and theory

In academic research, well-validated measures of need satisfaction and frustration allow us to assess both positive and negative effects of play on wellbeing, both in commercial games for entertainment and (potentially) serious games. Our results confirm and extend previous theory and empirical results showing that need satisfaction and frustration are distinct, and that both constructs are relevant for games. In particular, the dual process models proposed in self-determination theory (Bartholomew et al., 2011; Vansteenkiste and Ryan, 2013) depend upon assessment of need frustration, which BANGS accomplishes.

This might contribute to better understanding of unhealthy interactions with games (e.g., excessive gaming, spending, toxic interactions) and the identification of factors that lead to such interactions. Need frustration in particular may have utility in investigating negative emotional or behavioral outcomes from game experiences such as post-play aggression in future research (Przybylski et al., 2014).

Similarly, it can help us better understand how players use games when going though challenging times, e.g. for coping or escapism (whether it is healthy or maladaptive escapism). Whether players are using games well to cope with their real-world worries and troubles or if it is a maladaptive coping mechanism that permits players to escape from or compensate for problems in everyday lives.

Having a validated measure for multiple levels of generality can support research into the effects of in-game aspects and factors outside of gaming on player motivation, e.g. whether elements of competition or social aspects of games can satisfy or frustrate specific needs; evaluate the likelihood of one quitting a game (exit intentions, retention rates) if frustrated.

Related to the BANGS' good match with SDT theory and the nuances of the gaming domain, we want to highlight the formulation of relatedness items that are able to capture feelings of social connectedness with both other human players and non-player-controlled characters or virtual settings. That these experiences could contribute to the overall sense of relatedness that players derive from games has been theorized for several years (Rigby and Ryan, 2011; Tyack and Wyeth, 2017) and is herein operationalized as a single factor that can be broadly applied.

10.2. Game development and industrial player research

SDT sees extensive use in industry contexts (Schreiber, 2017). However, industry practitioners may not be fully up-to-date with the latest developments in SDT, and therefore may not be aware of its potential for predicting disengagement, churn, or negative emotional experiences. BANGS provides an accessible tool for extending need-related user experience research to also include need frustration. Assessing need frustration might help developers better understand where negative experiences arise, what drives disengagement and churn, and monitor community health. This could have applications both for understanding the success or failure of released games (e.g., comparing need satisfaction and frustration to similar titles in the genre), and for informing design decisions during development (e.g., running comparisons between different prototypes/variations to identify how design features affect the prevalence of need frustration).

We see particular potential for BANGS to be useful for designers seeking to create more complex experiences of meaning and appreciation (eudaimonic gaming; Daneels et al., 2023) that are not always inherently positive—for instance, in games that intentionally create uncomfortable or negative experiences for players (Bopp et al., 2016; Denisova et al., 2021). Evidence shows that need satisfaction and frustration are closely connected with emotionally challenging game experiences (Rigby and Ryan, 2016), and might play a role in differentiating those that are eventually appraised as meaningful vs. those that are appraised as adverse—and how both of these differ from experiences that are perceived as simply lighthearted fun.

Similarly, need frustration might offer an explanatory mechanism for understanding what makes certain experiences of frustration – that is, the emotional experience of having one's goal impeded – negative for players, and others motivating and ultimately positive. Positive experiences of frustration are frequently reported in video game play (Frommel et al., 2021; Petralito et al., 2017), and are in fact a common design goal. Perceiving one's goal-directed action to be impeded *without* feeling controlled, ineffective, or excluded (i.e., *need*-frustrated) may set apart the positive, motivating experiences of wanting to get past a difficult obstacle from negatively-valenced instances where goal attainment *and* needs are frustrated. Supporting this point, *need*-frustration may be more likely than colloquial frustration to induce aggression (e.g., Przybylski et al., 2014).

While we are hopeful that the measure can be useful in some industry research and testing contexts, further research will be needed to realize this potential. There is an inherent trade-off between measuring a construct across all possible gaming contexts, genres, and players, and zooming in on specific features or experiences of one

game. For example, the BANGS' overall assessment of whether players felt their actions were forced does not specifically capture how they might experience the monetization structures of free-to-play games as pressuring vs. offering purely optional opportunities. We hope to see further qualitative research that bears out context-specific need-frustrating mechanics and experiences in more depth. This would create opportunities for potential BANGS variants that are tailored to specific game genres and help explain why certain games, despite being superficially similar, may have vastly different effects on players.

