Assessing the Components of Skill Necessary for Playing Video Games

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ABSTRACT
It seems clear that different video games require different skills. However, there has been no systematic way of assessing what these skills are or assessing the extent to which particular skills are required by a particular game. This study used a psychometric approach to help identify these skills and profile particular games and genres of video games. Experienced gamers generated a list of 30 skills and then rated a number of games on the extent to which they required the skills. An exploratory factor analysis identified six general components: perceptual-motor, cognitive-verbal, problem-solving, information utilization, persistence, and human-human interaction. Different genres of games differed significantly on a number of these components. The resulting instrument can be used by the game industry to profile games for review and evaluation.

INTRODUCTION

It has been known since the inception of video games that each requires different skills to play the game. Often these skills involve perceptual speed, targeting and reaction time, but other games require strategic thinking and cognitive processing of information. While games require different skills, there is yet no definitive list of these skills or method to evaluate the skills required by a particular game. This study was conducted to develop an instrument that could be used by individuals familiar with a particular video game to assess the various skills required to play the game.

Review of the Literature

Previous research has identified some of the skills involved in playing different video games. For example, Dorval and Pepin (1986) found that subjects who played 8 sessions of Zaxxon in which the player controls a spaceship in a three-dimensional space and attempts to shoot enemies and avoid obstacles and being hit, showed significantly higher spatial skill scores than the control group. A number of studies have been primarily interested in using video games to develop skills that would transfer to other contexts. For example, Mulligan, Dobson, and McCracken (2005) looked at visual processing skills developed by video game players and hockey players. These studies have identified a skill of interest and then attempted to find a video game that could be used to develop this skill.

Other studies have looked at the effect of video game playing on the development of particular skills. Green and Bavelier (2004) summarize research on the effects on reaction time and perceptual-motor coordination, spatial skills, and visual attention. For example, Griffith et al. (1983) found that video game players far outperformed non-players on a rotary pursuit task especially at high speeds. In a controlled study, Orosy-Fildes and Allan (1989) found that when half of the subjects underwent a 15-minute practice on an Atari 2600 video game system they displayed a faster reaction time than the control group. However, in general, these studies have identified changes in skills as a function of either video games in general or specific games without identifying the skills required.

To identify all of the skills needed to play a particular video game requires a different approach. One method is to perform a task analysis of a game and then relate the tasks to skills. Human factors psychology has developed procedures for task analyses (e.g., Militello, Hutton, Pliske, Knight, & Klein; 1997). While this could be done for video games, it would be extremely laborious. For that matter video games today can be extremely complex making an exhaustive task analysis nearly impossible. Moreover, players play games in different ways using different skill sets so the skills identified in the task analysis might not necessarily relate to the skill sets or abilities of the players.

Another method is to do a more conceptual analysis of what skills are learned. Smith (2008) proposes a method for identifying the skills developed in video games in a manner similar to identifying the skills involved in college courses such as rhetorical and compositional skills. She bases this on Johnson's (2005) book, *Everything Bad is Good for You,* and his discussion on how students think and write critically about their experiences playing video games.

Laboratory methods that measure specific skills developed following game play or correlated with game performance are too time consuming and expensive to be of practical use considering the thousands of games that one would like to assess. Similarly, detailed task analyses are out of scope. However, the conceptual approach, suggested by Smith and implemented using player assessments from their game playing experiences, seems viable.

Consequently, the approach taken here was to use psychometric methods to develop a set of scales that could be used to evaluate the game. To develop the scale, a pool of questions was created by experienced gamers. These and other gamers then served as coders who rated games that they were familiar with. Each game was rated on the extent to which playing the game required each of these skills or abilities.

METHOD

Participants

Two different sets of coders participated in this study. The first group consisted of students participating in a one day a week Summer Video Game Internship on the psychology of video games, held from June 2nd to July 28th, 2010. The group consisted of four senior level undergraduates majoring in psychology, two graduate students in information studies, and the author of this paper. This group submitted 70 ratings. Three of the undergraduates were highly familiar with a number of video games and submitted the bulk of the ratings (JW, male, 19; RB, female, 20; and ZL, male, 25). The remaining 6 ratings were submitted by the author and two other students.

