

Original Research Article

Exploring Older Adults' Video Game Use in the PRISM Computer System

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Abstract

Background and Objective: As part of the PRISM (Personal Reminder Information & Social Management) randomized field trial, a large group of older adults ($N = 150$) received a computer system in their home that presented them with the opportunity to play eleven different video games. While researchers have often assessed older adults' gaming preferences and habits through survey data and focus groups, this trial represented a unique opportunity to study gaming behavior “in the wild” over an entire year.

Research Design and Methods: We present an exploration of game usage data, individual differences in game preferences and gaming habits, and individual difference predictors of game use.

Results: Although few individual difference variables consistently predicted game use and preferences, there were clear favorites among the different games, and results demonstrate that given the opportunity and training many older adults may become active and long-term gamers.

Discussion and Implications: Findings have implications for designing video games that older adults enjoy, supporting enjoyable and meaningful interactions with video games across the life span, and for designing cognitive, social, and health interventions involving games.

Translational Significance: Video gaming is a popular leisure activity that relatively few older adults engage in, but results demonstrate that with appropriate support and training, even older adults with minimal previous computer experience can not only participate in this activity, but in some cases become active gamers. Further, results suggest that including games as part of a technology system can encourage use by older adults, potentially overcoming barriers to adoption and supporting adherence to technology-based interventions.

Keywords: Computers, Entertainment, Technology, Video games

Like many forms of technology, there is a digital divide with respect to age and video gameplay. Although the stereotype of most gamers being young and male is clearly inaccurate (the average video game player is 35 years old and is equally likely to be male or female, [Entertainment Software Association, 2017](#)), representative U.S. data suggest that older adults are far less likely to engage in video gameplay compared to their younger counterparts. Only 25% of adults 65 years of age or older play video games compared to about 50% of American adults in general (age 18+) and 67% of 18–29-year olds ([Duggan, 2015](#)). Further, while 22% of 18–29-year olds consider themselves “gamers,” only 2% of older adults (age 65+) would use the same term to describe themselves.

Why is it that older adults are reluctant to play video games? One reason may be that, compared to younger adults, they have less experience with the devices and platforms necessary to engage in video gaming, and are less likely to own gaming devices. About 40% of American adults own a game console, compared to only 8% of older adults ([Anderson, 2015](#)). Not owning a game system, however, is not a substantial barrier to video gameplay as increasingly gaming takes place online or on mobile devices. However, as of 2016, 36% of older adults in America reported not using the Internet, and 58% reported not owning a smartphone ([Pew Fact Sheets, 2017](#)). This is compared to near universal Internet usage among the youngest adult cohort (18–29 years of age), with 92% of this group reporting owning a smartphone. In the absence of experience with, or ownership of, the devices and platforms necessary to engage in video gameplay, there may be little opportunity for older adults to become gamers.

Attitudinal barriers may also play an important role in discouraging older adults from engaging in video gameplay. In general, 26% of American adults believe that most video games are a waste of time ([Duggan, 2015](#)). Some older adults consider video games childish and meaningless, and are concerned that others might perceive them as childish for playing video games ([De Schutter & Abele, 2010](#); [Quandt, Grueninger, & Wimmer, 2009](#)). Some older adults also believe that they are unable to, or are not supposed to, enjoy gaming based on stereotypes about aging and video gamers ([McLaughlin, Gandy, Allaire, & Whitlock, 2012](#)). These ideas are consistent with the findings of [Brown \(2017\)](#) who recently surveyed a group of older adult non-gamers regarding why they do not engage in gameplay. Older adults expressed the ideas that video games are too challenging, and that in general they are a waste of time. Countering these attitudinal barriers, other evidence suggests that older adults perceive gaming as potentially beneficial for cognitive functioning (e.g., [De Schutter & Abele, 2010](#); [Dupl a, Kaufman, Sauv e, & Renaud, 2017](#); [Kaufman, Sauv e, Renaud, Sixsmith, & Mortenson, 2016](#)). These attitudinal barriers and facilitators are generally consistent with models of technology adoption and acceptance that posit that factors such as self-efficacy, social influence,

and perceived benefit play important roles in shaping older adults’ acceptance of technology ([Chen & Chan, 2014](#)).