10.3. Comparison with previous measures

Previous prominent game-specific scales such as PENS (Ryan et al., 2006) and UPEQ (Azadvar and Canossa, 2018) only measured need satisfaction. Other attempts to measure need frustration in games have relied on a domain-general scale, the BPNSFS, modified for a games context (Allen and Anderson, 2018; Kosa and Uysal, 2021). While these papers find good evidence for construct validity, some items stand out as not neatly applicable to games (e.g., 'I feel that people who are important to me are cold and distant towards me'), and some results with the questionnaires run counter to theory, such as a positive correlation between autonomy satisfaction and frustration in Allen and Anderson (2018). Our results show that although construct validity was similar between the BANGS and the BPNSFS, the BANGS was more predictive of a key gaming-related outcome, intrinsic motivation, than the BPNSFS.

With regard to the other gaming domain measures (the PXI and PENS), we found strong overlap between autonomy satisfaction in the PXI and in the BANGS (r = .77). The BANGS competence satisfaction subscale also showed correspondence with the mastery subscale of the PXI (r = .50). Looking at the items, the BANGS competence subscale captures a feeling of growth and improvement which is not explicitly included in the PXI or PENS (e.g., BANGS 'I felt I was getting better at playing this game' vs. PXI 'I felt I was good at playing this game' vs. PENS 'I feel competent at the game'). In line with theory suggesting that a key aspect of competence is growth (rather than simply mastery or effectance) (Deterding et al., 2022; Ryan and Deci, 2017), and with previous results showing that learning and improvement is a key predictor of video game engagement (e.g., Huang et al., 2019), we believe this the growth aspect is a valuable feature of the BANGS.

The UPEQ has separate items for NPCs and listed these as part of the same construct, but subsequent research found them to form two distinct factors (Ballou et al., 2022). Our results indicate that the BANGS relatedness subscales are able to capture experiences of social connectedness in both contexts, and still remain psychometrically valid. For example, previous relatedness measures have not captured the notion of toxicity, a widely-discussed topic in the literature on video games (e.g., Depping et al., 2018) with clear relevance for relatedness frustration.

In short, BANGS offers domain-appropriate measurement of need satisfaction and frustration with a degree of nuance and validity not available in previous measures.

10.4. Future directions for the BANGS

Although the validation undertaken here appears promising, there remains room for further iteration and improvement. In particular, we hope – with the help of the games research community – to refine and extend the questionnaire in four key ways: (1) advance our understanding of autonomy frustration in games and thereby improve the autonomy frustration subscale, (2) further assess the predictive validity of the questionnaire in conjunction with objective measures of gaming behavior, (3) investigate smallest effect sizes of interest, and (4) explore short or even single-item variants for easier use in diverse research contexts.

At present, the weakest element of the questionnaire is the autonomy frustration subscale: two items loaded only weakly onto their intended factor in the piped text version of the questionnaire (Study 3), and reliability of that subscale was consistently lower than the other subscales across all three studies. Despite having 16 candidate autonomy frustration items in the initial pool, we found it difficult to find a subset that consistently 'hung together'. The precise reason for this difficulty is at present not fully clear. One potential explanation comes from recent proposals to differentiate not just need satisfaction and frustration, but also need dormancy (Reeve et al., 2023) or need dissatisfaction (Cheon et al., 2019), which describe related proposed state in which a need is neglected or underdeveloped, without necessarily being actively thwarted. Because gaming is by and large an activity that is undertaken voluntarily, and where players undertake in-game actions voluntarily, it may be the case the autonomy dissatisfaction or dormancy is more salient than active frustration, and that certain items (e.g., the one related to boredom) map better onto these than the intended frustration factor. We encourage further SDT in games research to test the relevance of these constructs. Another potential explanation is that in practice, certain situations frustrate both autonomy and competence in games, and lead to cross-loadings that dilute the distinctiveness of the construct. For example, it is easy to see how players who feel forced to adopt a certain undesired playstyle to overcome a boss (a type of autonomy-frustrating experience reported in Ballou and Deterding, 2023) would also feel a lack of growth and mastery, and thereby lesser competence satisfaction.