The second group consisted of 30 upper level undergraduate students in a course on the "Psychology of Video Games and

Entertainment" in the Fall Semester of 2010 at the University of Maryland. Each student rated one game. The number of males and females was approximately equal.

Rating Scale

The items used for this questionnaire were discussed and generated by the participants in the Summer Video Game Internship. The rating form, shown in Appendix A, consisted of 24 items. The items consisted of a stem listing the skill or ability required for playing the game and a 9-point scale with the end points "Not necessary" and "Very necessary." Coders entered their name, the name of the game being rated, and any additional comments that they had about the game. The ratings were submitted on the Web and stored in a FileMaker Pro database.

RESULTS

A total of 79 games were rated, several games being rated twice or more. Super Smash Brothers Brawl received four ratings; Tetris, Fallout (2 and 3), Heavy Rain received three ratings, and 12 other games received two ratings each.

Factor Analysis

An exploratory factor analysis (principle components with a Varimax orthogonal rotation) was conducted on the data. Six factors were identified. Appendix 2 shows the table of factor loadings for the 24 items. The six factors could be labeled as follows: Factor 1: Perceptual-Motor Abilities, Cognitive-Verbal Abilities; Problem-Solving Abilities, Information Utilization Abilities, Persistence, and Human-Human Interaction.

Reliability

Cronbach's Alpha was .75 for all 24 items and for each of the six subscales: Perceptual-Motor, Alpha = .83; Cognitive Processing, Alpha = .75; Problem-Solving, Alpha = .67; Information Utilization, Alpha = .69; Persistence, Alpha = .54; and Human-Human Interaction = .41. Overall, the scale is in the respectable range. The first four subscales range from very good to acceptable. The last two are unacceptable.

Inter-Rater Reliability

Since a number of games were rated by multiple raters (two to four), it is possible to look at the inter-correlations between raters. This analysis was conducted on both the 24 individual items and on the 6 factor scores. The average correlation on the individual items was only .24 ($n = 27$, $p > .05$); but on the factor scores, it was .42 ($n = 27$, $p < .05$). The issue of rater reliability and variability of game ratings will be discussed later.

Rater Bias

Rater bias was investigated by looking at the individual profiles of the raters. Three raters contributed a sufficient number of ratings to be able to compare their average ratings. In other words, from the games they selected to rate and from their own bias for games requiring different abilities, were they high on some factors and low on others? Figure 1 shows the profiles of these three raters. Apparently, ZL was very high on Information Utilization and particularly low on Cognitive abilities; RB was high on Cognitive and Perceptual Motor abilities and low on Persistence; and JW was especially high on Persistence. The problems associated with rater bias will also be discussed later. A MANOVA was conducted on these data to see if the three raters differed from each

