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VALIDATION OF THE RELATEDNESS SCALE OF THE INTRINSIC MOTIVATION INVENTORY THROUGH FACTOR ANALYSIS

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Abstract:

This study serves as an initial validation ofthe relatedness subscale of the Intrinsic Motivation Inventory (IMI) with a factor analysis. The relatedness subscale is a recent addition to the IMI and it is not identified as validated on the social determination theory website (SDT, n.d). The measurements used to perform this analysis were taken from a sample of 124 secondary students aged 11-18 in developing a study of the social impact of exergaming between students over the internet. Measurements on social relatedness were made in the spring of 2012 and the subjects attended traditional public, public charter and private schools in a rural/suburban location in the southwestern part of the United States. Results suggest that the IMI displayed good internal consistency and correlations on item-totals. These results can help to position the relatedness subscale of the IMI as a valid way to identify participant feelings of connectedness while engaged in activities.

Key Words: Motivation, Exergame, Online Physical Education, Relatedness Subscale & IMI

Introduction:

The relatedness subscale was recently added to the Intrinsic Motivation Inventory (IMI) and its validity is uncertain (Deci& Ryan, 2008; SDT, n.d.). The website which describes the scale states; "Recently, a seventh subscale has been added to tap the experiences of relatedness, although the validity of this subscale has yet to be established" indicating that validity of the sub-scale has not been established (Self-Determination Theory, n.d.). Conversely, those who monitor the site state that the subscale has been validated (see appendix A). A check of the references listed on the site did not lead to a validation study for the relatedness subscale. This ambiguity led the researcher to establish the factorial validity of the IMI in his study on social value of exergaming against a remote partner.

The Self-Determination theory used to develop this subscale has covered the first of two requirements towards validation: (1) conveying the theoretical basis and interrelations, (2) creating techniques for measurement of the hypothetical constructs in the theory (Cronbach & Meehl, 1955). What remained was an empirical look at the constructs of the scale (Clark & Watson, 1995).

The investigation used to run the factor analysis on the IMI Relatedness subscale looked at the efficacy of using exergames over a distance for secondary students (grades 6-12) aged 11-18 as part of a remote PE curriculum. Research indicates that exergames may benefit learners with a moderate level of physical activity, increased motivation, enhanced executive functioning skills and opportunities for social interaction in face to face settings, but no investigations have examined the effect of distance on these aspects of physical education (PE) when accessed through exergames. Additionally, no research has produced empirical evidence that shows exergames to be effective for accessing PE standards. Exergames exist which enable students to connect for competitive and cooperative remote interaction over a distance. An empirical study which demonstrates that exergames can be useful as a part of the curriculum for an e-course in PE has not been published. Such a study would allow 'best practice' to be established with the immediate effect of bolstering efforts to provide relevant meaningful curriculum options to students who are learning remotely.

Exergames are a fairly new phenomenon. The genre first appeared in the United States in 2006. An exergame is any activity during which a person playing a video game is required to achieve movement beyond a sedentary position that may include strength, balance and/or flexibility (Oh & Yang, n.d.). Therefore, some researchers refer to these games as active video games (Duncan & Staples, 2010; Foley & Maddison, 2010; Manley & Whitaker, 2011; Sander et al., 2012). Many also call them exergames (Haddock et al., 2012; Morelli, Folmer, Foley & Lieberman, 2011; Pasco, Bossard, Buche & Kermarrec 2011; Perron, Graham, Feldman, Moffett & Hall, 2011; Sheehan & Katz, 2010; Sheehan & Katz, 2012; Staiano et al., 2012; Ulbrecht, Wagner & Gräßel¸ 2012). The investigator, in this study, chose to use exergames for the following reasons. First, The Exergame Network, The Interactive Fitness and Exergaming Network and the Canadian Exergaming Research Centre all exist for the promotion of this genre (Sheehan & Katz, 2010). No groups identify with active video games. Accordingly the term exergame will be used for video games which require kinesthetic bodily movement throughout this paper.

Playing an exergame over the internet with another person involves a unique type of social interaction. In developing a study of the social impact of exergaming between students over the internet social relatedness is a primary concern. The social presence theory has been defined as the cognizance of another person during interaction and the impact of the social connection (Tu, 2000). Social presence has also been defined as the connections made during facilitated encounters (Biocca, Harms & Burgoon, 2003). In a traditional PE class social presence is shaped by the cues derived from face to face contact (Tu, 2000). Verbal cues, non-verbal cues, partner gaze, clothing, odors, environmental factors, and partner posture can all help to determine the way individuals experience social presence. The extent of social presence is related to the degree of access each person experiences when accessing the other persons intelligence, intentions, and sensory impressions (Tu, 2000). The online setting can inhibit and change the perception of these critical components of social presence. It is important to identify what effect exergames and internet connected play have effect on the social presence of the participants (Biocca et al., 2003). In an effort to measure the social presence of the remote exergame participants the IMI relatedness subscale was selected.

