

PAX Scale Development - Supplementary Materials

This document includes extended information about the analyses conducted during development and validation of the PAX Scale, conducted by Banks and Bowman (in press). The 9 steps are presented here, and correspond sequentially with the findings presented in the main manuscript:

Banks, J., & Bowman, N. D. (in press). Emotion, anthropomorphism, realism, control: Validation of a merged metric for player-avatar interaction (PAX). *Computers in Human Behavior*.

Step 1. PAR Sociality Scale PCA (sample 1, balanced)

A battery of 95 questions derived from exploratory research addressing emergent themes in player-avatar sociality was completed by a broad sample of MMO players (N = 494). A Principal Components Analysis was conducted on the responses from a sub-set of this sample, balanced by self-reported player-avatar relationship type. This analysis resulted in a 16-item, three factor solution.

Table 1. Varimax Factor Structure of the 16-item PAR Sociality Scale

Item	1	2	3
Factor 1: Anthropomorphic Autonomy ($\alpha = .907$; M = 2.39, SD = 1.55; 28% variance explained)			
This avatar has its own thoughts and ideas.	.892	.186	.007
This avatar has its own feelings.	.861	.234	.042
This avatar is autonomous and acts on its own.	.818	.013	.164
When I log out of the game, this avatar has its own life.	.743	.134	.149
This avatar is like a human being.	.734	.134	.149
This avatar exists independently from me.	.719	.090	.115
This avatar is a real person.	.684	.112	.221
Factor 2: Emotional Investment ($\alpha = .901$; M = 5.42, SD = 1.47; 26% variance explained)			
This avatar is very special to me.	.161	.855	.203
I don't really care about this avatar.*	.112	.852	.033
I have no emotional connection to this avatar.*	.115	.841	.101
I appreciate this avatar.	.152	.812	.189
I love this avatar.	.181	.767	.118
I would be heartbroken if I lost this avatar.	.089	.743	.242
Factor 3: Sense of Companionship ($\alpha = .888$; M = 2.91, SD = 1.77; 16% variance explained)			
This avatar understands me.	.234	.154	.885
This avatar and I are friends.	.237	.230	.881
This avatar loves me.	.156	.252	.781

Item scale: 1 (strongly disagree) to 7 (strongly agree)

**Reverse coded*

Step 2. PAR Sociality and Character Attachment Factor Correlations (sample 1, balanced)

To examine the extent to which the PAR sociality dimensions were empirically distinct from CA dimensions, correlations were calculated among the three PAR dimensions and the four CA dimensions. These correlations show a low-to-moderate relationship among

Table 2. Inter- and cross-correlations of the PAR and CA scale dimensions.

	1	2	3	4	5	6	7
PAR Sociality							
1. Anthropomorphic Autonomy	1						
2. Emotional Investment	.354***	1					
3. Companionship	.420***	.431***	1				
Character Attachment							
4. Identification	.647***	.583***	.584***	1			
5. Suspension of Disbelief	.468***	.404***	.325***	.578***	1		
6. Care/Responsibility	.487***	.461***	.465***	.616***	.581***	1	
7. Control	- .425***	.059	-.210**	-.115	.027	-.056	1

NOTE: * = $p < .05$, ** = $p < .01$, *** = $p < .001$ or higher; $N = 175$

Step 3. PAR Sociality + Character Attachment – Initial PCA (sample 1, balanced)

To evaluate the potential for PAR Sociality and CA dimensions to be integrated into a more compressive and explanatory scale, a PCA was conducted on aggregated responses to a) 16 items from the PAR sociality solution (Step 1, above) and b) 17 items from the CA scale. This analysis resulted in an 18-item, four-factor solution wherein factors from both scales/approaches clustered into unique and interpretable factors. This factor model is called here the Player-Avatar Interaction (PAX) Scale.