Human factors issues also need to be considered when attempting to understand the lack of adoption of video games by older adults. A number of perceptual, cognitive, and motor abilities decline with advancing age, including declines in processing speed ([Salthouse, 2010](#)). The most popular video game genres of 2016 were shooter games and action games ([Entertainment Software Association, 2017](#)), fast-paced game genres that require quick responses and place substantial demands on processing speed (see [GITHYP, 2017](#); for trends and more information about the most played games each year). This highlights a potential mismatch between the perceptual and cognitive abilities of older adults and the demands of some of the most popular video games on the market that may discourage older adults from participating in gaming ([McLaughlin et al., 2012](#)). These usability challenges have been observed with exergames (video games that involve and promote physical activity) as well ([Barg-Walkow, Harrington, Mitzner, Hartley, & Rogers, in press](#); [Harrington, Hartly, Mitzner, & Rogers, 2015](#)). Like other forms of technology, if video games are not designed with the perceptual and cognitive abilities of older adults in mind they may cause frustration and a lack of adoption ([Boot et al., 2013](#); [Boot, Nichols, Rogers, & Fisk, 2012](#); [Loos, 2014](#); [McLaughlin et al., 2012](#)).

A number of studies have explored older adults’ video game preferences and gaming habits. For the most part, these have been survey and focus group studies asking older adults about their gaming habits, or briefly exposing them to different games or game descriptions and asking them about their enjoyment or likely enjoyment of different games. A few consistent patterns have emerged from these studies. Older adults tend to play or want to play “casual games” and educational games over more immersive and realistic 3D games (action games, fighting games, first-person shooters, real time strategy games; [Blocker, Wright, & Boot, 2014](#); [De Schutter, 2011](#)). These casual games are typically computerized versions of card games and board games, and simple puzzle and word games. This preference may be driven by the shallow learning curve associated these games due to their simplicity and relative familiarity; they are easy to learn, to play, and to start and stop ([Salmon et al., 2017](#)). Familiar games may also be preferred because they trigger memories of the past ([Brown, 2014](#); [Nap, de Kort, & Ijsselsteijn, 2009](#)). A preference for puzzle, strategy, and educational games is consistent with a desire for intellectually stimulating games over games that reward fast reactions ([Pearce, 2008](#); [Salmon et al., 2017](#)). A comprehensive review of the literature conducted by [Cota and Ishitani \(2104\)](#) confirmed older adults prefer “low complexity” games and games that have nondigital analogues (i.e., puzzles, board games, and card games). Game narrative (storyline) and familiarity (e.g., familiar real-world game elements, such as everyday objects) were also found to be important to older players. Other studies

have found that fast-paced games, and especially violent games, are unpopular with older adults (De Schutter, 2011; Nap et al., 2009; McKay & Maki, 2010), as are games that incorporate fantasy elements (Blocker et al., 2014).

While previous studies have typically asked older adults about their gaming habits, preferences, and experiences, no studies have yet tracked older adults' gameplay over an extended period. Here, we take advantage of a subset of the data collected as part of the PRISM (Personal Reminder Information & Social Management) randomized field trial to investigate the game preferences and gaming behaviors of a relatively large sample of older adults with minimal previous computer and Internet experience (for primary outcomes related to social isolation, see Czaja et al., 2015 and Czaja, Boot, Charness, Rogers, & Sharit, 2017). In addition to features related to the primary goal of reducing social isolation (a persistent lack of contact between an individual and others), older adults were presented with eleven different video games to play; this is the focus of the current paper.

Since older adults were not explicitly instructed to play games during this period, it was not clear how much gameplay would occur and which games would be preferred. These data were used to answer the following questions: (1) Would computer naive older adults spontaneously engage in gameplay? (2) Which games would be preferred? (3) If games were adopted, would gameplay continue throughout the year-long trial or would gameplay drop off substantially over time? (4) Could different types of gamers be identified based on their pattern of gameplay? (5) Could individual difference characteristics predict gameplay and game preferences (e.g., variations in cognition, the ability quickly and accurately process and retain information; or personality differences, characterized by relatively stable patterns of behavior, feeling, and thinking)? (6) Would gameplay encourage PRISM system use?

