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Challenge types in gaming validation of video game challenge inventory (CHA)

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ABSTRACT

Challenge is a key motivation for videogame play. But what kind of challenge types videogames include, and which of them players prefer? This article helps to answer the above questions by developing and validating Videogame Challenge Inventory (CHA), a psychometrically sound measurement for investigating players' challenge preferences in videogames. Based on a review of literature, we developed a 38-item version of CHA that was included in a social media user survey ($N = 813$). An exploratory factor analysis (EFA) revealed a latent structure of five challenge types: *Physical, Analytical, Socioemotional, Insight*, and *Foresight*. CHA was amended in another EFA with USA-based survey data ($N = 536$). The second EFA suggested a four-factor structure similar to the first EFA. A confirmatory factor analysis was executed after an item screening process with a 12-item version of CHA via UK-based survey data ($N = 1{,}463$). The 12-CHA had an acceptable fit to the data, and the model passed construct, convergent, and discriminant validity tests. The usefulness of the validated 12-CHA is shown by connecting the discovered challenges and their preferences to known videogame play motivations and to habits of playing specific videogame genres.

1. Introduction

Challenge belongs to many play activities, from traditional schoolyard games to contemporary videogames. Additionally, challenge and related concepts such as 'contest,' 'trial,' and 'conflict' are often perceived necessary constituents of games to begin with (see Avedon and Sutton-Smith, 1971; Crawford, 1982; Salen and Zimmerman, 2004; Juul, 2005). In perhaps the most famous academic definition of games, Bernard Suits delineates the concept along the same lines as the "voluntary attempt to overcome unnecessary obstacles" (2005 > [1978], 157). As a recent exemplary addition, Robert Furze (2014) has extended Suits' definition by stating that game playing involves the player's voluntary *and* persistent engagement with a game's rule-system and its challenges.

Challenges are associated with difficulty, but the terms are not to be equated. As an analytical concept, challenge can be considered a task or a problem, the difficulty of which depends on the performing person's skills, abilities, motivations, and knowledge (Iversen, 2012). From this subjective perspective, a further distinction should be made between challenges and demands: "*challenges* are always nontrivial (uncertain outcome), whereas *demands* can also be trivial (certain outcome)" (Karhulahti 2015b, p. 27). Finally, in the context of videogames, if an undertaken task is not related to the player's ongoing performance evaluation, i.e. how the events in the videogame proceed, the task is not to be considered a videogame challenge (e.g. Iversen, 2010; Vahlo, 2017).

Among other things, challenges are important motivations for *gameplay*, i.e. the interactional dynamics between players and videogame systems (Landay, 2014; Ryan et al., 2006). Espen Aarseth (1997; 1999) has described these dynamics as negotiations (struggle and conflict) between the player and the videogame; the latter posing challenges for the former who pursues towards a desirable outcome. According to Ernest Adams (2014, p. 9), in turn, gameplay consists of challenges presented to the player, and of the actions the player can take to overcome these challenges. Whenever a player faces a challenge, they cannot be sure about the outcome of the situation at hand (cf. Costikyan, 2013; Linderoth, 2013; Vahlo et al., 2017).

The purpose of this study is to develop and validate Videogame Challenge Inventory (CHA) that will function as a tool for investigating players' challenge preferences across cultures. Such a tool is much needed in both the industry and the academia: the primary means for challenge preference analysis within videogame developers is currently

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ad hoc playtesting, and to our knowledge, the related scholarly discourse has not developed a single validated challenge inventory for general research purposes yet. Of note, while culture-specific gaming preferences have been studied previously by genre (Vahlo et al., 2018b), genres are not always an accurate reflection of the challenges involved (Karhulahti, 2011). A validated inventory may thus aid player-centric videogame development and targeted marketing as well as related game user research enterprises in general. As Johnson et al. (2018) have recently noted, only a few player experience questionnaires have been validated extensively with empirical data.

Our work is related to what Alena Denisova and colleagues (2017) have done in their attempt to develop a scale for measuring "experience of challenge" in videogames. The present study differs from the above by not being concerned about how challenges are experienced by players (e.g. perceived difficulty and experienced flow, psychological absorption, or immersion). Instead, the present aim is to create a comprehensive and validated inventory for studying players' sustaining preferences for videogame challenge types. The main goals of this study are to, first, identify distinct game challenge preferences players have and, second, to develop and validate a measurement instrument for investigating these challenge preferences.

Next, the article continues by contextualizing the topic within branches of player preference research. A theoretical framework, key concepts, and a literature review is presented, based on which preliminary survey items for the CHA are created. The first empirical section of this article reports results from an exploratory factor analysis (EFA) that was conducted with survey data of 813 respondents. This led to developing additional inventory items, the functioning of which is reported via another EFA based on survey data collected in the USA ($N = 536$). The CHA scale was thus shortened according to an item screening procedure before conducting a confirmatory factor analysis (CFA) with one more survey sample from the UK ($N = 1,463$). The article concludes by demonstrating the practical utility of the CHA scale and by discussing how results of the study relate to prior research.

1.1. Play and player studies

Studies on challenge preferences fall under the broad category of player preference research. This research field can be further divided into four subcategories: motivations to play, player behavior, gaming intensity, and gameplay preferences (Vahlo and Koponen, 2018; see Hamari and Tuunanen, 2014).

Motivations to play literature (e.g. Bateman et al., 2011; De Grove et al., 2016; Hamari and Keronen, 2017; Krcmar and Strizhakova, 2009; Przybylski et al., 2010; Sherry et al., 2006; Yee et al., 2012) investigates the reasons why people play videogames. Play motivation models may assume that people have particular reasons for playing videogames (e.g. Yee, 2006), or alternatively, they may derive from a premise that people play because it satisfies general human needs (e.g. Ryan et al., 2006).

Player behavior models (e.g. Bartle, 1996; 2003; Cowley and Charles, 2016; Mulligan and Patrovsky, 2003; Tseng, 2010) are interested in the patterns of specific play styles or behaviors. Differently put, player behavior models ask how players play and like to play. While these models are useful in understanding player experiences (of specific videogames), they lack in arguments about how players' play styles transform or may transform from one videogame or genre to another.

Gaming intensity models (e.g. Deterding, 2013; Ip and Jacobs, 2005; Kallio et al., 2011) represent players' experiential preferences for play, including related values. These models divide players into categories such as hardcore gamers, committed gamers, and casual gamers, or examine them via mood or mode preferences (e.g. single-player gaming, multiplayer gaming, competitive gaming).

Finally, studies on *gameplay preference* investigate players' generic preference patterns in gaming (Tondello et al., 2017; 2018; Vahlo et al., 2017; 2018a). They analyze players' preferences for activity types, aesthetics, mechanics, and challenges, and as such, contribute to the factors that impact videogame choice. The study at hand is of this fourth type.

Players' disliked and liked challenges are not associated with players' gameplay or genre preferences alone but also with what motivates them to play. Challenge has been regarded a key motivation for videogame play at least since 1980 when Thomas Malone argued challenge to be a factor of intrinsically motivating play alongside with fantasy and curiosity. Later, John Sherry and his group (2006, p. 220) conducted an empirical study that evidenced challenge to be a top reason to play videogames among youth. Challenge is also closely related to competence, which, according to Self-Determination Theory, is a basic human need (Ryan and Deci, 2000). Our research goals thus come with two specific research questions:

RQ1: Can players' challenge preferences predict their genre preferences?

RQ2: Are players' challenge preferences associated with their play motivations?

In lack of previous research on these connections, we set no hypotheses for the research questions. In the next section, we review the existing literature on videogame challenge types.

2. Video game challenge types

Since challenges entail effort from the player, *skill* is relevant in overcoming challenges. The combination of skill and challenges has been studied in play and games research extensively, perhaps most memorably within the framework of Mihály Csikszentmihályi's theory on *flow* (1975; 1990; 2002 [1992]). Csikszentmihályi studied activities in which people show exceptionally high levels of motivation, personal excitement, and enjoyment. These "peak experiences" resembled each other so that individuals described their first-person experiences as "flow-like states." According to Csikszentmihályi, flow experience can be reached when the demands of the environment are in line with the subject's skills and abilities. He calls this experience *autotelic*, i.e. rewarding in itself (1975, p. 49). Arguably, autotelic rewards are fundamental in videogame play and some authors have even suggested videogames to be the only medium capable of facilitating autotelic flow experiences (Isbister, 2016, p. xviii).