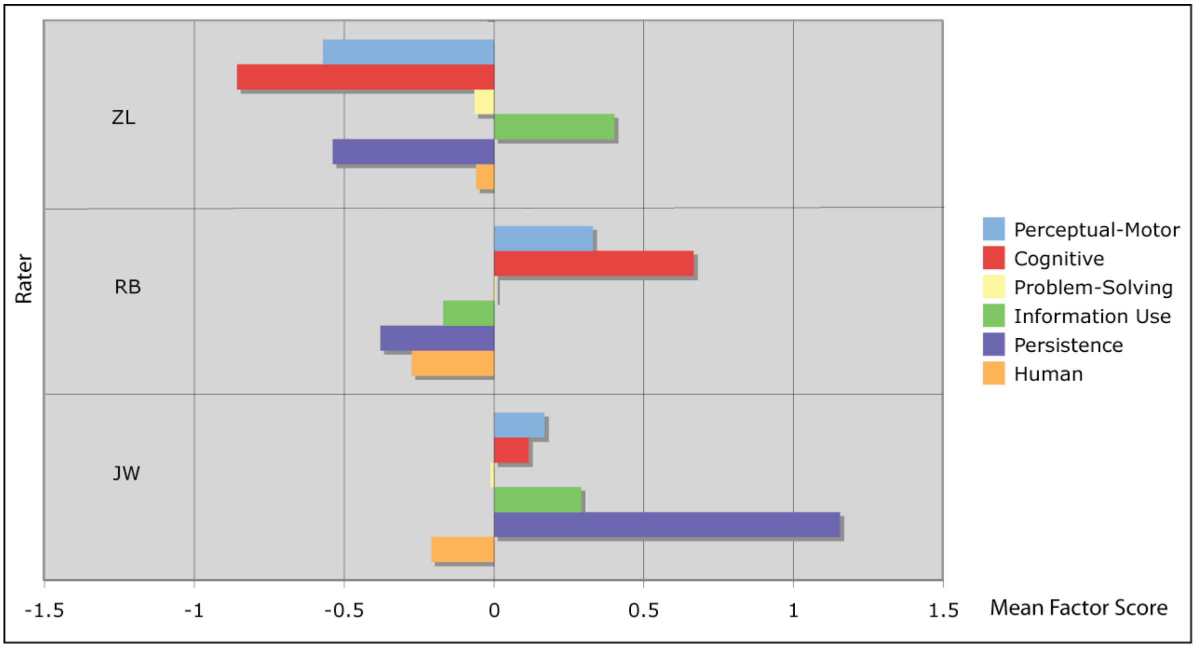

Figure 1 – Factor Variate Means for Each of the Three Raters.

other. Overall, the raters differed significantly ($p < .001$). In particular, they differed on the factors of Perceptual-Motor abilities ($p < .01$), Cognitive abilities ($p < .001$), and Persistence ($p < .001$), but not on the factors of Problem Solving ability, Information Utilization abilities, and Human-Human interaction ($p > .05$).

Factor Variates as a Function of Game

There were at most four ratings of the same game so the reliability of average factor scores for a particular game will not be high. Nevertheless, it is instructive to look at the profiles of several games, particularly where the inter-rater reliability is high. The following games were profiled: Super Smash Brothers Brawl ($n_{raters} = 4$, average $r = .40$), Civilization ($n_{raters} = 2$, $r = .84$), Guitar Hero ($n_{raters} = 2$, $r = .726$), FIFA ($n_{raters} = 2$, $r = .68$), Grand Theft Auto IV ($n_{raters} = 2$, $r = .68$), and Pokemon ($n_{raters} = 2$, $r = .64$). These profiles are shown in Figure 2. Since the sample sizes for comparing games is insufficient at this point, no further statistical analyses were conducted.

Profiles of Different Genres of Games

It is expected that different genres of games in general will require different sets of abilities. Consequently, an attempt was made to identify the genre of the 79 games. Rather than attempting to classify the games anew, genres of games listed in Wikipedia were used. An inspection of the discussion pages of articles on games reveals considerable interaction and consensus among a number of contributors to the classification. The only problem is that often games fit into several genres such as First Person Shooter (FPS) and Role Play Game (RPG). Also, some genre tend to refer more to the narrative of the game rather than the game play itself such as Survival Horror and Sci-Fi. These were ignored. Table 1 lists the number of games in each genre. Figure 3 shows the factor profiles for each genre.