A second finding that runs counter to theoretical prediction is the negative, but small and non-significant correlation between relatedness satisfaction and frustration. One likely contributor to this is the fact that the most stable relatedness frustration factor ended up assessing a feeling of toxicity in games. Players commonly encounter toxicity in games (Beres et al., 2021) and may therefore select moderate responses to those items, but simultaneously be desensitized and expect a certain level of toxicity, and thereby be less affected by it (Ballou and Deterding, 2023)—not letting it diminish their positive experiences of connection with valued others. To better understand the degree to which this finding is a construct validity problem vs. an idiosyncrasy of the video games domain whereby relatedness frustration may coexist with relatedness satisfaction more so than in other domains, replication and further qualitative research are needed.

Next, we would like to extend our predictive validity analyses to include more detailed analysis of logged behavioral measures. In the current study, we predicted only intrinsic motivation and a simplistic measure of total playtime in a 2-week period (Study 5). Although both are important constructs, more nuanced behavioral outcomes such as playtime in a particular session or game over time, or in-game actions and performance, are of great interest for both industry research on engagement and for academic research on video game effects. Substantial research is needed to understand how much playtime varies over time, and the primary factors that influence this variation—comparing both player experience measures such as need satisfaction and frustration, and real-world constraints such as family responsibilities.

Another way to extend the usefulness of the BANGS is to define smallest effect sizes of interest—minimal changes in scale scores that would be considered practically significant. This idea recognizes that statistical significance is not a good measure of practical importance (Kirk, 1996). One promising way to achieve this is through anchor-based methods (Anvari and Lakens, 2021). One example of this method would have players would fill out the BANGS in reference to two games, and further complete an item about the degree to which they experienced one of those games as more enjoyable, or more need-satisfying. The difference in mean need satisfaction and frustration associated with one game being e.g., 'a little bit more enjoyable' than the other would be a plausible smallest effect size of interest in future research.

Table A.1
EFA results. Comm = communality; Uniq = uniqueness; Comp = complexity.