Self-Determination Theory:

The IMI Relatedness subscale is based upon the self-determination theory (SDT). The SDT provides a schema which champions the innate human propensity for self-sustaining healthy actions (Deci & Ryan, 2008; SDT, n.d.). This inclination towards healthy actions helps to push a person towards preferred self-selected actions as opposed to living a wholly subjective existence dependent upon external forces (Vansteenkiste, Williams & Resnicow, 2012).This system is grounded on the belief that change flows from individual intrinsic motivation and engagement (Teixeira, Palmeira & Vansteenkiste, 2012). Autonomy, competence and relatedness are viewed as producing the greatest volition in individuals. Individuals with a high level of volition will exhibit increased choice for an activity which can lead to augmented performance, persistence and creativity (Deci & Ryan, 2008; SDT, n.d.).

Autonomy refers to the ability humans have to make choices and have input which helps them to self-endorse activities and viewpoints. Competence reflects our need to garner positive effects in our interactions with the world and the people around us. Relatedness points to our need to feel united with and recognized by those we value (Standage, Duda, Ntoumanis & Nikos, 2005). A deficit in these needs will result in diminished interest and well-being with a posited upturn in maladaptation and discontent in a person's life (Deci & Ryan, 2000).

Deci and Ryan (1985) identify three types of motivation: intrinsic motivation, extrinsic motivation and amotivation. These three types of motivation help to explain why an individual engages in activities. Extrinsic motivation is further divided into three subcategories; internal regulation which exhibits a very high degree of self-regulation, introjected regulation which exhibits a moderately low degree of self-regulation and identified regulation which exhibits a very low degree of self-regulation (Deci & Ryan, 1985; Deci & Ryan, 2002). A linear view of the three types of motivation shows that intrinsic motivation is related to the greatest level of autonomy and amotivation is related to the lowest level of autonomy (Standage, Duda, Ntoumanis & Nikos, 2005).

Based on a holistic view of the individual the SDT is focused on the organization and accord individuals obtain as they naturally develop and grow in response to their exposure to new and varied experiences. The theory states that as individuals interact with their surroundings, other people and understandings they tend towards the integration of their life events into a coherent understanding of self (Deci & Ryan, 2008; SDT, n.d.).

This move towards self-determination cannot occur in isolation but requires social nourishment. Social nourishment is derived from the social context of the event which can perpetrate positive or negative tendencies in the individual's response to stimuli. Relevant people who come into contact with individuals can impact the learners overall well-being. The self-determination theory posits that individuals will persist in an activity when those who are guiding them hold the learner in high esteem and evoke real concern for their success (Teixeira, Palmeira & Vansteenkiste, 2012). This leads to higher levels of integration, growth and wellness in the learner (Vansteenkiste, Williams & Resnicow, 2012). Indeed, the impact of other people has a profound impact on whether individual needs are met which impacts whether peak motivation is achieved (Vallerand, Koestner & Pelletier, 2008). This impact is related to autonomy support which is the active support of others in launching self-initiating capacity in others (Vallerand, Koestner & Pelletier, 2008).

It is the smaller situations in a person's life which help to produce increased circumstantial motivation that results in lasting changes in individual motivation to continue or stop the activity (Vallerand, Koestner & Pelletier, 2008). This continual feedback loop drives the individual towards greater internalization of the positive or negative effect of the event. The response and understandings of the individual to these events help them develop the desire to continue or cease events in settings they have and will encounter (Vallerand, Koestner & Pelletier, 2008). Thus, small repeated positive interactions with stimuli can create a contextual perception, of the interaction, which leads to incremental changes that are adopted by the individual which can impact future intrinsic motivation to engage in the activity (Vallerand, Koestner & Pelletier, 2008). Simply put; positive experiences can lead to improved perceptions of that event which in turn lead to a propensity to repeat the event for intrinsic reasons. This can result in a return to the event which is less reliant on outside influences or prompting.

The intrinsic motivation inventory (IMI) was developed by the creators of the SDT (Self-Determination Theory, n.d.). Edward L. Deci and Richard M. Ryan working at the University of Rochester, Department of Social Sciences in Psychology are credited with the development of the theory and continue training and research into its use (Deci& Ryan, 2008; SDT, n.d.). The IMI was developed to measure the subjective experiences of subjects in a clinical setting (SDT, n.d.).