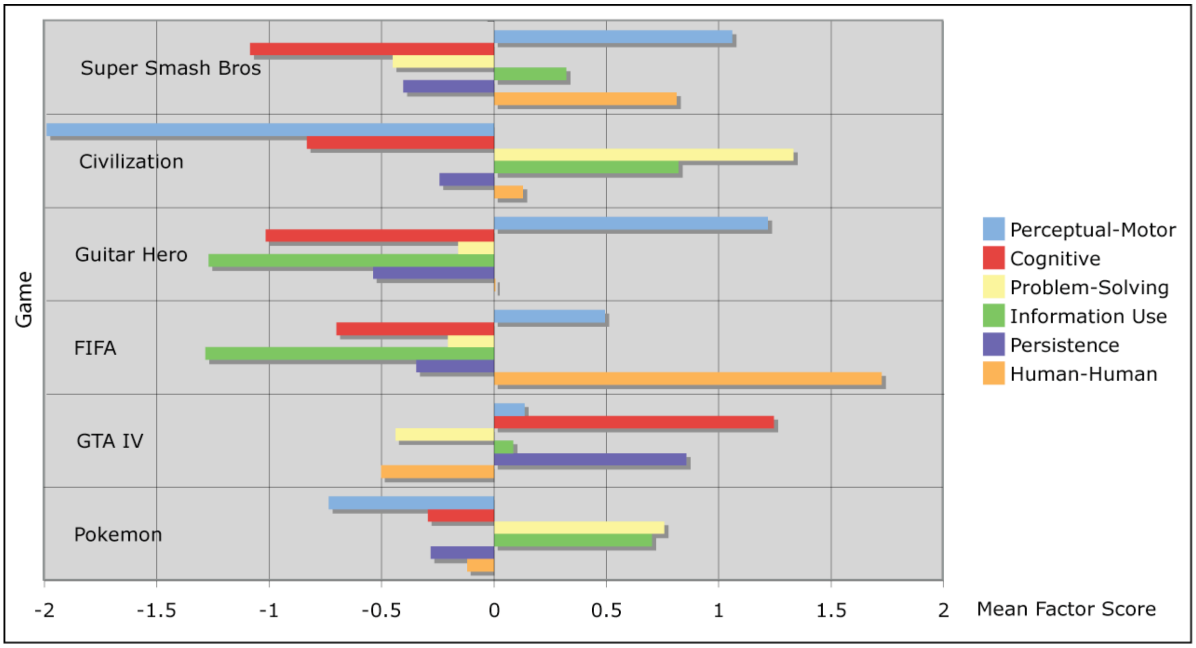

Figure 2 – Factor Variate Means for Games.

Table 1. Number of Games in Each Genre

Genre	**Number**
Action	31
Fighting	6
FPS (First-Person Shooter)	9
Life Simulation	3
MMORPG	3
Platform	6
Puzzle	7
RPG (Role Playing)	15
Sports	4
Strategy	6
TPS (Third-Person Shooter)	13
Not Classified	9

A MANOVA was conducted to see if the factor means differed significantly among the genre. Overall, the difference was significant ($p < .001$). All of the univariate factors were also significant ($p < .01$), except Problem Solving ($p > .50$). Specific comparison tests between genres could be conducted, but this goes beyond the purpose of this paper.

DISCUSSION

Six factors of player abilities necessary for playing a variety of video games were identified. This conclusion is based on an exploratory factor analysis of 24 items pertaining to skills or abilities required to play a particular game. The factors were as follows:

Perceptual-Motor Abilities. It is well known that many video games require advanced perceptual-motor abilities. These involve a number of components pertaining to perceptual speed, pattern recognition, object identification, simple and choice reaction time, tracking, targeting, timing, rhythm, and response mapping. Some games obviously require these abilities more than others. Guitar Hero and other rhythm

