

Children's attitudes towards immersive virtual reality exergames: Validity and reliability of a psychometric questionnaire

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Abstract

The aim of this research was to translate the English self-report questionnaire of Ho and colleagues (2017) into Greek, determine the factor structure, validity and reliability of the Greek version of the questionnaire, expand knowledge on the psychometric behaviour of the measure and gain further empirical knowledge in the field. Participants were 347 primary school students with mild ID aged 7 to 12 ($M = 9.64$, $SD = 1.364$) years old. The underlying dimensions of the scale were checked with an Explanatory Factor Analysis (EFA). Cronbach's α -coefficient was used to test the internal consistency reliability of the scale. Results from the factor analysis yielded five factors accounting for 60.73% of the variance. Reliability analysis indicated a satisfactory internal consistency estimate of reliability (Cronbach's alpha value: 0.873) for the Greek version of the questionnaire. In conclusion, data confirm the validity of the Greek version of the questionnaire of Ho and colleagues (2017). Hence, the Greek version of the questionnaire of Ho and colleagues (2017) could be used as a useful instrument in research. Nevertheless, further examination is warranted in order to obtain additional information concerning the difficulties of exergaming experience on children's attitudes towards immersive virtual reality exergames.

Keywords: Virtual reality; Exergame; Presence; Mood; Enjoyment.

1 Introduction

Over the last few years, global Physical Activity (PA) levels have shown signs of evident decrease, while sedentary behaviour of people has followed a quite opposite trend (World Health Organization [WHO], 2012). Greece's case couldn't be the exemption to this conclusion and to make matters worse, childhood obesity has been observed to reach ominous levels, as population-based data revealed that the prevalence of overweight and obesity among 8- to 9-year-old Greek children is alarmingly elevated, with the overweight rates rising continuously (Tambali et al., 2009).

In an effort to promote PA and to restrain childhood obesity, researchers are progressively more interested in the use of Exergames (Graves et al., 2010; Maloney, Threlkeld, & Cook, 2012). Their main incentive is the fact that exergames are generally considered to be an enjoyable physical activity choice (Mullins et al., 2012), with potential to enhance cardiorespiratory fitness and improve balance and functional mobility (Mullins et al., 2012; Cone et al., 2015). Furthermore, exergames can foster children's intrinsic motivation to exercise, given that they offer enjoyment and challenge through their various difficulty levels that require increasing player expertise (Ho et al., 2017; Malone, 1981; Sun, 2012).

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Recently, numerous researchers have introduced Virtual Reality (VR) exergames into their intervention tools and methodologies to increase PA. Additionally, VR technology can be combined with exergame technology to provide highly immersive physical activity experiences (Shaw et al., 2015; Finkelstein et al., 2011) and relevant studies have shown encouraging results. Children's and adults' heart rate significantly increased after having played the VR exergame "Astrojumper", while their perceived workout and their level of motivation were found to be positively correlated according to a study by Finkelstein and colleagues (2011). Shaw and colleagues (2015) demonstrated that immersive VR is a promising tool to motivate and engage sedentary adults, given that in their study, such individuals performed better in VR exergaming sessions than in exercise sessions based on a bike and a monitor interface only. In addition, immersive VR exergames have proved to be more engaging than standard, non-technology-based physical activity alone, and VR coupled with exercise was found to increase enjoyment and energy and to reduce the feeling of tiredness in adult exercisers (Plante, Aldridge, Bogden & Hanelin, 2003). Finally, VR exergaming was found to improve performance during high-intensity interval training in adults (Farrow, Lutteroth, Rouse & Bilzon, 2019). Taking into consideration the above mentioned, the goal of this study was to investigate factors associated with a person's experience of using a VR exergame, which in turn can influence her/his motivation to engage with physical activity. These factors are: a) self-presence, b) mood experience, c) game enjoyment, d) attitude toward exergames and e) preference for future game play.

A number of researches have been undertaken to assess the aforementioned factors by means of questionnaires and interviews. Some of the questionnaires utilised are as follows: Physical Activity Enjoyment Scale (PACES) (Graves et al., 2010; Mestre et al., 2011; Garn et al., 2012), Player Experience of Need Satisfaction (PENS) model (Ijaz et al., 2020), Short Feedback Questionnaire (SFQChild) (Kizony, 2003), Perceived Ease of Use, Perceived Usefulness, Intention to Use of Technology Acceptance Modeling (TAM) model (Wang et al. 2017).