Table 3. Varimax factor structure of the 18-item integrated Player-Avatar Interaction (PAX) Scale

Item	1	2	3	4
Factor 1: Emotional Investment ($\alpha = .910$; $M = 5.42$, $SD = 1.47$; 24% variance explained)				
This avatar is very special to me.	.863	.161	.162	.015
I don't really care about this avatar.*	.811	.126	.118	.031
I would be heartbroken if I lost this avatar.	.803	.126	.118	-.045
I have no emotional connection to this avatar.*	.800	.092	.144	-.067
I appreciate this avatar.	.784	.135	.220	.089
I love this avatar.	.774	.220	.166	.042
Factor 2: Anthropomorphic Autonomy ($\alpha = .891$; $M = 2.46$, $SD = 1.65$; 20% variance explained)				
This avatar has its own thoughts and ideas.	.200	.840	.251	-.128
This avatar has its own feelings.	.232	.823	.266	-.135
This avatar is autonomous and acts on its own.	.075	.807	.187	-.182
When I log out of the game, this avatar has its own life.	.163	.805	.155	-.119
This avatar exists independently from me.	.123	.698	-.013	-.106
Factor 3: Suspension of Disbelief ($\alpha = .891$; $M = 4.38$, $SD = 1.80$; 17% variance explained)				
It is important to check for inconsistencies in this avatar's game.	.240	.111	.859	.090
I concentrate on inconsistencies in this avatar's story and the game story.	.186	.145	.853	.019
I pay attention to errors or contradictions in this avatar's world.	.166	.162	.850	.074
I think about whether this avatar's actions are plausible.	.184	.259	.744	.057
Factor 4: Sense of Control ($\alpha = .796$; $M = 6.08$, $SD = 1.09$; 12% variance explained)				
I control this avatar.	-.109	-.288	-.006	.854
This avatar does what I want.	-.057	-.269	.027	.809
I enjoy controlling this avatar.	.223	-.014	.200	.797

Item scale: 1 (strongly disagree) to 7 (strongly agree)

*Reverse coded

Step 4. PAX Factor Stability Test via Second-Sample PCA (sample 2)

To test the stability of the factor rotations from the sample 1 PCA (Step 3, above), a second PCA with Varimax rotation was performed on responses to the 18-item integrated PAX Scale. Although this analysis resulted in similar factor loadings as for the first sample, three items fell below the .600 loading threshold and were dropped from the scale. Those items removed, a repeated PCA resulted in a 15-item, four-factor solution explaining 66% of variance. Items in this solution are below:

Table 1. Varimax factor structure of the 15-item integrated Player-Avatar Interaction (PAX) Scale (second sample of WoW players only)

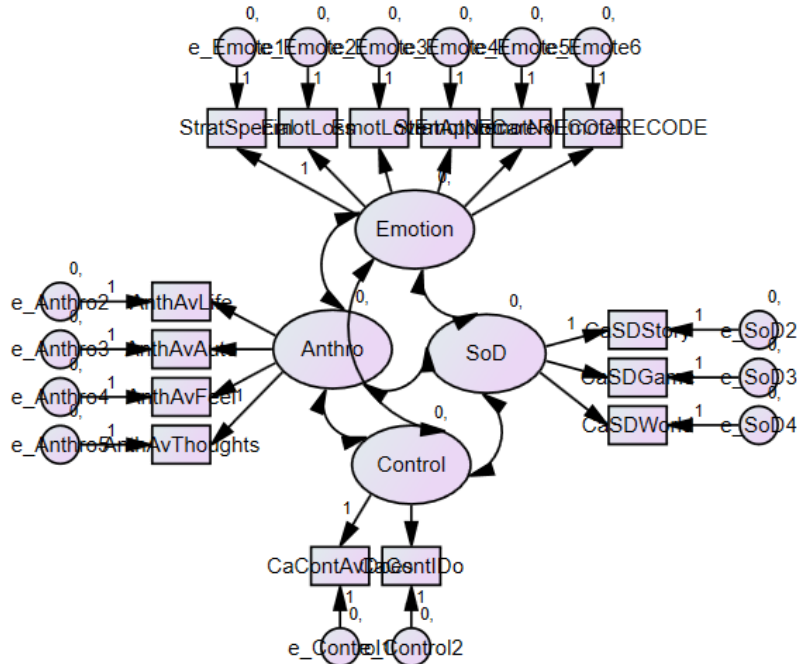
Item	1	2	3	4
Factor 1: Emotional Investment ($\alpha = .835$; $M = 4.87$, $SD = 1.64$; 22% variance explained)				
This avatar is very special to me.	.782	.215	.147	.085
I don't really care about this avatar.*	.755	-.028	.038	-.034
I have no emotional connection to this avatar.*	.744	.127	.081	-.077
I would be heartbroken if I lost this avatar.	.689	.183	.161	.141
I appreciate this avatar.	.683	.169	.216	.122
I love this avatar.	.622	.265	.186	.093
Factor 2: Anthropomorphic Autonomy ($\alpha = .876$; $M = 1.98$, $SD = 1.52$; 20% variance explained)				
This avatar has its own thoughts and ideas.	.223	.822	.246	-.077
This avatar has its own feelings.	.263	.812	.206	-.050
This avatar is autonomous and acts on its own.	.072	.800	.144	-.079
When I log out of the game, this avatar has its own life.	.188	.772	.195	-.107
Factor 3: Suspension of Disbelief ($\alpha = .821$; $M = 4.07$, $SD = 1.91$; 15% variance explained)				
I pay attention to errors or contradictions in this avatar's world.	.204	.206	.837	-.024
It is important to check for inconsistencies in this avatar's game.	.185	.178	.786	.029
I concentrate on inconsistencies in this avatar's story and the game story.	.166	.302	.784	.011
Factor 4: Sense of Control ($\alpha = .796$; $M = 6.27$, $SD = 1.14$; 9% variance explained)				
This avatar does what I want.	.114	-.034	-.104	.834
I control this avatar.	.045	-.185	.118	.777