It was hypothesized in the study of Crocker, Bouffard, and Gessaroli (1995) that connectedness measured by the IMI relatedness subscale would be positively correlated with participation with a human in a remote condition over participation against a game created non player character. The purpose of this paper is to examine the factorial validity of the IMI relatedness subscale through factor analysis and test the convergent validity of the subscale in a sample of secondary students.

The measurements selected and used for this study on exergaming were part of a larger group of tests. The other tests were included to measure physical (heart rate), emotional (physical activity enjoyment scales), and cognitive (Bender Gestalt Visual Motor Test – Second Edition) changes following exergame participation. These additional tests fall outside the scope of this paper but are mentioned to help position the IMI relatedness results in context.

Prior to the tests the study design was approved by the institutional review board (IRB) at Trident International University. The use of underage minors also necessitated that each parent consented to the study for their child and that each child assented to be part of the study. On the days of testing the researcher and research assistant administered the IMI relatedness subscale to the students following their exergame participation in rooms selected for the study by school site administrators. All students were given uniform directions, and all questions were the same. Student participation in the exergame and the complete battery of measurements took approximately 30 minutes to administer.

Factor Analysis:

Factor analysis is used to illustrate and establish the number of components in a data set. There is a long standing debate as to which type of factor analysis to use and when to use which (Costello & Osborne, 2005; Schmitt, 2011). Exploratory factor analysis may best be used in the early stages of scale expansion (Schmitt, 2011). Conversely, confirmatory factor analysis may be best when a theory it is based upon is solid (Schmitt, 2011). When choosing which one to use it is up the researcher to defend their choice of factor analysis (Schmitt, 2011). The Relatedness subscale of the IMI is based on the Self-Determination Theory. This theory has been well established and many researchers have worked to validate its constructs and extend the concepts which it is established on. The purpose of this investigation is to examine the structure of the data. For this reason a common factor analysis of this subscale is deemed most appropriate (Kim, 2008).

Matsunaga (2010) presents seven steps towards conducting a factor analysis. These steps will be summarized below with relevancy noted for the IMI Relatedness subscale factor analysis in this paper. Step one requires the researcher to theorize a list of concepts that will be used. At this stage it is suggested that more questions are better than too few. This prevents missing important facets of the topic being investigated. Careful queries of all stakeholders can help to determine what all the constructs will be. The Relatedness subscale being analyzed in this paper was vetted for possible concepts previous to this validation by those who developed the IMI measurement tool (SDT, n.d.).

Step two involves the use of items identified during step one to collect quantitative data. There is much debate over an appropriate sample size for this step (Costello & Osborne, 2005). A sample of at least 200 is suggested with a minimum of 100. The study cited for this paper contained 124 subjects who each completed the IMI relatedness subscale twice (N=248) putting it above the suggested sample size of 200. In step three a principal component analysis is used to narrow items in use to fewer pieces or components. Different pieces of original constructs are identified during principal component analysis (Ringnér, 2008). These construct pieces need to be studied for their effect. The process of principal component analysis helps to keep the topic in full view so that no pieces are missed while allowing for consolidation of pieces into similar constructs. This paper details a look at a principal component analysis for the IMI Relatedness subscale. This process can allow the subscale to be validated for future use.

Step four is an examination of the factor loadings which can be accomplished using three methods. Methods differ on how the factors load onto each other. Factors need to be chosen before loadings and retained for the entire process. Next each factor should be examined to see if what is thought to be true from theorizing and factor loadings indicates an item should be retained. If the item relates to the construct being assessed it should be kept. Exploratory factor analysis is undertaken in step five. All questions or factors that have eigenvalues above 1.0 should be retained. In step six the researcher needs to determine the factor loading patterns and analyze for effect. Step seven results in a confirmatory factor analysis. This analysis is based upon structural equation modeling that comes from the a priori model of the factor structure.

The IMI was tested by McAuley and Duncan (1989) in a competitive sport setting much like the present study. In this study the IMI was shown to have statistically significant internal consistency (⍰ = 85) with no item adjustments. Adjustments to items #9 and #13 of the interest-enjoyment subscale did have a positive effect on the overall alpha coefficient but the overall the IMI still retained its reliability (McAuley & Duncan, 1989).