Ho and colleagues (2017) questionnaire (PMEAP) has all factors presented simultaneously. Based on the findings of their study on children aged 8 to 12 years old, they used a self-report questionnaire that consisted of the above five factors and developed based on prior relevant research.

Therefore, the purpose of this study was to translate the English PMEAP into Greek, determine the factor structure, validity and reliability of the Greek version of PMEAP, expand knowledge on the psychometric behaviour of the measure and gain empirical knowledge in the field.

The objectives of this study were to:

1. Test a Greek version of the PMEAP and assess its reliability and validity at measuring a) self-presence, b) mood experience, c) game enjoyment, d) attitude toward VR exergames and e) preference for future game play in a sample of primary school children.
2. Examine the factor structure of the Greek PMEAP.

2 Method

2.1 Participants

The study was conducted in public schools in Dodecanese islands, in Greece. Three hundred and forty-seven ($n = 347$) children between 7 to 12 years old ($M = 9.64$, $SD = 1.364$) took part in the study. Initially, the researchers formally communicated the principal and the teachers of several public schools in order to thoroughly explain the

target, type, structure, and timeline of the study. Then, the principals and directors, in turn, notified parents accordingly. Any parents agreed to participate received a formal letter of invitation by the researchers as well as a relevant consent form, highlighting that children's participation was voluntary and providing them with the option to refuse to grant their permission. Finally, the study participants comprised only children that had submitted the consent form signed by their parents.

2.2 Instrument

2.2.1 Ho and colleagues (2017) questionnaire- PMEAP

The purpose of this questionnaire is to assess the relationship among level of presence, game enjoyment, mood experience and attitude toward exergames as well identify the way these factors can have an impact on the persons' preference for future game play (Ho et al., 2017). The content of the scale involves 25 self-report Likert-type questions. Responses to the questions can be selected by a default four-option or five-option range, for three formats as follows: (i) "strongly disagree" (1) to "strongly agree" (5), (ii) "does not describe" (1) to "accurately describes" and (iii) "not at all" (1) to "very much" (5).

2.2.2 PMEAP translation

The PMEAP scale was translated from the original English into Greek by two bilingual independent translators, fluent in Greek and English. One translator worked in a physiological setting and the other in an educational setting. Upon receiving their proposals, a four-member research team at a time, assembled, summarized, rechecked, and reviewed the final version of the scale. Thereafter, the reviewed translated scale was directed to a third translator who was an English native speaker but fluent in Greek, so that a reverse-translation into English would be performed. Finally, comparisons between the reverse-translated and the original English version took place by another native English speaker to identify if the original meaning was still conveyed consistently.

Eventually, the primary school students and the research team received the preliminary translated questionnaire in order to comprehend the evaluated items, the equivalence testing of its semantic and content dimensions.

2.3 Procedure

Before commencing the experimental procedure, an approval from the Ethics Committee of the University of Thessaly was to be obtained. The procedure also complied with the Helsinki declaration of 1975.

Then, the experimental procedure began with the participants practising with the Playstation VR under the researcher's supervision for two weeks, in two sessions per week. The immersive VR exergames, chosen for the intervention, were the Carnival Games, sourced from the Playstation VR platform. The total duration of the intervention program was 40 minutes, including 10 minutes of exercise, stretching, main activities and cool-down movements.

Prior to each session, a 20-min introductory period was given to the participants, comprising instructions on how to use the Playstation VR exergames. Upon completion of the intervention, participants populated the self-report PMEAP.

2.4 Data analysis

Statistical analysis was performed using IBM SPSS Statistics Version 19. Descriptive characteristics (including means, standard deviations, frequencies and percentages) were calculated for the socio-demographic variables. Assumptions of normality, homogeneity and independent cases of the sample were checked.