Structurally, the efforts required to overcome challenges have been divided earlier into physical kinesthetic and cognitive nonkinesthetic work, the two often occurring in combination (Adams, 2014; Karhulahti, 2013a; Järvinen, 2007; Sutton-Smith, 1997; Denisova et al., 2017; Ermi and Mäyrä, 2007; Cox et al., 2012). Physical kinesthetic challenges test, for instance, players' accuracy, motoric, reaction, and endurance faculties. Cognitive nonkinesthetic challenges test, for instance, players' memorization, problem-solving skills, planning, and comprehension. Denisova's group (2017) further suggests that social challenges of online multiplayer games fall under cognitive nonkinesthetic challenges because they are about hidden information in the same way as other cognitive challenges. According to those authors, also mobile puzzle games such as *Candy Crush Saga* consist mostly of cognitive challenges like planning, spatial reasoning, and decision-making.

Veli-Matti Karhulahti (2013b) has argued that physical kinesthetic and cognitive nonkinesthetic challenges of videogames can be further studied via their relationships in temporal and vicarious dimensions. Both temporal and vicarious dimensions can be regarded paramount in an ontological understanding of challenges in general. Karhulahti presents a typology of four videogame challenge types: physical kinesthetic challenges with and without time pressure, and cognitive nonkinesthetic challenges with and without time pressure. Jonas Linderoth (2005; 2013), in turn, has approached gaming challenges by dividing them into exploratory and performative ones. In performative challenges a player knows what they should do, but the challenge is in how to do the required task. In exploratory challenges the player knows how to take an action, but the challenge is in deciding which action should be chosen. Physical kinesthetic challenges are typically performative, as the uncertainty lies in performing and sequencing known actions correctly and efficiently. Cognitive nonkinesthetic challenges emphasize exploratory and preliminary elements, as the dilemma is often about making correct decision and predicting their outcomes. Since exploratory challenges precede action, they can also be thought of as preliminary or preparatory challenges that eventually lead to evaluated performance.

In addition to challenges, videogames tend to afford free-form play behavior. As pointed out earlier, not all player efforts in videogames count toward progress and outcomes, and it makes little sense to consider those efforts that have other purposes videogame challenges. Players may well come up with their own personal goals in any gaming environment, but the efforts that contribute to those should be kept conceptually separate from the challenges and demands related to the measurable progress that videogame artifacts evaluate by definition (Karhulahti, 2015a; Vahlo, 2017). An investigation of actual videogame challenges, as the present one, should thus be less concerned about the literally infinite amount of actions, efforts, and ways of playing that each videogame is open to (see Barr, 2007, pp. 66–67, 79–80; Deterding, 2013, p. 145).

According to Malone's (1980) original findings, videogame challenges emerge in situations of uncertainty that can be related to time constraints, competition between players, or measured outcomes among others (see also Greenfield, 1984; Ritterfeld and Weber, 2006; Costikyan, 2013). For instance, in physical kinesthetic challenges the player can be uncertain about their ability to perform correctly, whereas players facing cognitive nonkinesthetic challenges cannot be completely sure about how their exploratory decision-making impacts the environment and its events. Moreover, a player may encounter all of these challenge types in environments of perfect or non-perfect information.

Recently, Tom Cole et al. (2015) as well as Julia Bopp's group (2018) have argued that emotional challenges should be separated as a distinct category in addition to physical kinesthetic and cognitive nonkinesthetic challenges. Such emotional challenges deal with ambiguous elements in the representational and semiotic videogame layers. Cole et al. (2015) suggest emotional challenges to deal with resolution of tension within fictive settings, their characters, and the plot. Bopp et al. (2018) note that in addition to confronting difficult themes, also making tough in-game decisions and dealing with negative emotions can be argued to be facets of emotional gaming challenges. While it would not be illogical to discuss these challenges as a specific subclass of cognitive nonkinesthetic challenges – emotional engagement being a cognitive instance (LeDoux and Brown, 2017) – the intuitive evidence for the prominence of challenging social interaction in videogames is convincing enough for emotional challenges to be probed respectively.

2.1. Developing videogame challenge inventory (CHA)

The first version of Videogame Challenge Inventory (CHA) was written based on the previous review of literature. For instance, in the field of game design, Adams (2014) argued that challenges can be divided into logical and mathematical challenges, challenges of time pressure, challenges of lateral thinking, pattern recognition challenges, memory challenges, and factual knowledge challenges. Drawing from this list and its parallels in Andrew Rollings and Adams (2003), a preliminary set of inventory items was created. The set was complemented with items based on the findings presented by Aki Järvinen (2007); Denisova's (2017) and Cole's (2015) teams, Karhulahti (2013a; 2015a), and Laura Ermi and Frans Mäyrä (2007). During the peer-review process we were introduced to a new study by Julia Bopp's team (2018); this study was not part of our original review, but the emotional challenges it deals with were largely included in our original inventory.

Altogether, the item development process had five stages as follows: 1) all authors of this study read the relevant literature and collected all potential challenge items mentioned in it. While some of the items were mentioned multiple times in earlier literature, we decided to include in the inventory development all types of challenge that were discussed at least once. This is a recommended procedure in exploratory factor analysis, because the exploratory phase of scale development aims to cover all possible aspects of the phenomenon under analysis (Matsunaga, 2010). The authors then 2) studied the results of their own literature review and relabeled the potential challenge types if different concepts clearly overlapped. For instance, challenge types of "speed and reaction time" was combined with "reflex/reaction time" (see Adams, 2014; Rollings and Adams, 2003). This process resulted in an initial item pool of 92 potential challenge types.

Next, 3) the authors' challenge item lists were collectively analyzed and synthesized. In this phase, the items were reviewed carefully in order to distinguish them from game motivations, play styles, game elements, and gameplay activity types (Vahlo and Hamari, 2019). For example, a preliminary item of "challenges of stealth and careful movement" was omitted at this stage because it refers to gameplay activity type of stealth and sneaking instead of specifying what kind of challenge this kind of gameplay includes. It was concluded that stealth and sneaking players are likely to face challenges of precision and accuracy, timing and rhythm, and mastering complex controls all of which are of a higher level of abstraction than "stealth and sneaking" (Vahlo et al., 2018a). The synthesized challenge item list was then 4) formulated into a preliminary inventory which was reviewed and refined in an expert seminar with professional videogame scholars. Finally, 5) all feedback and information of the seminar was assessed and interpreted one more time to assure the comprehensiveness and quality of the preliminary challenge inventory item list.

The set of inventory items was next triangulated with the help of meta-review articles on the effectiveness of challenges on cognition and learning outcomes. According to Gillian Dale and Shawn Green (2016), potential effects of videogames have been investigated from the perspectives of perceptual, cognitive, and motor skills. In this rubric, some of their reviewed studies have focused on analyzing action videogames' effects on their players' high-level executive functions such as planning, task-switching, and problem-solving. Other reviewed studies had investigated similar effects such as those on processing speed, reaction time, divided attention, contrast sensitivity, mental rotation, temporal-order tasks, multitasking, task-relevant information recognition, attentional capacity, and memory processes (see also Granic et al., 2013). These approaches were taken into consideration.

Walter Boot et al., 2008 and his research group (2008), in turn, were found to have reviewed and studied how videogame playing impacts attention, memory, and executive control. The authors discuss effects of gaming on visual selective attention, pattern-detection, reaction time, object-tracking, task-switching, reasoning, spatial skills, mental rotation, and short-term memory. Similar entities were mentioned by numerous other related studies (see Gentile et al., 2009; Jackson, 2012; Barlett et al., 2009; Ferguson, 2009; Gentile, 2011; Granic et al., 2013; Jackson and Games, 2015). Based on the rationale that neuropsychological tests are designed to measure the effectiveness of player efforts as they face videogame challenges, a comparison between this literature and the play-games research literature was compiled.

The key difference between the two fields of literature seems to be that the neuropsychological one suggests a third challenge category of "perceptual challenges" in addition to the physical kinesthetic and cognitive nonkinesthetic challenges. Furthermore, the neuropsychological literature does not discuss the so-called emotional challenges of videogames. These findings at hand, a preliminary Videogame Challenge Inventory (CHA) of 38 respective challenges was compiled (Table 1).

Table 1
The CHA inventory. Thirty-eight videogame challenge types and their mean preference scores and standard deviations in the first survey (N = 813).