Item	F1	F2	F3	F4	F5	F6	Comm	Uniq	Comp
rs05: I felt I formed relationships with other players and/or characters.	0.89	−0.01	−0.07	0.06	−0.02	0.04	0.77	0.23	1.02
rs09: I consider the relationships I formed in the game fulfilling.	0.89	−0.02	0.01	−0.05	0.04	−0.02	0.77	0.23	1.01
rs08: I consider the relationships I developed in the game meaningful.	0.87	−0.01	−0.06	0.01	−0.01	0.01	0.71	0.29	1.01
rs10: I consider the relationships I developed in the game valuable.	0.87	−0.05	−0.06	0.02	0.01	0.00	0.73	0.27	1.02
rs15: I felt satisfying relationships in engaging with this game.	0.82	−0.01	0.03	0.00	−0.05	−0.03	0.73	0.27	1.01
rs14: Engaging with the game, I felt I was bonding with others.	0.78	0.06	0.00	0.01	0.07	−0.03	0.61	0.39	1.03
rs13: Engaging with the game, I felt a connection to others, virtual or real.	0.75	−0.06	0.07	0.03	0.06	0.01	0.66	0.34	1.05
rs02: I felt a sense of connection with other players and/or characters.	0.75	−0.01	0.11	−0.04	−0.01	0.01	0.63	0.37	1.05
rs03: I felt that other players and/or characters in the game cared about me.	0.63	0.06	0.16	−0.09	−0.18	0.05	0.47	0.53	1.39
rs04: I cared about what happened to other players and/or characters.	0.60	0.01	−0.01	0.08	−0.04	−0.06	0.42	0.58	1.07
rs01: I could put myself in other characters' shoes.	0.56	−0.09	0.04	0.02	−0.04	0.04	0.36	0.64	1.09
rs12: I felt like part of a community.	0.50	0.12	0.26	0.10	0.11	−0.07	0.52	0.48	1.89
cf12: I felt like the game was too difficult for me.	−0.04	0.84	−0.04	0.02	−0.08	−0.05	0.66	0.34	1.03
cf01: I often felt that I lacked the skills necessary for the game.	0.04	0.81	0.05	−0.06	0.06	−0.04	0.66	0.34	1.04
cf08: I had doubts about being able to do things well in the game.	−0.07	0.69	0.10	−0.02	0.04	0.06	0.52	0.48	1.08
cf09: I felt disappointed with my performance in the game.	0.00	0.68	−0.13	0.02	0.08	0.06	0.63	0.37	1.12
cf05: I kept failing to accomplish what I wanted to while playing.	0.03	0.65	−0.03	−0.05	0.05	−0.04	0.46	0.54	1.04
cf14: I felt its too difficult to make progress in the game.	−0.13	0.61	−0.08	0.03	−0.03	0.17	0.54	0.46	1.30
cf03: I felt incompetent while playing the game.	0.03	0.57	−0.15	−0.07	0.09	0.06	0.55	0.45	1.26
cf07: I felt helpless when playing the game.	0.02	0.50	−0.25	−0.01	0.11	0.06	0.52	0.48	1.63
cf13: Playing this game, I often felt stuck.	−0.11	0.48	−0.06	−0.06	0.07	0.23	0.52	0.48	1.68
cf02: I felt that the game put me in impossible situations.	0.04	0.43	−0.05	0.02	0.13	0.12	0.33	0.67	1.41
cs13: I felt I was getting better at playing the game.	0.00	−0.12	0.78	0.04	0.01	0.01	0.73	0.27	1.05
cs14: I was improving at the game.	−0.05	−0.16	0.76	0.02	0.04	0.03	0.65	0.35	1.10
cs12: I felt my ability to play this game was growing.	0.05	0.01	0.74	0.09	0.03	−0.02	0.68	0.32	1.04
cs02: I felt that I made progress while playing.	0.04	−0.01	0.73	0.04	−0.07	−0.08	0.69	0.31	1.05
cs06: I felt a sense of achievement while playing.	0.11	0.09	0.72	0.05	−0.06	−0.06	0.67	0.33	1.12
cs03: I felt a sense of mastery while playing.	0.05	−0.06	0.65	0.09	0.00	0.07	0.55	0.45	1.09
cs01: I felt a sense of growth when playing the game.	0.25	−0.01	0.48	0.17	0.01	−0.03	0.59	0.41	1.79
cs11: I was able to fully use my abilities.	0.02	−0.12	0.45	0.15	−0.03	−0.08	0.46	0.54	1.46
cs04: I felt I could exercise my capabilities while playing.	0.15	0.09	0.43	0.21	0.02	−0.08	0.47	0.53	1.93
as06: I could make choices regarding how to play the game.	0.06	−0.07	−0.09	0.90	0.00	0.02	0.78	0.22	1.04
as08: I could choose different strategies or actions to use in the game.	−0.04	0.11	0.09	0.74	0.05	−0.01	0.57	0.43	1.09
as01: I could play the game in the way I wanted.	0.00	−0.09	0.10	0.71	−0.01	−0.12	0.76	0.24	1.13
as05: I could direct my own play experience.	0.05	−0.04	0.10	0.71	−0.08	−0.03	0.71	0.29	1.08
as04: I had the agency to decide how I wanted to play.	0.00	−0.01	−0.01	0.64	−0.06	0.13	0.38	0.62	1.10
as07: I could develop or apply different strategies when I wanted.	−0.03	0.09	0.24	0.64	0.01	−0.04	0.63	0.37	1.34
as09: I was able to choose how I explored the game environment.	0.03	−0.03	0.10	0.49	−0.11	−0.08	0.43	0.57	1.24
rf07: Interactions with other players and/or characters felt toxic to me.	−0.01	0.03	−0.01	−0.01	0.78	0.05	0.68	0.32	1.01
rf08: Others in the game were unfriendly towards me.	0.02	0.07	0.02	−0.03	0.78	−0.09	0.60	0.40	1.05
rf09: I disliked some of the other players.	0.00	−0.05	0.06	−0.01	0.77	−0.01	0.56	0.44	1.02
rf05: The community or virtual world in the game made me feel unwelcome.	−0.10	0.03	−0.11	0.00	0.60	0.13	0.54	0.46	1.23
rf02: I found the community in and around the game off-putting.	0.10	0.02	0.02	−0.06	0.56	0.09	0.38	0.62	1.14
rf01: I felt distance between myself and other players in the game.	−0.09	0.12	−0.03	0.03	0.40	0.16	0.32	0.68	1.64
rf04: I felt alienated from others.	0.09	0.21	−0.07	−0.07	0.38	0.14	0.38	0.62	2.21
af10: I felt like I had to keep playing the game even though I did not want to.	−0.05	−0.03	−0.05	0.05	0.20	0.67	0.60	0.40	1.22
af02: At times, I found myself playing the game despite not really wanting to.	0.03	−0.03	−0.10	0.00	0.23	0.61	0.58	0.42	1.33
af16: Many actions in the game were boring.	−0.12	−0.01	−0.09	−0.14	−0.07	0.57	0.48	0.52	1.29
af04: I often found myself wishing I could do something else within the game.	0.10	0.19	−0.06	−0.13	−0.06	0.57	0.51	0.49	1.44
af05: A lot of my in-game activities felt like things I had to do.	0.04	0.13	0.17	0.02	−0.10	0.53	0.27	0.73	1.42
af01: I felt forced to take certain actions in the game.	−0.08	0.04	0.08	−0.29	0.06	0.48	0.44	0.56	1.81
af09: I felt pressured to progress through the game at a certain speed.	0.03	0.29	0.06	−0.02	−0.02	0.45	0.35	0.65	1.77
af15: It feels like the things I did in the game, I did out of external pressure.	0.12	0.22	−0.10	0.08	0.12	0.33	0.29	0.71	2.76