The construct validity of the PMEAP was assessed by performing an exploratory factor analysis (EFA). A Principal Components Method was applied with a Equamax Rotation to determine the dimensional structure using: (a) the factors that attained an eigenvalue ≥ 1 were retained, (b) minimum factor loading coefficient of 0.40 was required to maintain each item in the scale, and (c) interpretation of factor structure was meaningful. The appropriateness of the sample for factor analysis was supported by the Kaiser-Meyer-Olkin (KMO) and Bartlett's test. The threshold value of 0.80 was considered satisfactory for the KMO to indicate an adequate sample, while a significance level of Bartlett's test represented the homogeneity of item variances (Jones, 1994).

Reliability coefficients measured by Cronbach's alpha to assess reproducibility and internal consistency reliability of the instrument and its tentative dimensions; values of 0.70 and above were considered satisfactory (Altman et al., 2000).

3 Results

3.1 Descriptive analysis

Among the 347 participants, the male accounted for 52.7% (Table 1). Participants' mean age was 9.64 years, and 47.58% of the students were study at the third and the fourth grade. Sociodemographic data of 347 participants are presented in Table 1. The measures of skewness and kurtosis were examined to determine if any items needed to be removed due to distribution of responses deviating significantly from a normal distribution curve. Several authors (Baron, 2018; Tabachnick & Fidell, 2019) have suggested that items with levels of skewness > 2.5 and levels of kurtosis > 3.0 should be eliminated. Transformations have been applied in order for data to follow a normal distribution.

Table 1. Characteristics of sample

	Frequency (n)	Percent (%)	Mean	SD
Age			9.64	1.323
7 years old	17	4.9		
8 years old	61	17.6		
9 years old	76	21.9		
10 years old	96	27.7		
11 years old	70	20.2		
12 years old	27	7.8		
Class				
Second	36	10.4		
Third	83	23.9		
Forth	82	23.6		
Fifth	79	22.8		

Sixth	67	19.3
Gender		
Male	183	52.7
Female	164	47.3

Table 2 summarizes the Cronbach's α of PMEAP scale and its five dimensions, their means, standard deviations and skewness. The internal consistency characteristics showed good reliability (Cronbach's α was 0.873 for the total scale).

Table 2. Descriptive Statistics

	Cronbach's a	Mean	Std. Deviation	Skewness	Kurtosis
Self-presence	0.701	3.3682	1.14173	-.397	-.616
Mood experience	0.701	.1184 ⁽ⁱ⁾	.15109 ⁽ⁱ⁾	1.241 ⁽ⁱ⁾	.840 ⁽ⁱ⁾
Game enjoyment	0.832	.1685 ⁽ⁱ⁾	.16328 ⁽ⁱ⁾	1.001 ⁽ⁱ⁾	.543 ⁽ⁱ⁾
Attitude toward VR exergames	0.85	4.1590	.88796	-1.314	1.403
Preference for future game play	0.907	4.0225	1.13772	-1.237	.699

Note: ⁽ⁱ⁾ = Transformations have been applied.

3.2 Exploratory Factor Analysis

The normality and sphericity measures on the PMEAP were performed through the KMO and Bartlett's sphericity tests. The KMO test attained a value of 0.930, and Bartlett's test provided a value of 4037.705 ($df = 300$; $p = 0.00$). The results indicated that the number of factors with an eigenvalue of ≥ 1 was five. Therefore, the sample was considered acceptable for factor analysis, which identified a five-factor structure accounting for 60.73% of the total variance. The first factor was Self-presence with four questions (9.427% in explanatory power); the second factor was Mood experience with four questions (9.699% in explanatory power); the third factor was Game enjoyment with six questions (13.972% in explanatory power); the fourth factor was Attitude toward VR exergames with six questions (12.206% in explanatory power) and the fifth factor was Preference for future game play with five questions (15.426% in explanatory power).