Challenges of…	Item	Mean	SD
… creative problem-solving	1	3.88	0.98
… moral and ethics	2	3.80	1.21
… using imagination	3	3.78	1.03
… dealing with emotionally difficult subjects and themes	4	3.51	1.29
… in-depth understanding	5	3.63	1.08
… thinking out-of-the-box	6	3.69	1.04
… improvising	7	3.57	1.01
… construction (e.g., jigsaws)	8	3.12	1.14
… quizzes and knowledge tests	9	2.91	1.26
… crosswords and other word puzzles	10	2.74	1.25
… finding hidden objects	11	3.31	1.17
… mazes and labyrinths	12	2.97	1.10
… memorizing	13	2.70	1.06
…pattern recognition and finding out correct combinations	14	3.06	1.10
… riddle solving	15	3.45	1.14
… spatial puzzles of mental or psychical rotation	16	3.17	1.13
… fast reaction	17	2.87	1.12
… precision and accuracy	18	3.32	1.01
… dexterity and agility	19	3.17	1.10
… tactics (e.g. battle tactics)	20	3.41	1.19
… acting in a constant hurry	21	2.28	1.09
… endurance and stamina	22	3.00	1.08
… mastering complex controls	23	2.51	1.17
… rapid and repetitive input (e.g. button-mashing)	24	2.00	1.05
… timing and rhythm	25	2.62	1.13
… performing a set of actions in sequence (i.e. combos)	26	2.76	1.15
… multitasking skills	27	2.92	1.02
… logical problem-solving	28	3.89	0.98
… strategy and strategic planning	29	3.56	1.15
… optimizing (finding the most useful solution or combination)	30	3.22	1.09
… cause-and-effect reasoning (e.g. "if I do this, that will happen")	31	3.88	0.97
… considering probabilities (e.g., "how likely something is")	32	3.09	1.08
… diplomacy	33	3.24	1.16
… leadership and delegating	34	3.19	1.14
… mathematics	35	2.69	1.22
… negotiating	36	3.29	1.11
… reasoning and predicting	37	3.76	0.97
… teamwork	38	3.04	1.24

3. Exploratory factor analysis

An exploratory factor analysis (EFA) was executed for investigating latent factor structures of the CHA scale (Table 1). EFA is a not a theory-driven method but an exploratory approach for identifying possible factors measured by an inventory. The EFA aimed at identifying whether player preferences in videogame challenges could be understood according to a limited number of challenge dimensions. For this purpose, a survey on players' challenge preferences was constructed.

3.1. Survey participants and procedure

The survey included a 38-item Videogame Challenge Inventory (Table 1). Survey participants were asked: "Imagine yourself playing a videogame (mobile or non-mobile) new to you, and the things you will do as the player. How pleasurable do you find the following challenges based on your earlier experiences?" (1 = very unpleasant, 5 = very pleasant).

The survey included also questions related to survey participants' habits of playing videogame genres ("How much do you play videogames of the mentioned genres" 1 = Not at all, 5 = Very much, a list of 10 genres), favorite videogame titles (open-ended questions), interest in gaming on a 5-point scale (1 = not at all interested, 5 = very interested), and a 15-item version of the Intrinsic Motivations to Gameplay (IMG) inventory ("How important the following reasons are for you to play videogames?" 1 = Not at all important, 5 = Very important), as presented by Vahlo and Hamari (2019). The survey also had questions regarding age, gender, income, expenditure of money on gaming, and weekly play time.

The data was collected with a web-based survey that took up to 20 min to complete with a computer or smartphone. Before opening the survey, it was piloted with 41 university students. Respondents were recruited from social media platforms such as Facebook groups and Reddit threads. The survey was targeted to everyone between the ages of 10 and 75. A total of 1,397 participants opened the survey, out of which 818 submitted completed responses. In total, 818 complete survey responses were received. Before analysis, the data was cleaned of participants who implied content nonresponsivity by responding similarly to every question. Five respondents were excluded from the analysis based on this criterion. The final sample thus consisted of 813 respondents (mean age 28.9, 59.4% male).

Challenges of logical problem-solving (item 28), creative problem-solving (item 1), and cause-and-effect reasoning (item 31) had the highest preference means, whereas challenges of rapid and repetitive input (item 24), acting in a constant hurry (item 21), and mastering complex controls (item 23) had the lowest means. Lastly, the participants showed high interest in gaming (mean 4.45) and reported to play role-playing games, action-adventure games, adventure games, action games, and strategy games more than other genres such as puzzle games (mean 2.97), platformers (mean 3.00), and simulations (2.74). The descriptive statistics of the survey (Sample 1) and the two later surveys (Sample 2, Sample 3) are presented in Table 2.

3.2. Results

A parallel analysis, PA (Henson & Roberts, 2006), was conducted to identify the number of factors to be extracted for the 38-item inventory (Table 1). The PA test suggested that five factors were to be extracted. The Kaiser–Meyer–Olkin (KMO) test was utilized to measure sampling adequacy for conducting a factor analysis. The KMO value was high (0.930).

By using statistical software Stata 14.2, an exploratory factor analysis with five factors was then put in motion by using principal axis factors and promax rotation. Promax was selected as the rotation method instead of varimax rotation because the former allows factors to correlate with each other and does not assume the factors to be

Table 2
Descriptive statistics of the three survey samples (N = 813, N = 536, N = 1,463) including demographics, mean weekly play hours, most played genres (1 = Not at all, 5 = Very much), and favored gaming modes (1 = Very unpleasant, 5 = Very pleasant).

	Sample 1	Sample 2	Sample 3
N	813	536	1,463
Female respondents	37.2%	49.7%	62.6%
Male respondents	59.4%	49.5%	36.7%
Other	2.3%	0.7%	0.5%
Undisclosed	1.1%	0.1%	0.2%
Mean age	28.9	33.2	36.6
Mean game interest	4.45	3.98	3.49
Mean weekly play hours	15.1	12.8	9.9
Most played videogame genres			
Action	3.62	3.17	2.68
Action-Adventure	3.86	3.38	2.79
Adventure	3.77	3.49	2.94
Puzzle	2.97	3.24	3.48
Role-playing	3.88	3.40	2.71
Strategy	3.15	3.43	3.11
Popular gaming modes			
Single-player PC/console games	4.56	4.24	4.02
Local co-op	3.91	3.42	2.95
Multiplayer PC/console games	3.50	3.31	2.76
Single-player mobile games	2.97	3.67	3.82
Multi-player mobile games	1.87	2.58	2.32

Table 3.
Factor loadings (Loadings >0.4), uniqueness for items, and descriptive statistics for scale sums after the third iteration of PA test, rotated solution. Mean, standard deviation, and Cronbach's Alpha are calculated using items with loadings above 0.4.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqn.
Item 1	0.7592					0.3868
Item 2				0.7343		0.3600
Item 3	0.6087					0.4545
Item 4				0.7288		0.4359
Item 5				0.4135		0.5258
Item 6	0.6583					0.4393
Item 7	0.5641					0.4875
Item 8			0.4452			0.6568
Item 9			0.6335			0.6686
Item 10			0.7403			0.5214
Item 11			0.4199			0.7023
Item 12			0.5421			0.5932
Item 13			0.5574			0.5580
Item 15			0.5052			0.4781
Item 16	0.4396					0.5936
Item 17		0.8084				0.4292
Item 18		0.5786				0.5950
Item 19		0.7256				0.4648
Item 20					0.6913	0.4572
Item 21		0.6564				0.5129
Item 22		0.4678				0.6143
Item 23		0.6844				0.5587
Item 24		0.6348				0.6175
Item 25		0.5387				0.7035
Item 26		0.5918				0.6122
Item 27		0.5020				0.5912
Item 28	0.4911					0.4703
Item 29					0.7679	0.4080
Item 30					0.4997	0.6563
Item 32					0.4389	0.6553
Item 33				0.7435		0.3589
Item 34					0.4489	0.5601
Item 35			0.4243			0.5991
Item 36				0.7645		0.3323
Mean	3.6627	2.7451	2.9849	3.4934	3.2937	
Std.	0.7660	0.7395	0.8687	0.9340	0.8186	
Alpha	0.8384	0.8687	0.7997	0.8560	0.7730	

orthogonal to each other (Matsunaga, 2010, p. 100). Since videogames usually include multiple challenges, it is reasonable to assume that players may find many types of challenges pleasurable at the same time.

A loading over 0.40 was selected as a criterion to determine whether an inventory item belonged to a factor (see Hair et al., 2010, pp. 114–115). In the first five-factor solution, items 14, 37, and 38 did not load on any factor. These items were excluded before the next PA test, which suggested an underlying five-factor structure. Item 31 did not show clear loading, and it was removed for the third PA test that continued to suggest a five-factor structure. This iteration resulted in a solution with all remaining items showing a factor loading over >0.40 (Table 3).

Six items [1, 3, 6–7, 16, 28] loaded on the first factor ($\alpha = 0.84$). Of these items, challenges of creative problem-solving and thinking out-of-the-box showed the highest loadings. Challenges of imagination, improvising, and logical problem-solving loaded on this factor too. These challenges require cognitive effort, reflective thinking and reasoning, and creative understanding from the player, and thus it was named the ***Analytical*** factor.