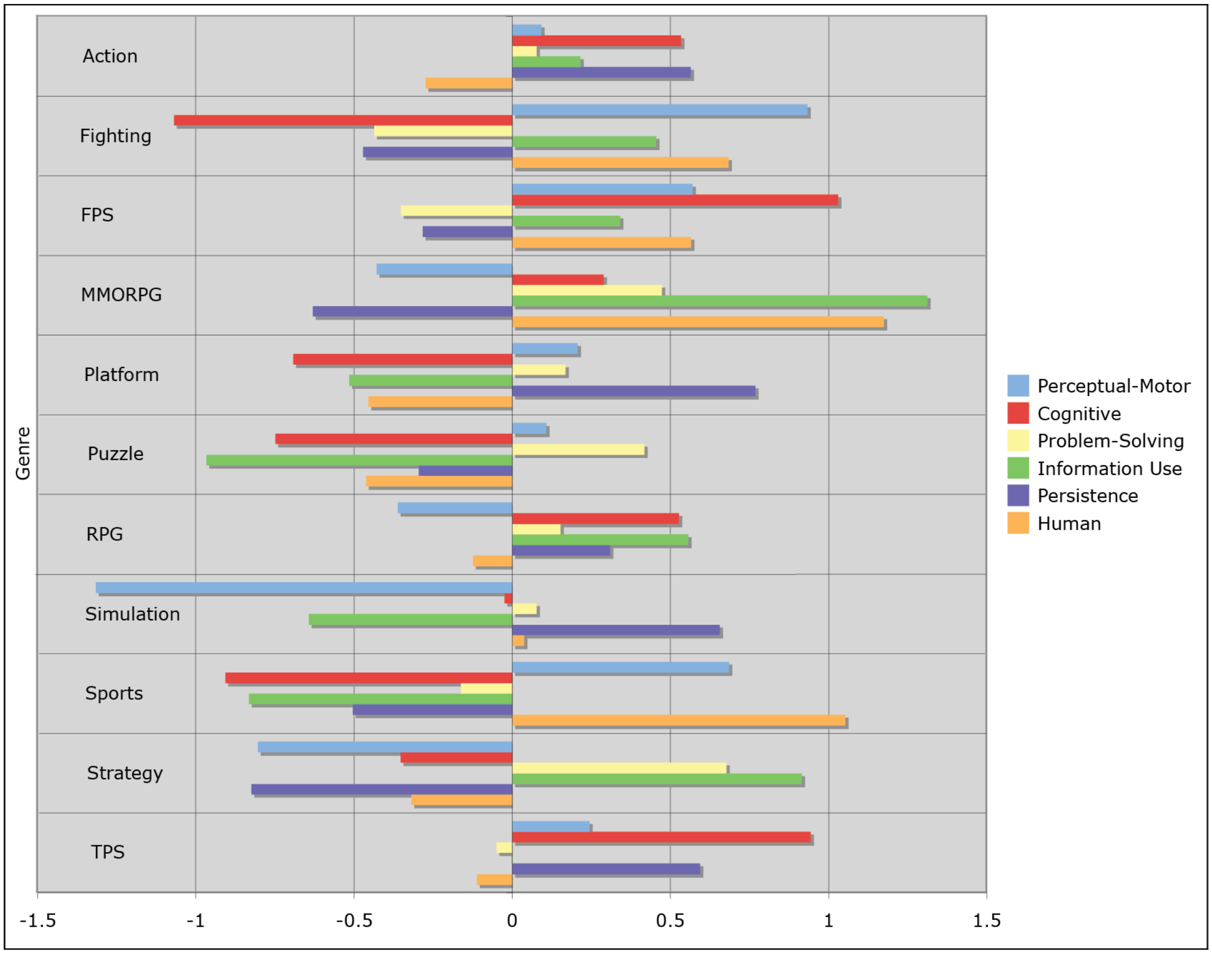

Figure 3 – Factor Variate Means for Genres of Games.

games require this ability, while turn based games such as *Civilization* do not, as seen in Figure 2. In addition, Perceptual-Motor abilities are also required in fighting games such as Super Smash Bros. Brawl and sports games such as FIFA.

Cognitive Processing Abilities. This factor involves the ability to process or interpret written and spoken information as well as detecting hidden objects and the ability to operate in secrecy and deception. Ideally, one would have hoped this factor would have been more of a pure verbal skills factor. It could be that in this sample, games such as Metal Gear Solid and Left for Dead tended to require both verbal skills (e.g., listening to instructions from the commander or teammates) and the ability to operate in stealth. This factor also shows up in Grand Theft Auto IV, as seen in Figure 2, where the player interacts verbally with non-player characters (NPCs).