Item scale: 1 (strongly disagree) to 7 (strongly agree)

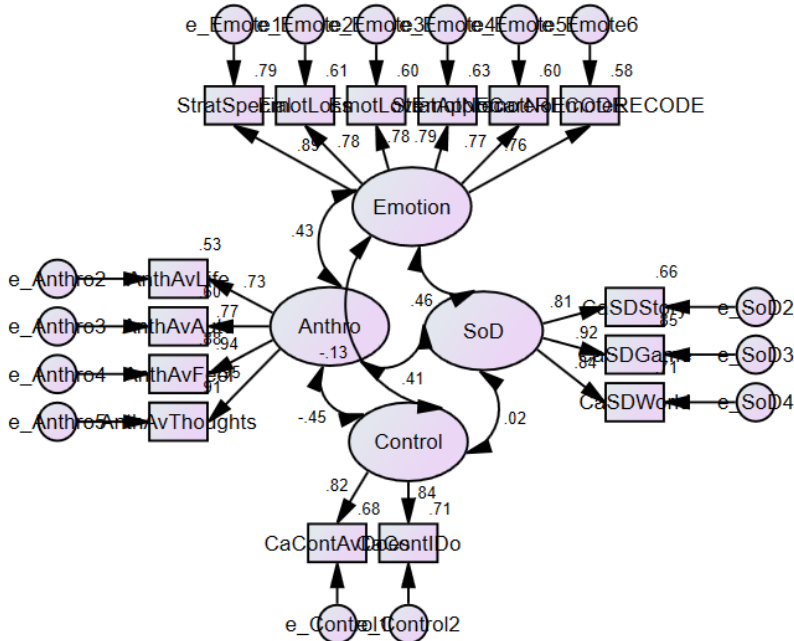
**Reverse coded*

Step 5. Confirmatory Factor Analysis (both samples)

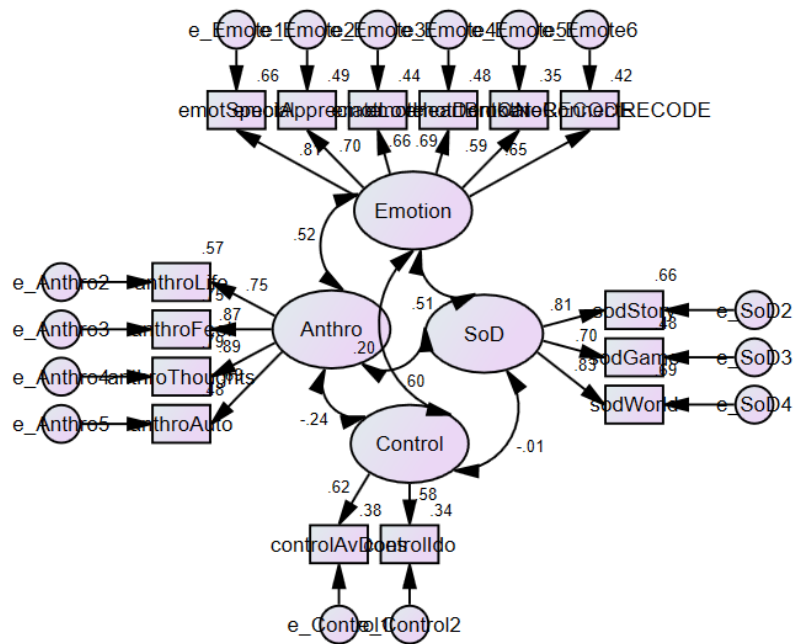
A confirmatory factor analysis was conducted to test the measurement below:



Scale data fit the specific model in both data sets without modification. For the broad sample (sample 1), NNFI (Tucker-Lewis index) = .978, IFI = .983, CFI = .982, RMSEA = .046, see below:



For the WoW-specific sample (sample 2), NNFI (TLI) = .972, IFI = .978, CFI = .978, RMSEA = .040.



Step 6. Construct validity testing – Human-like relatedness (broad sample)

Based on Author (2013), a positive relationship is expected with scale factors of anthropomorphic autonomy, suspension of disbelief, and emotional investment, and a negative relationship with sense of control. As expected, there was a statistically significant relationship between human-like relatedness and both emotional investment and anthropomorphic autonomy, as well as the expected non-relationship with sense of control.

Table 5. Step-wise regression for (1) demographics and (2) PAR scale dimensions.

	Step 1			Step 2		
	β	t	Sig.	β	t	Sig.
Gender	.092	1.77	.077	-.012	.281	.779
Age	.060	1.16	.249	.112	2.63	.009
Hours Played	.281	5.51	~.000	.130	2.94	.003
Emotional Invest.				.309	6.13	~.000
Anthro. Autonomy				.359	6.97	~.000
Susp. of Disbelief				.070	1.47	.144
Sense of Control				-.005	-.111	.911
			$F(3,353) = 12.3, p \sim .000,$			
			$R^2 = .087$			
			$F(7,349) = 34.4, p \sim .000,$			
			$\Delta R^2 = .309$			

Note: Analyses were only conducted for participants that had complete data on all measured variables.

Step 7. Construct validity testing – PAR type

It was predicted that emotional investment, anthropomorphic autonomy, and suspension of disbelief should be highest among players designating the avatar as symbiotic or separate and lowest among those seeing the avatar as objects or representations; conversely, sense of control should be highest among those with object or representation perspectives and lowest among those with symbiosis and separate-entity perspective.

Table 6. Mean differences for PAR scale dimensions among player-avatar relationships types.

	Object Est. <i>M</i> (<i>SE</i>)	Me	Symbiote	Other	η^2
<i>Sample 1 (MMO players, broadly)</i>					
Emotion	4.07a (.08)	5.62b (.15)	5.96b (.15)	5.50b (.20)	.273
Anthro	1.29a (.08)	1.78b (.13)	3.31c (.13)	3.45c (.18)	.352
SoD	3.57a (.12)	4.47b (.20)	4.86b (.21)	4.50b (.28)	.077
Control	6.51a (.07)	6.48a (.12)	5.80b (.12)	5.78b (.16)	.079
<i>Sample 2 (WoW-only players)</i>					
Emotion	4.62a (.07)	5.81b (.11)	6.09b (.11)	5.75b (.18)	.269
Anthro	1.49a (.08)	2.60b (.13)	3.55c (.13)	3.48c (.20)	.343
SoD	2.88a (.11)	3.87b (.16)	4.31c (.16)	4.42c (.25)	.146
Control	6.12a (.07)	6.24a (.10)	6.08a (.10)	6.12a (.16)	.005

Note: Means with different subscripts within each row differ at $p < .05$ level of higher. Bolded rows had an overall significant ANCOVA.