Ten items [17–19, 21–27] loaded on the second factor ($\alpha = 0.87$). These items reflect preference for challenges that require fast reaction, dexterity and precision, mastering of complex controls, and acting under time pressure. The challenges cohere with earlier research on challenges of physical kinesthetic effort and were termed, accordingly, ***Physical***.

The eight items [8–13, 15, 35] that loaded on the third factor ($\alpha = 0.80$) include word puzzles, quizzes, memory puzzles, riddles, jigsaws as well as challenges of mathematics, mazes, and hidden objects. These challenges can be overcome by figuring out or knowing the correct solution. The factor was labeled ***Insight***, for such challenges tend to entail insight thinking, as described by Marcel Danesi (2004): a moment of realization combining memory and imagination in solving a pattern.

Five items [2, 4–5, 33, 36] loaded on the fourth factor ($\alpha = 0.86$). These items describe a preference for challenges of moral and ethics, emotionally difficult subjects or themes, diplomacy, negotiating, and in-depth understanding. These ***Socioemotional*** challenges necessitate the player to explore their own feelings, responsibilities, and values. The player is thus expected to be able to consider and empathize perspectives and needs of others.

Finally, the challenge items [20, 29–30, 32, 34] of strategy, tactics, optimizing, leadership, and considering probabilities loaded on the fifth factor ($\alpha = 0.77$). All these challenges require cognitive ability to plan and predict, that is, ***Foresight***.

The factors *Analytical, Insight*, and *Foresight* are congenial with literature on cognitive challenges. Also, both *Socioemotional* and *Physical* are supported by prior research on videogame challenges. However, the five factors did not include a challenge type similar to “perceptual challenges” that were suggested in neuropsychological research literature. It should also be noted that the analyzed EFA data was not representative and that survey participants decided to take the survey based on their own interest in videogames. Individuals reported to play role-playing games, action-adventure games, adventure games, and action games over puzzle games (Table 2), while earlier research indicates the latter to be the most popular genre (Vahlo et al., 2018b). These biases may have had an effect on results of the EFA. To probe the issues further, an additional EFA with another survey data was organized. The goal was to develop a more reliable CHA version and to explore whether the five-factor structure could be identified consistently.

4. Inventory development

A single EFA is not considered sufficient for scale validation studies (Matsunaga, 2010), for which an additional survey data for a second EFA was collected. This time the data was not collected from social media groups but via a UK-based crowdsourcing platform Prolific that holds an online panel of approximately 70,000 users in multiple countries. Two samples were bought from Prolific: a smaller one from the USA and a larger one from the UK. The second survey included identical questions about survey participants’ challenge preferences, genre play, and gaming motivations (as in the first survey).

The new survey started with a screener that was posed to all recruited Prolific users (N = 3,012). The screener inquired the users’ age, gender, country of residence, interest in videogames, and how often they played with different gaming technologies such as smartphones, personal computers, and consoles. The full survey was then opened only for those respondents who expressed that they were at least a bit interested in videogames (N = 2,170) – it would not make sense to study videogame challenges with individuals who have no experience of them. A total of 2,085 completed survey responses was received (USA, N = 564; UK, N = 1,521). After cleaning the data according to a similar process as earlier, the number dropped to 1,999 with more participants from the UK (N = 1,463) than the USA (N = 536). Again, descriptive statistics of both samples are reported in Table 2.

The UK sample (Sample 3) differed from the USA sample (Sample 2) and the first sample (Sample 1) in three important ways. First, mean age in the UK sample was over 3 years more than in the USA sample, and approximately 8 years more than in first sample. Second, the participants of the UK sample reported significantly lower interest in gaming than participants of the USA sample and the first sample. Third, the UK respondents reported to play puzzle games clearly more than those of the two other samples, the latter having much stronger preference for role-playing games, adventure games, strategy games, and action-adventure games. This third difference indicates that players of the three samples may have different types of knowledge and experience of videogames and their challenges.

On the other hand, participants of the USA survey reported similar preferences for videogame challenges than the respondents of the first survey. The USA-based participants had the highest preference means in challenges of creative problem-solving (3.83), logical problem-solving (3.82), and using imagination (3.77), and lowest preference means in challenges of mathematics (2.59), rapid and repetitive input (2.59), and acting in a constant hurry (2.63). Not far from the above, the UK-based respondents preferred challenges of logical problem-solving (3.83) and creative problem-solving (3.76) the most, but also challenges of quizzes and knowledge tests (3.68) and challenges of finding hidden objects (3.57). The least favored challenges were those of rapid and repetitive input (2.41), acting in a constant hurry (2.56), and challenges of mastering complex controls (2.77).

4.1. Results of the second EFA

The second factor analysis was done with survey data collected from the USA ($N = 536$). Exactly the same inventory, analysis software, and similar analysis procedures were used as in the first exploratory EFA. The PA test suggested again that five factors ought to be extracted from the 38-item inventory. The Kaiser–Meyer–Olkin (KMO) test produced a high value (0.96), which supported conducting factor analysis on the data.

In item screening processes of scale validation studies, factor loadings over 0.50 are typically utilized for identifying those survey items that reliably measure a particular factor. Also, a researcher should take into consideration secondary factor loadings on other factors. In this study, a primary factor loading of 0.50 and a discrepancy score of 0.30 between primary and secondary factor loadings were utilized (see Matsunaga, 2010; Hair et al., 2010).

In the first solution of five factors, several items showed a loading higher than 0.4 but lower than the threshold of 0.5. All these items (11, 13, 25, 32, 35, 38) were removed from the analysis. After excluding these six items, only two items remained on the factor *Foresight*. These two items were “Challenges of tactics (e.g. battle tactics)” and “Challenges of strategy and strategic planning”. Since three items is considered a minimum amount of items per factor (Brown, 2015, pp. 61–62), both items and the fifth factor were dropped from the analysis.

Another PA test was ran, which now suggested a four-factor solution. Four factors with promax rotation and 0.5 factor loading threshold were extracted. In the second solution, items three (“Challenges of using imagination”) and seven (“Challenges of improvising”) showed loadings under 0.5 and were therefore removed. The PA test suggested still a four-factor solution, and in this third solution, all remaining items loaded on a factor with a loading over 0.5. Furthermore, none of the remaining 28 items had a uniqueness over 0.6. Uniqueness, which is equal to “1–communality,” should be less than 0.6 – if an item has uniqueness over 0.6, the item may be related to other items and therefore it may struggle with showing high factor loading on any of the identified factors (Costello and Osborne, 2005). High uniqueness (or low communality score) may also indicate that an additional factor should be identified.

Next, a calculation of discrepancy scores for all 28 items of the second iteration of the CHA scale followed. The items 31 (“Challenges of cause-and-effect reasoning”), 15 (“Challenges of riddle-solving”), and 14 (“Challenges of pattern recognition and finding out correct combinations”) had a discrepancy under 0.3 between their primary and secondary factor loadings. After excluding these three items, the revised CHA scale consisted of 25 items, each of which loaded on exactly one of the four identified factors (Table 4). Items one, six, and 28 loaded on the first factor, items 17–19, 21–24, 26–27 on the second factor, items 2, 4, 33, 36 on the third factor, and items 8–10, 12, and 15 on the fourth factor, very similarly as in the first EFA. Because of this, the factor names *Analytical, Physical, Socioemotional,* and *Insight* were retained.

The results from the second EFA with USA-based data largely echoed the results from the first EFA, with the exception of lacking the *Foresight* factor. The reason for the dropped factor's weakness likely derives from its two key items’ (“Challenges of tactics” and “Challenges of strategy”) direct references to popular “tactic” and “strategy” videogame genres. Such direct references can be suggested to have had a major impact on how these two items were able to construct a factor also in the first EFA.

5. Confirmatory factor analysis

A confirmatory factor analysis (CFA) for the 25-item CHA scale was put in motion. It is important to validate a scale with cross-cultural data, especially in the case of experience goods such as videogames (Quant et al. 2009; De Grove et al. 2017). Hence, it was a deliberate choice to accompany the USA sample with a UK one, the duo thus constituting a pair of separate countries but not undermined by major linguistic differences. CFA is a theory-based method for constructing measurement models in scale validation and structural equation modeling (SEM) studies. A measurement model is put together to investigate relationships between observed measures such as survey items and hypothesized latent factors. In CFA, a researcher specifies the number of factors and how observed items relate to these theorized factors (see Brown, 2015).