Problem Solving Abilities. Many games require the player to either directly solve puzzles, such as the Professor Layton series where NPCs pose brain-teasers for the player to solve or problematic situations in the game play such as

Portal and Heavy Rain. Figure 2 shows that Civilization and Pokemon in particular require problem solving abilities. Interestingly, the ability to assess and use probabilities loads on this factor probably due to the occurrence of probability in brain-teasers and its importance in strategy games.

Information Utilization Abilities. Many games require the player to manage resources such as guns and ammo, health packs and potions, and attend to numeric information about status of self and opponents. This is essentially an ability to optimize these resources. This factor includes use of information from memory about events, names and places in the game. But it also includes the ability to filter out irrelevant information and to adapt to changing requirements and opponents. As seen in Figure 2, Civilization and Pokemon depend highly on this ability.

Persistence. This factor refers primarily to the player having patience to continue through difficult or boring parts of the game. Interestingly, the need for "dumb luck" loads negatively on this factor. In the absence of luck what is needed is personal effort and perseverance. Oddly, the ability to control the camera angle loads on this factor and on the Cognitive Abilities factor. It could be that camera control is viewed as an ongoing activity that requires persistence. In the set of games profiled in Figure 2, only Grand Theft Auto seems to depend on this factor.

Human-Human Interaction. This last factor is primarily the ability to deal with other players in a competitive manner or a communicative manner. Essentially, it is the interaction with other people playing the game either as team members or opponents. Consequently, Super Smash Bros. Bawl, often played with up to four competing players, is high on this factor as is FIFA. Single player games will by nature not require this ability. The ability to attend to graphical information loaded negatively on this factor. It could be that with limited attention, games that require high human-human interaction do not require attention to graphic signs in the game. This negative dependency deserves further study.

Rater Bias

The profiles of the three raters suggest that it is important to have a fairly large and representative sample of players evaluating the games. Ratings done by one person are very likely to be biased according to his or her own game playing abilities and the types of games that he or she likes to play. This particularly calls into question the reviews of games in many periodicals that are based on the opinions of one critic rather than those based on psychometric methods and a statistical sample of game players.

Reliability and Validity of Factors

The reliability of the skills questionnaire is established by the value of Cronbach's Alpha. Overall, Alpha was .752. For each subscale, or factor, the values were acceptable except for the factors of Persistence and Human-Human Interaction. Additional work is needed on these two scales to increase their reliability.

The validity of the factors can be established by looking at the correspondence of their actual values with the expected values for particular games as indicated in the previous section. For example, games such as Guitar Hero that obviously require perceptual-motor skills get high scores and games such as Civilization that do not to require perceptual-motor skills get low scores. The same is true for each factor, arguing that the factors have external validity. The same holds true for the factor scores for different genre as seen in the next section.

Profiles of Different Genres of Games

While there was not sufficient data to establish reliable differences between particular games, there was for grouping of games by genre. The fact that four of the skills factors differed significantly among genre helped to establish the validity of the scales.

The profiles of Action and Fighting games are very similar except when it comes to Utilization of Information and Human-Human Interaction. Fighting requires a skill of using health information and weapon information while Action games do not seem to require this as much. Fighting also requires competitive Human-Human Interaction while Action games do not.

The profiles of Action and RPG games are very similar partly owing to the fact that games are often classified in the same genre.

FPS and TPS games are also very similar except for the Persistence and Human-Human Interaction factors. TPS games require more persistence to get through boring parts than FPS games, and FPS games require more Human-Human Interaction abilities as they are often played in a multi-player mode.

Puzzle and platform games are also similar but differ in Persistence. Platform games require more persistence than puzzle games.