Step 8. Predictive validity testing – Gameplay Motivations

Predictions for PAX factors' associations with gameplay motivations were as follows:

Both social and immersion motivations should align with high emotional investment, high anthropomorphic autonomy, high control, and low SoD as the avatar serves as a social surrogate (Gee, 2008) and as a real social actor (Author, 2013), respectively. Achievement motivations should have little to no association with emotional investment, anthropomorphic autonomy, or SoD, but should be associated with high sense of control as the avatar is engaged as a tool for achievement (Williams, Yee, & Caplan, 2008).

Table 7. Step-wise regression for **social motivations** as a function of (Step 1) demographics and (Step 2) PAR scale dimensions.

<i>Sample 1 (MMO players, broadly)</i>						
	Step 1			Step 2		
	β	<i>t</i>	Sig.	β	<i>t</i>	Sig.
Gender	-.024	.495	.621	-.098	2.05	.041
Age	.046	.975	.330	.041	.891	.373
Hours Played	.172	3.68	~.000	.099	2.11	.035
Emotion				.323	6.04	~.000
Anthro				-.099	1.73	.084
SoD				-.007	-.141	.888
Control				.018	.349	.727
			$F(3,451) = 4.65, p = .003, R^2 = .02$	$F(7,447) = 7.75, p \sim .000, \Delta R^2 = .07$		
<i>Sample 2 (WoW-only players)</i>						
	Step 1			Step 2		
	β	<i>t</i>	Sig.	β	<i>t</i>	Sig.
Gender	.052	1.09	.276	.030	.622	.534
Age	.087	1.84	.066	.096	2.03	.043
Hours Played	.168	3.59	~.000	.158	3.35	.001
Emotion				.047	.837	.403
Anthro				-.025	.412	.681
SoD				.119	2.08	.038
Control				-.043	.884	.377
			$F(3,442) = 5.94, p = .001, R^2 = .03$	$F(7,438) = 4.37, p = .001, \Delta R^2 = .01$		

Note: Analyses were only conducted for participants that had complete data on all measured variables.

Table 8. Step-wise regression for **immersion motivations** as a function of (Step 1) demographics and (Step 2) PAR scale dimensions.

<i>Sample 1 (MMO players, broadly)</i>						
	Step 1			Step 2		
	β	t	Sig.	β	t	Sig.
Gender	.202	4.33	~.000	.115	2.61	.009
Age	-.011	.241	.810	.006	.132	.895
Hours Played	.122	2.65	.008	.016	.355	.723
Emotion				.238	4.76	~.000
Anthro				.096	1.83	.069
SoD				.211	4.37	~.000
Control				.132	2.87	.006
			$F(3,453) = 9.29, p \sim .000, R^2 = .05$	$F(7,349) = 18.3, p \sim .000, \Delta R^2 = .16$		
<i>Sample 2 (WoW-only players)</i>						
	Step 1			Step 2		
	β	t	Sig.	β	t	Sig.
Gender	.190	4.04	~.000	.090	2.05	.041
Age	-.011	.236	.814	.029	.666	.505
Hours Played	.068	1.46	.144	.033	.780	.436
Emotion				.162	3.19	.002
Anthro				.225	4.17	~.000
SoD				.169	3.27	.001
Control				.034	.763	.446
			$F(3,442) = 6.25, p \sim .000, R^2 = .03$	$F(7,338) = 18.9, p \sim .000, \Delta R^2 = .19$		

Note: Analyses were only conducted for participants that had complete data on all measured variables.

Step 9. Predictive validity testing – MMO Genre Preference (broad sample)

Table 9. Mean differences for PAR scale dimensions among MMO game genres.

	Fantasy RPG Est. <i>M</i> (<i>SE</i>)	Open-World	Sci-Fi RPG	Arena/PvP	η^2
Emotion	4.93a,b (.08)	5.49b (.39)	3.98a (.31)	5.28b (.57)	.028
Anthro	1.94a (.08)	1.77a (.37)	1.70a (.30)	1.47a (.54)	.004
SoD	4.12a (.10)	4.76a (.48)	3.12b (.39)	2.80b (.71)	.027
Control	6.34a (.06)	6.54a (.27)	6.45a (.22)	6.05a (.40)	.003

Note: Means with different subscripts within each row differ at $p < .05$ level of higher. Bolded rows had an overall significant ANCOVA.