The CFA model of this study was based on the results of the two EFAs reported above, and also on the theoretical considerations introduced earlier. From a theoretical perspective, it is important to highlight that the four preliminary factors of the second CHA iteration (Table 4) fit well with the literature review on cognitive, physical, and emotional challenges. *Socioemotional* covers many elements that were referred to as emotional challenges, *Physical* is closely related to physical kinesthetic challenges, and both *Analytical* and *Insight* deal with cognitive challenges, albeit from different perspectives.

By means of the CFA, it was then investigated if the 25 CHA items could be validated psychometrically, i.e. if they are indicators of measuring the four latent dimensions of *Analytical, Physical, Socioemotional,* and *Insight* in challenge preferences. Also, a goal was to make the present CHA shorter so that it would be more usable in future research. Since three is considered the smallest number of observed variables for a factor to be sufficiently identified (Brown, 2015), four three-item constructs were designed to measure the hypothesized four-factor model of videogame challenge preferences.

Twelve CFA items were selected by the following criteria: each selected item 1) showed a strong loading of over 0.50 on the corresponding factor in the second EFA, 2) loaded on the same factor also in the first EFA, 3) had a high discrepancy value between primary and secondary factor loading (over 0.30), 4) managed to cover qualitative aspects not covered by the other selected items, and 5) did not include wordings which referred directly to the label of the hypothesized latent construct. The selected 12 items and their descriptive statistics in the UK data are reported in Table 5.

A confirmatory factor analysis with the data collected from the UK was made by using statistical software Stata 14.2 and maximum likelihood estimation procedure in structural equation modeling (SEM). The measurement model is presented in Fig. 1. Construct validity of the CHA model was investigated by calculating the Tucker Lewis Index (TLI), the root mean squared error of approximation (RMSEA), the comparative fit index (CFI), and the standardized root mean squared residual score (SRMR). The chi square test was not utilized, because this test fits poorly to studies with large sample sizes such as the present one (Matsunaga, 2010; Russell, 2002).

The goodness-of-fit values for the model (Fig. 1) were: TLI 0.916, CFI 0.936, RMSEA 0.077, and SRMR 0.066. These values indicate an acceptable model fit to the continuous data (see Kenny et al., 2015).

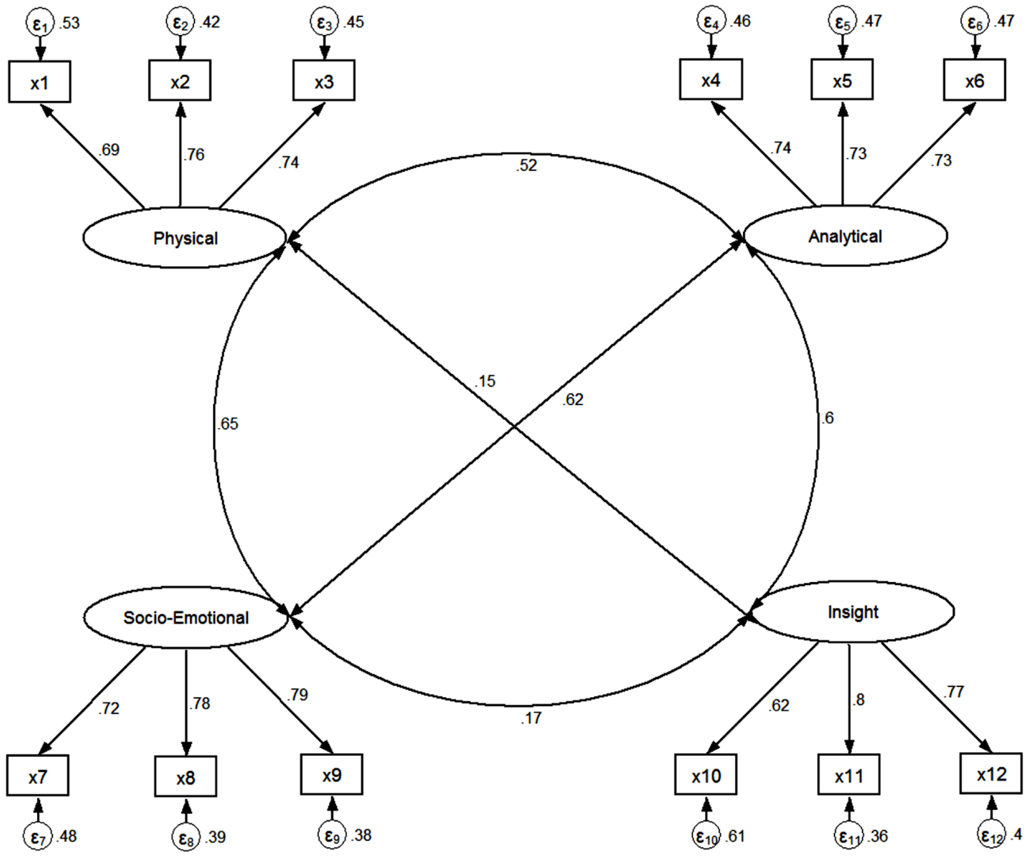

Fig. 1. The measurement model reporting confirmatory factor analysis for the 12-item CHA with UK data (N = 1,463). All loadings of the scale are significant on the level $p < 0.001$.

Although the fit cannot be regarded close or good, these fit indices taken together support construct validity for the model (Brown, 2015; Hu and Bentler, 1999; Kline, 2010; Marsh et al., 2004; Schreiber et al., 2006).

Next, discriminant validity and convergent validity tests were done for the CFA model. In order to study the convergent validity of the model, composite reliability (CR) score was calculated for the four factors. An acceptable value for CR to support convergent validity is 0.7 (Zait and Bertea, 2011). The CR test results for the present model were *Physical*:0.78, *Analytical*: 0.77, *Socioemotional*: 0.81, and *Insight*: 0.78, which exceed the required minimum value.

The average variance extracted analysis (AVE) was then conducted to further study both the convergent and discriminant validity of the CHA model. The AVE test should first result in values over 0.50 to demonstrate convergent validity for each factor. Then, the AVE procedure is used to investigate whether the AVE for each construct is higher than the square of the correlation, i.e. shared variance, between latent constructs. If AVE value exceeds values of shared variance, the results support discriminant validity for the CHA construct (see Farrell, 2009; Fornell and Larcker, 1981). The AVE test results are presented in Table 6.

The AVE values for each factor exceeded the required value of 0.50 and the AVE values were also higher than their shared variance between other factors. The results of both the CR tests and the AVE tests (Table 6) thus support convergent and discriminant validity for the four factor 12-item CHA model.

As reported in Table 2, the player preference data of the UK sample differs from the two other samples. The UK respondents reported playing puzzle games significantly more than other videogames, whereas both the social media survey respondents and the USA survey participants reported playing role-playing games, adventure games, action-adventure games, and strategy games more than puzzle games. Also, the mean for being interested in gaming was much lower in the UK data than in the two other datasets.

It is plausible that players' experiences in playing different genres affect their perception of challenges and how their preferences measure the confirmed four latent factors of *Physical, Analytical, Socioemotional*, and *Insight*. Because of this, one more study on the model fit for the CHA construct (Fig. 1) was needed with a UK subsample that would be more similar with the datasets studied in the two EFAs prior the CFA. To construct this subsample, those UK respondents who did not play at least one of the genres of role-playing games, action-adventure games, adventure games, or strategy games at least occasionally were removed. After this modification, the constructed UK subsample consisted of 959 respondents (54% female, mean age 33.9, mean interest 3.9, mean weekly play hours 11.8) who reported to play mostly adventure games (3.67), action-adventure games (3.54), strategy games (3.48), role-playing games (3.41), and puzzles (3.36).

A second CFA was thus made with the subsample by using exactly the same model that was reported in Fig. 1. The model fit indices for the UK subsample (N = 959) were: TLI 0.946, CFI 0.961, RMSEA 0.057, and SRMR 0.047. These results indicate a good fit of the CHA model to the UK subsample. This result suggests that players who have first-hand experience of playing a variety of videogame genres have more nuanced challenge preferences than those players who only play puzzle games. The two CFAs confirm that the four videogame challenge factors can be reliably measured with the 12-item CHA

6. Relating CHA to videogame choice and motivations to play

Earlier literature has suggested that gameplay preferences can be used to predict players' videogame choice (RQ1) and thereby in making

Table 4
The second iteration of the CHA scale, a 28-item version with factor loadings >0.50, item uniqueness, and discrepancy value between primary and secondary loadings.