The relatedness subscale of the IMI was analyzed using a factor analysis. This analysis was conducted to see if the data collected would match the variances that appeared during factor analysis thus validating the questions inclusion in the subscale. The purpose of this type of analysis is to expose concealed variables which cause the primary variables to show variance with another variable in a predictive manner (Costello & Osborne, 2005). Factor extraction allows any shared variance between variables to be segregated from the primary variable so that the foundational structure of the factor is exposed leading to the identification of shared variance in the product (Costello & Osborne, 2005). Peason's Correlations were all below .9 indicating that the data set did not suffer from singularity. The Kaiser-Meyer-Olkin measure of sampling adequacy was good to great (.754) (Field, 2005). Bartlett's Test of Sphericity was highly significant ($p < 0.001$) indicating that this was not an identity matrix and that there was at least some of relationship between the items in the subscale and that a factor analysis is appropriate.

A factor analysis of the eight items on the relatedness subscale of the IMI was undertaken during research towards a dissertation on exergaming. The data was checked for outliers and none were found in the Pearson's correlations or the 1-tailed significances listed for all eight items. The Kaiser-Meyen-Olkin measure of sampling adequacy was above the recommended value of .6 (.784) and Bartlett's test of sphericity was significant, χ^2 (28) = 327.792, p = .001. Sample size (N=248) in this study is very large compared to contemporary factor analysis which often settles for smaller sample sizes. This sample provides a ratio of over 30:1 making it larger than 96% of all other studies on factor analysis (Costello & Osborne, 2005). As with any other factor analysis this initial work on this scale will simply be the opening round towards its continued validation. Given these overall indicators, principal component analysis was deemed to be suitable for all eight items.

Factor analysis was used since the purpose of the analysis was to calculate the composite scores for this subscale of the IMI. Four of the eight items accounted for 24%, 18%, 16% and 13% of the variance in the model according to the after rotation Eigen values (see table 1). These four primary components in the data set accounted for over 71% of the variance between the items. The items on this subscale needed to be reversing coded due to the inverse relationship between items 1/8, 2/7, 3/6 and 4/5. These item pairings can be identified around the four relatedness sub-themes of connectedness, friendship, interaction and trust. Each of the four primary components are attached to one of the pairs so all four of the major themes are represented in the four highest loadings. The factor analysis supported the use of four components as did an examination of the scree plot of items. The nearly normal distribution of composite scores in this study indicates that this scale is well suited for statistical analysis. Hence, the eight items on this scale can be validated for use.

Table 1: Factor Loadings for Relatedness Subscale of the IMI

Component	**Initial Eigen Values**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
Closeness	2.689	33.609	33.609	1.901	23.758	23.758
Friend	1.151	14.384	47.993	1.436	17.951	41.708
Trust	1.021	12.758	60.751	1.282	16.028	57.737
Interaction	.828	10.355	71.106	1.070	13.370	71.106
Interaction	.703	8.790	79.896			
Trust	.618	7.725	87.621			
Friend	.534	6.677	94.299			
Closeness	.456	5.701	100.000			

Extraction Method: Principal Component Analysis.

Relatedness Test Data Analysis:

A one-way within subjects (or repeated measures) ANCOVA was conducted to equate the effect of exergaming on social relatedness during play. Data was analyzed with a within-subjects factor of subscale (NPC IMI, remote IMI) and the covariates of age, school type, exergame experience, and gender. Mauchly's Test of Sphericity indicated that the assumption for sphericity had not been violated, χ2 (2) = .001, p = .001. Therefore, no corrections were needed. The predicted main effect on relatedness increased significantly after exergaming, F (1, 119) = 5.158, p = .025, ηp2 = .042. The interaction between IMI scores and age was also significant, F (1, 119) = 17.608, p = .001, ηp2 = .042. The interaction between IMI scores and school type was not significant, F (1, 119) = 1.139, p = .288, ηp2 = .009. A similar non-significant interaction was found for IMI scores and exergame experience, F (1, 119) = 33.798, p = .344, ηp2 = .008 and relatedness and gender, F (1, 119) = 2.778, p = .098, ηp2 = .023.

The interaction between age and relatedness was significant along with the main effect on relatedness.

The total of the first IMI scale, NPC exergaming (n = 8, M = 47.294, SD = 5.223) and the total of the second IMI scale, remote human exergaming (n = 8, M = 46.952, SD = 5.986) conditions were very close with slightly higher mean scores for the NPC condition. This small point summative difference (.342) between the conditions prompted additional testing to reveal the unique qualities of these item scores.

To gain a better understanding of the data set the difference between untransformed Likert scores for each of the NPC IMI scores were compared with their counterparts from the remote human IMI condition. Inspection of boxplots for each of the eight pairings did not reveal any outliers. In testing for normality none of the Shapiro-Wilks tests provided a value of <.05 and so normality was not established. Visual inspection of normal Q-Q plots did show that all of the eight items conformed to normal. These corrected results of the tests for normality and outliers indicate that the data meets the assumptions for paired t-tests.