Note: Bolded items are those selected for the final measure. To see this table in a larger text size, please see TablesFigures/EFA/efa2_reduced_table.html within the supplementary materials.

Finally, we hope to validate a single-item version of the questionnaire. Single-item measures have begun to see greater use in games research (e.g., Vuorre et al., 2023), for their ability to be administered quickly—potentially even interspersed throughout a play session. This therefore makes the questionnaire much easier to deploy in playtesting settings where an 18-item questionnaire would otherwise be too burdensome. For non-playtesting administration, we note that the BANGS is slightly shorter than existing similar questionnaires (e.g., the 24-item modified BPNSFS; Chen et al., 2015 or the 21-item UPEQ; Azadvar and Canossa, 2018), and that researchers need not use all subscales if they are not relevant to their study.

In short, we see this as the beginning, not the end of the measure development process. If researchers have concerns about certain BANGS items, we encourage them to include additional items alongside the ones validated here—this would allow them to use a well-validated questionnaire while also creating opportunities for exploratory analyses and comparison with items that they feel better capture the experience of basic needs in their particular context. Collaboratively, these efforts and others can develop the BANGS as a valuable resource for the games research community.

10.5. Constraints on generalizability

Participants across all studies were adult players, majority from Western countries, majority male, and relatively homogeneous with regard to the type of gaming they were involved in—participants were either primarily Xbox users or, in the case of Prolific participants, tended to play console and PC games. Although we had a wide variety of games and genres in the sample (e.g., MOBAs, sports games, puzzle games, FPSs, and more), and theory and evidence suggest that basic needs are universal across age, sex, gender, and culture, we intend to test the measure among more diverse types of games (e.g., mobile gacha

games) and players (e.g., diverse age ranges, gender and sex, players from non-Western countries).

11. Conclusion

Above, we presented the development of the BANGS and show that it is a reliable and theoretically sound tool for measuring basic psychological need satisfaction and frustration. We improve upon previous similar measures by capturing need frustration in a domain-appropriate way, and adhere to high standards of measurement validity standards across 5 studies. Across these studies, BANGS demonstrates high levels of measurement validity, though results also highlight areas to improve upon in future iteration related to the lower reliability in the autonomy frustration subscale, and a surprising non-significant correlation between relatedness satisfaction and frustration. We hope the BANGS can be of use to researchers in both industry and academia who are interested in investigating player (dis)engagement, motivation, and wellbeing.

CRediT authorship contribution statement

Nick Ballou: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Alena Denisova:** Conceptualization, Methodology, Writing – review & editing. **Richard Ryan:** Conceptualization, Supervision, Writing – review & editing. **C. Scott Rigby:** Conceptualization, Supervision, Writing – review & editing. **Sebastian Deterding:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: CSR and RR are employed by Immersyve Inc, which provides UX testing and consulting services to the commercial video game market. SD holds a position at Amazon UK Services Ltd, who had no role in the above work. The remaining authors have no competing interests to declare.

Data, code and materials availability

All underlying data, analysis code, and materials are available on the OSF (https://osf.io/uq8mp).

A basic user guide to deploying the questionnaire is available at https://nickballou.com/docs/bangs.

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Appendix

See Table A.1.

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