	Factor 1	Factor 2	Factor 3	Factor 4	Uniqn.	Discpr.
Item 6	0.689		0.126		0.389	0.563
Item 28	0.678			0.174	0.487	0.505
Item 1	0.655			0.160	0.421	0.495
Item 37	0.629		0.12		0.466	0.511
Item 30	0.596	0.247			0.472	0.349
Item 5	0.574		0.217		0.447	0.356
Item 31	0.547		0.275		0.517	0.272
Item 17	0.018	0.861			0.368	0.843
Item 21		0.755	0.096		0.440	0.659
Item 23	0.041	0.711			0.442	0.672
Item 18	0.242	0.648			0.468	0.406
Item 26		0.646		0.114	0.481	0.532
Item 19	0.186	0.639			0.454	0.453
Item 24		0.639		0.162	0.571	0.477
Item 22		0.608	0.300		0.432	0.309
Item 27		0.555		0.149	0.534	0.406
Item 33	0.052		0.732		0.396	0.680
Item 2			0.718	0.050	0.465	0.668
Item 36		0.102	0.697		0.383	0.596
Item 4	0.099		0.651		0.527	0.552
Item 34		0.186	0.572		0.470	0.385
Item 10			−0.056	0.876	0.394	0.933
Item 9			0.095	0.733	0.439	0.639
Item 8			0.108	0.647	0.538	0.539
Item 16		0.144		0.599	0.478	0.455
Item 15	0.287			0.560	0.425	0.273
Item 12	0.130			0.518	0.540	0.388
Item 14	0.326			0.502	0.443	0.176

personalized gaming recommendations (Vahlo and Koponen, 2018; Vahlo et al., 2018a). Furthermore, prior research has shown that challenge is an important motivational factor in videogame play (RQ2), and closely associated with competence as a basic human need of self-determination (see Sherry et al., 2006; Ryan et al., 2006). In the final part of this study, these topics are investigated and, by doing so, CHA's usefulness demonstrated.

6.1. Do challenge preferences predict genre play?

The survey employed in the UK and the USA samples included questions about the respondents' habits related to videogame genres. The survey participants were asked to report on a 5-point scale how much (1 = Not at all, 5 = Very much) they had played e.g. action games, action-adventure games, role-playing games, puzzle games, strategy games, and racing games.

According to media choice theory, users' preferences are systematically and consistently connected to their choices to consume media content (Webster and Wakshlag, 1983; Scherer and Naab, 2009). Since all videogames arguably include an element of challenge, and different videogame genres tend to present distinctive or at least similar challenges to players, it is a reasonable hypothesis that all four challenge preference factors predict players' habits of playing particular genres.

To demonstrate the usefulness of the four-factor CHA scale, a structural model for studying players' preferences for challenges with a genre habit predictor was created (RQ1). A structural equation model (SEM) was designed based on the CFA measurement model reported in Fig. 1. The idea was to investigate path coefficients between latent challenge preference factors and observed variables of frequency of genre play Tables 4. The structural model is presented in Fig. 2 and the estimates in Table 7.

The results reported in Table 7 show that all four challenge preference factors predict genre play (RQ1). A preference for *Physical* showed a strong effect on playing racing games, action games, action-adventure games, and platform games. It was also associated to playing puzzle games, and it furthermore predicted a habit of playing multiple genres more than the other three challenge preference factors.

Preferences for *Socioemotional* challenges predicted strongly a habit of playing role-playing games, simulation games such as life simulations, and less strongly a habit of playing action-adventure games, action games, strategy games, and games of multiple genres. Furthermore, preference for *Socioemotional* predicted negatively a habit of playing puzzle games.

Analytical challenge preferences predicted strongly that the person plays strategy games, but also action-adventure games, role-playing games, action games, and games of multiple genres. These preferences were negatively associated with a habit of playing racing games.

A preference for *Insight* challenges was strongly associated with a habit of playing puzzle games. It was also negatively associated with playing action games, action-adventure games, and role-playing games. Enjoying *Insight* was the sole factor that predicted negatively a habit to play multiple genres.

All four factors of challenge predicted a habit of playing particular videogame genres. Furthermore, the predictions were dissimilar. These results supported the hypothesis that challenge factors can be utilized in predicting videogame choice (RQ1).

6.2. Are motivations to play associated with challenge preference types?

To examine whether play motivations predict videogame challenge type preferences, a motivations to play model presented by Jukka Vahlo and Juho Hamari (2019) was utilized. We selected this model because these authors have recently validated it with videogame players of multiple genres across cultures such as Japan, Canada, and Finland. According to the model by Vahlo and Hamari, players' motivations include five dimensions: *Relatedness, Competence, Autonomy, Immersion*, and *Fun*. The three surveys reported in this study all included the same 15-item motivations to play inventory. In this inventory, *Relatedness* is measured by items such as "I play because I enjoy especially playing together", *Competence* by e.g. "I play because of the challenge", *Autonomy* by e.g. "I play because it allows me to make meaningful

Table 5
Descriptive statistics for the 12-item CHA (N = 1,463). Hypothesized factors: P = Physical, A = Analytical, S = Socioemotional, and I = Insight.

Variable		Mean	SD	Skewness	Kurtosis
x1	Challenges of fast reaction (P)	3.11	1.21	−0.017	2.13
x2	Challenges of acting in a constant hurry (P)	2.55	1.16	0.34	2.26
x3	Challenges of mastering complex controls (P)	2.77	1.22	0.12	2.09
x4	Challenges of creative problem-solving (A)	3.76	1.05	−0.71	2.98
x5	Challenges of thinking out-of-the-box (A)	3.55	1.12	−0.55	2.68
x6	Challenges of logical problem-solving (A)	3.83	1.03	−0.78	3.13
x7	Challenges of moral and ethics (S)	3.16	1.23	−0.12	2.10
x8	Challenges of diplomacy (S)	2.95	1.16	−0.05	2.27
x9	Challenges of negotiating (S)	3.05	1.18	−0.12	2.18
x10	Challenges of construction (e.g. jigsaws) (I)	3.31	1.18	−0.30	2.22
x11	Challenges of quizzes and knowledge tests (I)	3.68	1.14	−0.63	2.59
x12	Challenges of crosswords and other word puzzles (I)	3.42	1.29	−0.41	2.09

Table 6
The Average Variance Extracted Analysis (AVE) on the four-factor model of the 12-item CHA for measuring players' challenge preferences. AVE values are bolded.

	Physical	Analytical	Socioemotional	Insight
Physical	**0.54**			
Analytical	0.27	**0.53**		
Socioemotional	0.43	0.38	**0.59**	
Insight	0.02	0.37	0.03	**0.54**

choices", *Immersion* by e.g. "I play because I want to be part of the gameworld and its events", and *Fun* by e.g. "I play because it's entertaining". The five motivational factors had the following Cronbach's alphas in our study (N = 1,999): *Relatedness* 0.83, *Competence* 0.71, *Autonomy* 0.84, *Immersion* 0.82, and *Fun* 0.76. We report the estimates in Table 8.

Not surprisingly, playing videogames because of *Competence* predicted a preference for all four challenge types. This effect was strongest on *Insight* and *Analytical* challenges, followed by *Physical* challenges. The effect of *Competence* on *Socioemotional* challenges was clearly weaker but still significant. Being motivated by *Relatedness* was positively associated with a *Physical* challenge preference, and negatively with both *Insight* and *Analytical* challenge preference. Playing because of *Immersion* predicted a preference especially for *Socioemotional* challenges, but also, albeit weakly, for *Physical* and *Analytical* challenges. Being motivated by *Fun* did not show strong effects on any of the four challenge types. Playing because of *Autonomy* predicted a lower preference for *Physical, Analytical*, and *Insight* challenges. Finally, higher age and female gender were associated positively with a preference for *Insight*, but negatively with *Physical* challenges. Higher age was also associated negatively with a *Socioemotional* challenge preference, and female gender was also associated positively with a preference for *Analytical* challenges–although female gender was a positive predictor of *Insight* challenge with an even higher beta rate than for *Analytical.*

These results suggest that play motivations are connected to players' preferences for specific videogame challenges (RQ2). In the following final section, practical and theoretical implications of these results, along with limitations and prospects of future research, are discussed.

7. Conclusion and discussions

By means of exploratory ($N = 813 + 536$) and confirmatory (N = 1,463) factor analyses, this study found four videogame challenge factors: *Insight, Socioemotional, Analytical*, and *Physical. Physical* corresponds to what has been written earlier about physical kinesthetic challenges, whereas both *Analytical* and *Insight* are compatible with cognitive nonkinesthetic challenges. *Socioemotional* is also supported by earlier literature (Cole et al., 2015; Denisova et al., 2017; Bopp et al., 2018).