Table 3. Exploratory factors and Explained Variance after rotation for the Greek PMEAP

Factors and items	Rescaled Loadings	Eigenvalues	% of Variances
<i>Self-Presence</i>		2.357	9.427
1. I become less aware of my surroundings during my play	.719		
2. I become less self-aware during my play	.698		
3. I experience an altered sense of time during my play	.684		
4. I feel emotionally involved in the game	.739		
<i>Mood experience</i>		2.425	9.699

5. Active	.669		
6. Energetic	.755		
7. Excited	.545		
8. Lively	.765		
<i>Game Enjoyment</i>		3.493	13.972
9. I enjoyed playing the game very much	.736		
10. I found playing the game an entertaining experience	.820		
11. The game was fun to play	.737		
12. I thought this game was quite enjoyable	.551		
13. I would describe this game is somewhat interesting	.437		
14. While I was playing this game, I was thinking about how much I enjoyed it	.428		
<i>Attitude towards exergames</i>		3.051	12.206
15. Playing FI exergame helps me to relieve stress	.757		
16. Playing FI exergame is an enjoyable habit that I like doing	.593		
17. Playing FI exergame offers a pleasant way to fill time	.546		
18. I have fun when I exercise with FI exergame	.546		
19. I feel mentally and spiritually better when I exercise with FI exergame	.625		
20. I look forward to playing FI exergame	.566		
<i>Preference for future game play</i>		3.857	15.426
21. I intend to play the game in the near future	.768		
22. I will try to play the game in the near future	.778		
23. I will play the game in the near future	.820		
24. I would like to play the game in the near future	.797		
25. I plan to play the game in the near future	.771		

Note: Rotation Sums of Squared Loadings

4 Discussion

The aim of the present study was to investigate the psychometric properties of PMEAP in a sample of Greek primary school children. All the questionnaires were valid and were collected with a view to investigate validity and reliability of the PMEAP as a research tool in Greece. The internal consistency of the questionnaire showed an acceptable Cronbach's α -value. The data were found appropriate for undertaking a factor analysis, as the adequacy indicator of the sample was $KMO=0.930 > 0.70$. The principal component analysis was found reasonable considering the sphericity control (Bartlett's sign < 0.00). Following a Factor analysis, a five-factor structure was identified that accounted for 60.73% of the total variance.

Upon comparing the Greek version of PMEAP comparison with the original one, similarities were identified as both versions presented significant stability and comparability. Both Cronbach's α values for each of the five factors and the rotated loadings for each of the twenty-five items are found similar. The factors attributed with

the highest Cronbach's α values are Game enjoyment (PMEAP, $\alpha = 0.93$; PMEAP Greek version, $\alpha = 0.832$), Attitude toward VR exergames (PMEAP, $\alpha = 0.89$; PMEAP Greek version, $\alpha = 0.85$) and especially the Preference for future game play (PMEAP, $\alpha = 0.95$; PMEAP Greek version, $\alpha = 0.907$). These similarities may be deriving from the actual subtests types which are quite frequent and common since numerous studies evaluating these factors have been performed (Graves et al., 2010; Mestre et al., 2011; Garn et al., 2012; Ijaz et al., 2020).

The PMEAP questionnaire when compared to the PACES questionnaire, which is quite common for measuring game enjoyment and the preference for future game play, shows better internal consistency especially when the sample is younger. Graves and colleagues (2010) used PACES to evaluate game enjoyment of fourteen adolescents (11–17 years) who played exergames (Wii Fit yoga). The Cronbach's α values of the scale were found ≥ 0.742 . Similarly, Mestre and colleagues (2011), with the aid of PACES in French version, evaluated the game enjoyment of a sample of twelve adults, university students who played an exercbike. The Cronbach's α value of the scale was ≥ 0.93 . Another study performed by Garn and colleagues (2012) considered PACES for the calculation of the Cronbach's α for Wii Fit enjoyment ($\alpha = .71$). The sample was comprised of college students.

This study represents a first exploration and factorial evaluation of the PMEAP. However, limitations have also been identified. Data were gathered from children living in the Dodecanese and therefore the sample was not representative for the whole population of Greece. Future studies that combine the use of the Greek PMEAP with an objective evaluation are recommended in order to test the predictive value of this instrument. Additionally, due to the small sample, the correlations between the factors of the questionnaire proposed by its owners were not checked.

5 Conclusion

The Greek PMEAP is a robust tool to evaluate the factor of a) self-presence, b) mood experience, c) game enjoyment, d) attitude toward VR exergames and e) preference for future game play. In terms of impact, the PMEAP can be requested for use by researchers to collect data both nationally and internationally, with results potentially correlated with other measures.

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