Conclusions

A coding instrument for assessing skills required for playing particular video games was developed. A factor analysis revealed six skill factors requiring: Perceptual-Motor abilities, Cognitive Processing abilities, Problem-Solving abilities, Information Utilization abilities, Persistence, and Human-Human Interaction abilities. The data on 79 games from a variety of coders indicates that the instrument has sufficient reliability and validity to be used as a standardized measure for assessing skills required by a video game. With additional work, the instrument can be used to profile both individual games and game genres and can be used in future research on video games and by the video game developers and by the media for evaluation of video games.

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Appendix A: Video Games Skills Survey

Video Game Skills Profile

Think of a video game that you are familiar with and determine the skills or abilities necessary for good performance.

0.1 Enter game title:

0.2 Name of coder:

For each of the following indicate the extent to which the skill or ability is necessary in the game:

	Not necessary — Very necessary
1.0 Creativity and innovative thinking	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
2.0 Problem solving strategies	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
3.0 Persistence and patience getting through difficult or boring parts	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
4.0 Ability to tune out irrelevant stimuli	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
5.0 Spatial navigation	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
6.0 Ability to control the camera angle	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
7.0 A competitive nature	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
8.0 Ability to adapt to movement, orientations, and physics	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
9.0 Quickly adapt to new rules, levels, and opponents	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
10.0 Operate in secrecy, stealth, and deception	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
11.0 Rapid, ballistic motor movements	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
12.0 Fine, controlled motor movements	○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9

13.0 Good eye-hand coordination	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
14.0 Ability to detect hidden figures	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
15.0 Ability to manage resources (e.g., weapons, possessions, health)	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
16.0 Ability to attend to graphical information in the game (e.g., arrows, lights, signs)	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
17.0 Ability to understand and follow written information in the game	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
18.0 Ability to understand and follow spoken instructions in the game.	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
19.0 Ability to use numeric information in the game (e.g., health bars, ammo counters, damage dealt)	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
20.0 Ability to communicate with other (human) players in order to succeed at in-game tasks	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
21.0 Ability to master the buttons on the controller or keyboard	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
22.0 Dumb luck	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
23.0 Ability to assess and use probabilities	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	
24.0 Ability to remember events, names, and places in the game	Not necessary	Very necessary
	◯1 ◯2 ◯3 ◯4 ◯5 ◯6 ◯7 ◯8 ◯9	

Do you have anything else to add about the skills or abilities required by this game?:

Submit

Appendix B: Rotated Component Matrix with Factor Loadings for Each Item

Rotated Component Matrix

Item	Factor					
	Perceptual -Motor	Cognitive Processing	Problem-Solving	Information Utilization	Persistence	Human-Human
13. Eye-Hand	.823			-.115		
12. Fine Move	.823	.233				-.145
21. Controller	.756		-.129	.154		
8. Physics	.657	.134		-.324	.256	.125
5. Navigation	.537	.391			.472	
11. Ballistic	.510	.335		-.232	-.275	
18. Spoken	.212	.755	.184	.128		
14. Detection	.288	.676		.196		
17. Written	-.116	.599	.424	.205		-.257
10. Stealth		.524	.369	.261	-.186	.298
2. Problem	-.163	.144	.860			-.145
1. Creativity		.118	.826		.201	.143
23. Probabilities	-.295	-.149	.428	.207	-.387	.377
19. Numeric	-.261	.187	-.131	.768		
15. Resources	-.118	.232	.229	.653		.235
24. Memory	-.133	.300	.492	.510	.163	-.123
4. Irrelevant	.396	.336	-.185	.510		
9. Adapt	.466		.343	.507	.126	
22. Luck	-.202		-.106	.141	-.743	
3. Persistence	-.129	-.137	.208	.344	.649	-.145
6. Camera		.513			.591	.134
7. Competitive	.164	-.390		.159	-.517	.448
20. Communicate		.112		.150	-.188	.687
16. Graphic	.331	.204		.260	-.180	-.648