According to Robert Sternberg's (1985, pp. 80–81) classic theory, insight consists of three psychological processes: selective encoding of fleshing out relevant information from irrelevant information, selective combination of bringing together two or more seemingly isolated pieces of information to make sense of a new whole, and selective comparison in which newly acquired information is considered in relation to the information acquired in the past. All these three cognitive processes are important for challenges of *Insight* that appear especially in puzzle games. For instance, hidden object games challenge our abilities of selective encoding, matching puzzles such as *Tetris* or *Candy Crush Saga* challenge our selective combination skills, and riddles, jokes as well as graphic adventure games such as *Grim Fandango* and *Monkey Island* test our selective comparison skills. The challenges of construction, knowledge, and word puzzles that loaded on *Insight* correspond to these processes of selective encoding, selective combination, and selective comparison.

According to some scholars (e.g. Clay and de Waal, 2013; Hutchings et al., 2015), socioemotional skills of empathy and emotion recognition are needed, for example, in forming and maintaining social relationships, being sensitive of others' perspectives, and regulating and managing one's own emotions. Understood in this vein, *Socioemotional* challenges are cognitive nonkinesthetic challenges but distinct from *Analytical* challenges by their explicit focus on dealing with emotionally difficult subjects via self-reflexive thinking, as the three items of diplomacy, negotiation, and ethical or moral challenges illustrate

Table 7
The direct effects of the four challenge preference factors on playing videogames of several genres (N = 1,999). The significance levels are for the unstandardized solution of the model shown in Fig. 2.

Model Estimates	Physical		Socioemotional		Analytical		Insight		R^2
	coef.	p	coef.	p	coef.	p	coef.	p	
All Genre Mean	0.303	0.000	0.195	0.000	0.196	0.000	−0.134	0.000	0.313
Action	0.439	0.000	0.103	0.004	0.121	0.006	−0.404	0.000	0.377
Action-Adventure	0.293	0.000	0.199	0.000	0.177	0.000	−0.372	0.000	0.323
Platform	0.288	0.000	0.020	0.625	0.111	0.021	−0.034	0.329	0.131
Puzzle	0.110	0.000	−0.166	0.000	0.033	0.434	0.667	0.000	0.458
Racing	0.451	0.000	−0.010	0.807	−0.110	0.021	0.005	0.878	0.162
Role-Playing	0.000	0.607	0.439	0.000	0.143	0.001	−0.274	0.000	0.272
Simulation	0.006	0.512	0.336	0.000	0.023	0.625	−0.057	0.101	0.119
Strategy	0.000	0.561	0.131	0.036	0.292	0.000	−0.056	0.110	0.131

Table 8
Regression analyses for preferences in physical, cognitive, emotional, and solving challenges in videogames, based on five intrinsic play motivations, age, and gender (N = 1,999).

	Physical		Analytical		Socioemotional		Insight	
	R^2 = 0.326		R^2 = 0.200		R^2 = 0.316		R^2 = 0.185	
	β	p	β	p	β	P	B	P
Competence	0.385	0.000	0.399	0.000	0.150	0.000	0.404	0.000
Relatedness	0.153	0.000	−0.059	0.048	0.000	1.000	−0.079	0.009
Immersion	0.200	0.000	0.115	0.000	0.397	0.000	−0.080	0.009
Fun	−0.103	0.000	0.077	0.014	0.051	0.075	−0.032	0.315
Autonomy	−0.075	0.010	−0.076	0.017	0.001	0.975	−0.073	0.022
Higher age	−0.104	0.000	−0.012	0.575	−0.094	0.000	0.135	0.000
Women	−0.052	0.006	0.071	0.001	−0.023	0.237	0.292	0.000

(Table 5). Nonetheless, our study found no significant connection between *Relatedness* motivation and *Socioemotional*challenge preference. This could be explained by the fact that many contemporary *Socioemotional* challenges appear in the form of human-AI interaction, which is typical to single-player role-playing games that do not necessarily contribute to *Relatedness*. This hypothesis is further supported by our finding of *Immersion* as a key motivation for *Socioemotional* challenge. While this finding contradicted with earlier related findings (Bopp et al., 2018), the discrepancy might be due to the latter being not collected with a motivations-specific instrument but the general Immersive Experience Questionnaire (Jennett et al., 2008).

Analytical cognitive processing, in turn, can be considered a general means of reasoning and thinking that takes place in almost all videogame play to some extent. The key difference between *Analytical* and *Insight* is that the latter is functional mainly in static environments where information is accessible, while the former operates also in dynamic environments (multiplayer games, complex AIs, etc.) where players need to cope with unpredictable elements. The three related items – creative, logical, and out-of-the-box problem solving – corresponds to this difference, yet visibly overlaps too. For instance, both logical and out-of-the-box thinking are standardly considered basic means for puzzle solving and the related insight (Danesi 2004).

Perhaps the most well-known challenges in videogame history, *Physical* challenges, are often unpredictable and dynamic (cf. Buckles 1985). In the 12-item CHA, these challenges are represented by three kinesthetic items: fast reaction, time-critical input, and mastering of controls. An interesting detail in the measurement model (Fig. 1) is that *Insight* is only weakly correlated with *Physical* and *Socioemotional*, but strongly with *Analytical*. On the other hand, all factors were strongly correlated with *Analytical*. This suggests that *Analytical* is the core videogame challenge type, which supports a recurring yet previously unevidenced premise that is often credited to Sid Meier: “a game is a series of interesting decisions.” The fact that *Insight* challenges are weakly correlated with the other challenge factors is likely because of their unique static nature, that is, *Insight* challenges are “solved” based on available information whereas *Socioemotional* challenges, for instance, surface as more ambiguous and complex due to dynamic elementslike character AI. Earlier theories that consider puzzles and puzzle-based adventure games conceptually different from games in general thus gain support (Crawford 1982; Karhulahti, 2013a; 2015b), although we should bear in mind that *Insight* challenges are nevertheless associated also with all the other challenge types, as shown in the measurement model (Fig. 1).

Moreover, our data and their analysis does not yield evidence on the debated ontology of “social” challenges, i.e. challenges based on human-human interaction. Earlier studies have sometimes suggested such challenges to form a class of their own (Schell 2014), whereas others (Karhulahti 2015b; Denisova et al., 2017) have considered it to belong to what is here termed *Analytical* challenges. Social challenges can also be argued to be closely related to *Socioemotional* challenges, the latter of which link to social emotions such as empathy. Since none of our items were exclusively linked to human-human social interaction (vs. human-AI social interaction), we cannot confirm or disconfirm the link between human sociality and any of the factors. Lastly, we rereview and provide summarizing answers to the two research questions.

RQ1: Can players’ challenge preferences predict their genre preferences?

A SEM was designed to figure out whether the four challenge factors predict videogame genre preferences (Fig. 2). All four challenge preference factors were found to predict genre play. In particular, *Physical* predicted multiple genre preferences and, in fact, more than any other factor. *Insight,* in turn, predicted puzzles alone. The central role of *Physical* challenge can be considered to be supporting evidence for the so-called “kinesthetic theory” of videogames (Karhulahti 2013b) and distinct role of *Insight* further evidences the above conceptual distinction between puzzles and games. Overall, the above suggests that the validated 12-item CHA can be used for future genre preference studies. It is nevertheless worth a note that genre preferences alter along with how the genres are designed; hence, if and when the present videogame genre challenge structures evolve, new relationships between challenge preferences and genres expectedly emerge too.

RQ2: Are players’ challenge preferences associated with their play motivations?

Intrinsic motivations for playing videogames were found being associated with challenge preferences. Playing because of *Competence* predicted higher preference in all four challenge types. *Relatedness* predicted mostly a preference for *Physical* and a dislike for *Insight*, whereas *Immersion* predicted most strongly a preference for *Socioemotional* challenges. Playing because of *Fun* predicted negatively a preference for *Physical* challenges, and the motivational factor of *Autonomy* was associated negatively with other challenge factors besides *Socioemotional*. Again, *Insight* was associated to no other gaming motivation than competence, which once more supports its unique status. In general, the results suggest that challenge preferences are related to play motivations in complex ways.

7.1. Practical implications

The unique nature of *Insight* challenges should be taken into serious consideration by game designers and producers. For instance, many contemporary million-budget action games, action-adventure games, and role-playing games include a significant number of puzzles. However, according to our data, a high preference for *Insight* predicted strongly a habit to play puzzle games but negatively a habit to play action games, action-adventure games, and roleplaying games. The designers of action, action-adventure, and roleplaying games should thus consider carefully how to implement *Insight* challenges in their videogames. Furthermore, our data and analyses suggest that there may exist a specific player cluster that is motivated by *Insight* and plays almost exclusively puzzle games. Since previous theory also suggests (Crawford 1982; Karhulahti, 2013a) that puzzle games are ontologically different from other genres, we should ask if there is a specific player cluster who enjoys only static game challenges, and if active players of action, action-adventure, and roleplaying games would rather avoid these static *Insight* challenges in their gaming experiences.