A Paired samples t-test for each of the eight questions on the IMI scale revealed significant changes between the two conditions and provided increased clarity when viewing the data. All eight items increased significantly from the NPC condition to the remote condition. Details for each pairing are found in table one.

Table 2: Correlations between IMI Items

Item #	NPC Condition	Remote Condition	Correlation Results	Sig. Change: YES/NO
1*	M = 5.741, SD = 1.242	M = 2.080, SD=1.144	t (123) = 22.558, p = .001, d = 2.025	Yes
2*	M = 6.088, SD = 1.067	M = 1.790, SD = .998	t (123) = 29.403, p = .001, d = 2.640	Yes
3*	M = 1.919, SD = 1.071	M = 5.548, SD = 1.107	t (123) = 24.416, p = .001, d = 2.192	Yes
4*	M = 2.435, SD = .163	M = 5.774, SD = 1.174	t (123) = 20.674, p = .001, d = 1.856	Yes
5*	M = 5.792, SD 1.142	M = 1.871, SD = 1.020	t (123) = 24.415, p = .001, d = 2.192	Yes
6*	M = 5.903, SD = 1.093	M = 2.073, SD = 1.127	t (123) = 23.606, p = .001, d = 2.119	Yes
7*	M = 2.137, SD = 1.121	M = 5.903, SD = 1.239	t (123) = 26.010, p = .001, d = 2.335	Yes
8*	M = 1.637, SD = .905	M = 5.501, SD = 1.204	t (123) = 26.010, p = .001, d = 2.312	Yes

*1/8 (Closeness, 2/7 (Friend), 3/6 (Trust), 4/5 (Interaction)

Mean scores between the IMI participant responses to the first condition and the second condition changed dramatically (see appendix A). The difference on item scores between conditions ranged from 3.339 – 4.298 (see table 2) and indicated a large shift in relatedness between conditions. On a seven point Likert scale these differences accounted for nearly half to over half of the range of scores. Since mean difference for each question between conditions was statistically significantly different from zero as determined by the Paired t-tests we can reject the null hypothesis and accept the alternative hypothesis. Relatedness does increase in the remote condition over the NPC condition.

Table 3: IMI Score Differences between Conditions

IMI Item #	Score: NPC Condition	Score: Remote Condition	Difference	Changes in Relatedness from NPC to Remote Condition
1	5.741	2.080	3.661	Changed from distant to close
2	6.088	1.790	4.298	Changed from less friend to more friend
3	1.919	5.548	3.629	Changed from less trust to more trust
4	2.435	5.774	3.339	Changed from less interaction to more interaction
5	5.792	1.871	3.921	Changed from less interaction to more interaction
6	5.903	2.073	3.830	Changed from less trust to more trust
7	2.137	5.903	3.766	Changed from less friend to more friend
8	1.637	5.501	3.864	Changed from distant to close

The results of this investigation show that all eight items on the IMI improved statistically significantly over the NPC for the remote condition. This allows the null hypothesis to be rejected and the alternative hypothesis to be accepted (see table 4).Meaning that when participants played another subject over the internet they felt more related to the actual person than to the NPC created by the gaming system. This bodes well for the use of exergames in online physical education as students may develop social benefits while playing remotely.

Table 4: Tests of Within-Subjects Effects / IMI

Source		df	F	Sig.	Partial Eta Squared
IMI	Sphericity Assumed	1	5.158	.025	.042
IMI * School Type	Sphericity Assumed	1	1.139	.288	.009
IMI * Age	Sphericity Assumed	1	17.608	.001	.042
IMI * Exergame Experience	Sphericity Assumed	1	33.798	.344	.008
IMI * Gender	Sphericity Assumed	1	2.778	.098	.023
Error (IMI)	Sphericity Assumed	119			

Discussion:

Prior to this analysis it was unclear if the IMI-RS had been validated. If it was already validated then this will serve as an axillary to the others and if not then this analysis will serve as an initial validation of the IMI-RS.The eight items on the subscale are designed to provide a measurement of personal connectedness, friendship, interaction and trust. The subscale was used in a study on the efficacy of remote exergaming for a secondary curriculum in physical education. The data set collected during the study proved useful for common factor analysis of the subscale. This analysis showed support for the four components on the subscale. The composite scores, in the study, indicated that the subscale could be analyzed statistically. The results of this analysis demonstrate that the relatedness subscale of the IMI can be validated for future use.

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