We recall also that being motivated by *Fun* did not show strong effects on any of the four challenge types. While this may suggest that modern videogame players are not always interested in gameplay that explicitly challenges them, it also functions as counterevidence for the usefulness of “fun” in game design (cf. Koster 2013). Although fun is found to be the most important motivation to play digital games (Vahlo and Hamari, 2019), it also has very limited exploratory use: players differ in how they perceive fun and what kind of challenges they consider to be entertaining.

Lastly, *Analytical, Physical, Socioemotional*, and *Insight* challenges can be implemented not only in studies on digital games but also in research on different gamified systems and services. The study at hand provides new knowledge on players’ preferences in challenge types, and this information may be useful for user research and designers of gamified solutions: it should be asked if the designed gamified system is targeted for all kinds of users and whether its challenge types are also able to satisfy the identified four types of challenge preferences.

7.2. Limitations of the study

This study has limitations. First, challenge types are not easily identified. Although earlier research has discussed the subject of “challenge” extensively, this discussion has not been based on actual players but either on the qualities of videogame artefacts or the perceived effects of gaming. Hence, it must be acknowledged that formulating items for the CHA was not a trivial task, and the developed items are thus partly a result of human interpretation. The same critique is valid in the case of labeling the factors.

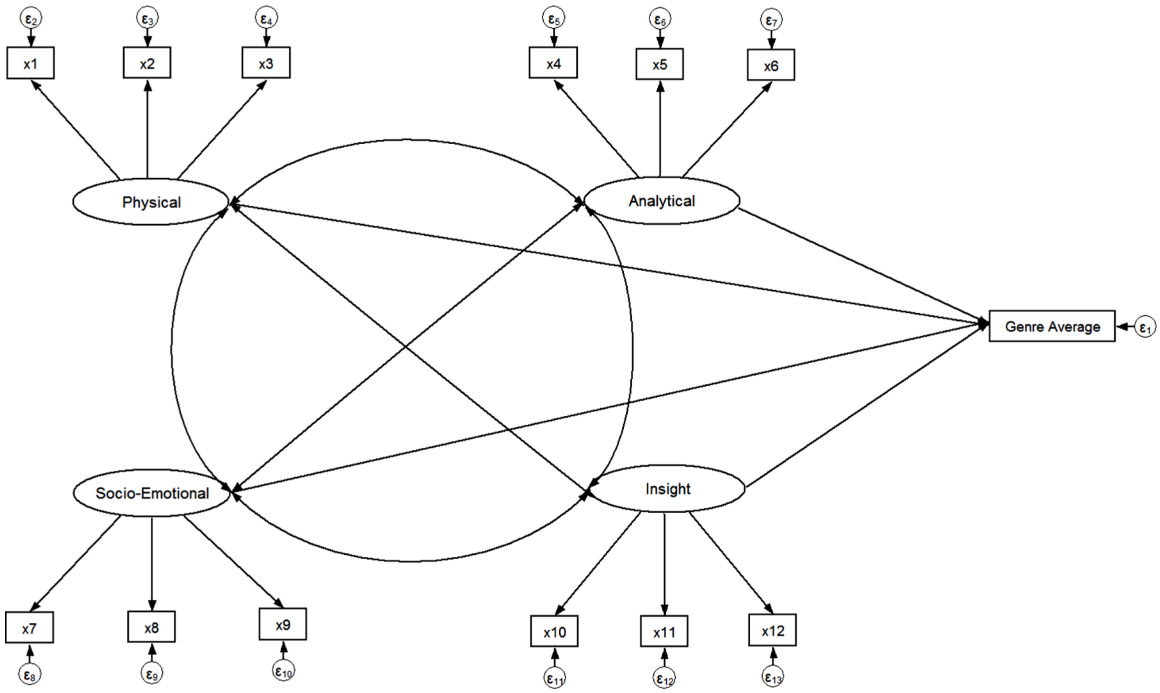

Fig. 2. The Structural Model for investigating how challenge preferences predict habit of playing videogame genres. Model fit RMSEA 0.070, CFI 0.945, TLI 0.924, SRMR 0.060 to the combined data collected from UK and USA (N = 1,999).

Furthermore, challenge preferences are abstract descriptions of what happens in the interaction between players and videogames (Karhulahti, 2020). This fact was taken into consideration in developing survey items. That said, players who have only little experience of videogames may have had difficulties in filling the survey, and it can be troublesome to report one's preferences without having enough corresponding experience. This may indeed be why the CFA model (Fig. 1) had a better fit to the data with the subsample of survey participants who reported playing multiple genres (contra those who played only puzzle games). Researchers who aim to employ CHA should take this into careful consideration.

The survey data sets for this study were collected by using two procedures: advertising the survey in social networks (Sample 1) and by collecting data in cooperation with a UK-based crowdsourcing platform company (Sample 2, Sample 3). Many of the online crowdsourcing panel participants take surveys constantly, and this may also have had some an impact on the results. For example, many USA-based and especially UK-based survey participants took the survey faster than was expected, perhaps because the monetization method of Prolific makes this a good strategy for them. However, the Kaiser–Meyer–Olkin (KMO) tests were made to examine this issue beforehand, and they resulted in good values that supported the decision to conduct factor analyses on the data.

Finally, we also stress that, regardless of cross-cultural UK-USA testing, the chosen two survey countries both represent oft-studied Western societies. Future validation work should thus include Asian and other cultures as well; however, since videogame challenges and their related genres are tightly connected to the languages that describe them, this will likely result in methodological limitations that our study was mostly able to avoid.

7.3. Future research

The validated four-factor CHA is a psychometrically sound and short measurement for studying videogame players' preferences. In future research, CHA could be used together with measures used in e.g. usability testing and gaming experience research, including psychophysiological measurements. The CHA model could also be included in studies that focus on investigating experienced difficulty, immersion, and flow experience in gaming (see Denisova et al., 2017; Ermi and Mäyrä, 2007). Future research should also investigate how videogame challenge preferences are correlated with gameplay activity preferences, the latter of which refer to semiotic settings of videogames and to what kind of representational agencies the videogame affords for its players (Vahlo et al., 2018a).

Interestingly, none of the identified four factors can be directly associated with perceptual challenges suggested by the research literature concerning gaming effects on cognition. In the item screening procedure with USA-based data, challenges of pattern recognition and challenges of object rotation loaded on *Insight* whereas challenges of multitasking loaded on *Physical* (N = 536). The item "Challenges of finding hidden objects", which arguably also measures perceptual challenge preferences, also loaded on *Insight* but with a loading under 0.50. Future research could look for alternative ways to better understand and study the notion of the so-called perceptual challenge.

During the scale development and the item screening process, several other challenge items were gradually dropped off. We highlight that this does not mean that such challenges do not exist; rather, it suggests that these videogame challenges do not constitute a higher-order preference dimension together with the challenge types included in the final CHA inventory. For instance, challenges of strategy and tactics were omitted in the item screening process of this study, although both are preferred by a large number of players. However, these two challenge types are also closely related to videogame genres (e.g. strategy games, tactical shooter games), which may lead respondents to think of their general gaming habits rather than challenge preferences. Furthermore, while *Physical* challenge has been theoretically divided into time-free action (e.g. Angry Birds) and time-critical reaction (e.g. Counter-Strike), these conceptually different challenge types fall both into the same factor in our model. Future research could aim specifically at charting these sub-challenge types, which (along with the evolving videogame industry) could provide a more accurate picture of the challenges that gamers of all genres engage with. The four factors unearthed in this study can function as a valuable foundation for such upcoming in-depth research.

Due to the lack of validated instruments for measuring videogame challenge preference structures, only little is currently known about how videogame challenges contribute to e.g. player experience, play time, player retention, and psychological outcomes of gaming. For instance, future research could investigate whether preferences for specific challenges are correlated with the newfangled "gaming disorder" (cf. King et al., 2011). Ultimately, the four-factor Videogame Challenge Inventory (12-CHA) is submitted as a reliable tool to be used in future research that will improve the understanding of gaming phenomenon across cultures.

Declaration of Competing Interest

This manuscript (or the data presented here) is not being considered by another journal nor has it been published elsewhere. The authors declare no competing interests.

Credit author statement

Jukka Vahlo: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Funding acquisition

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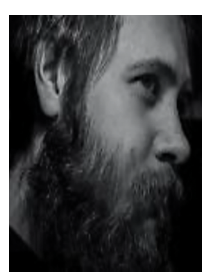

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