Method

All methods and the main outcome of the trial have been previously reported (Czaja et al., 2015; Czaja et al., 2017). Here, we present a brief summary of the sample characteristics and methods of the trial. One-hundred and fifty were participants randomly assigned the PRISM condition, the focus of the current paper. Participants in the PRISM condition were paid \$25 for each of three administrations of a cognitive/psychosocial assessment battery (baseline, 6 months, 12 months), but were not compensated for time spent on the PRISM system itself.

Participants

Recruitment took place in the Atlanta (GA), Miami (FL), and Tallahassee (FL) regions of the United States to obtain a racially and ethnically diverse sample (46% non-White). Participants were screened for dementia using the Mini-Mental State Examination and other cognitive assessments

(see Czaja et al., 2017). Eligible participants were 65 years of age or older, lived alone, did not spend more than 10 hr each week at a Senior Center, did not work or volunteer for more than 5 hr per week, spoke English, could read at the 6th grade level, and had minimal computer and Internet experience in the past 3 months. Participants could not own a working computer within their home, and ideally did not use e-mail or the Internet within 3 months. However, some exceptions were made if, for example, a participant infrequently went to a library to access the Internet, or used a computer at a doctor's office to fill out forms.

Consistent with the requirement of minimal computer and Internet experience, the computer proficiency of the sample was low (Boot et al., 2015). The Computer Proficiency Questionnaire asks participants to report their ability to perform different computer tasks across six different subscales: Computer Basics, Printing, Communication, Internet, Scheduling, and Multimedia. Participants rated their ability to perform each task of each subscale on a scale from 1 to 5 (1 = *Never tried*, 2 = *Not at all*, 3 = *Not very easily*, 4 = *Somewhat easily*, 5 = *Very easily*). For the Computer Basic subscale, the average response in the PRISM condition was 2.48, corresponding to participants indicating that they could not at all or not very easily complete basic tasks such as turning a computer on and off. Average responses for all other subscales ranged between 1.14 and 1.92, consistent with participants never having tried or being unable to perform most computer tasks.

Participants in the PRISM condition had an average age of 76.9 years ($SD = 7.3$ years). The sample was 79.3% female and was relatively low with respect to SES (43.3% had a high school degree or less; 84.7% had an income of less than \$30,000 U.S. per year). Over the course of the year-long trial, 19 participants assigned to the PRISM condition dropped out of the study. The presented analyses focus on participants who remained over the initial year-long period.

Materials

The PRISM system was developed with a user-centered design approach that involved multiple iterations of pilot testing with older adults. It was comprised of a 19-inch LCD monitor, keyboard, mouse (or trackball if the participant experienced difficulty using the mouse), and desktop PC. The PRISM software presented participants with a single-click navigation system that allowed them to choose between seven system features (E-mail, Internet, Classroom, Calendar, Photos, Games, Community). Internet service was provided for one year to all PRISM participants. The system also included a help system that provided general help regarding PRISM navigation and context-specific help within each feature. Participants were also given a paper user manual and help card that contained the number for a helpline they could call if they encountered any technical issues with the system.

Procedures

Study personnel installed the PRISM system in participants' homes and provided three sessions of PRISM training. This training covered computer basics such as how to turn the system on and off, how to use a mouse and keyboard, and then how to use each PRISM feature (e.g., how to send and read e-mail, how to access games, how to use search engines). Training also involved two practice games of Solitaire, a game of Chinese Checkers, and a homework assignment to play Solitaire and other games of interest between the first and second day of PRISM training. A check-in call occurred one week after the third day of training, and three and nine months later to determine whether participants had any difficulty with the system. As described elsewhere, cognitive and psychosocial measures were collected at baseline, 6 months, and 12 months into the study (Czaja et al., 2015). Whenever participants used a particular PRISM feature a message was sent to a central server in Miami. Usage data, including whenever each game was played, were collected from each participant for an entire year.

PRISM Games

The PRISM system presented participants with 11 different single-player video games:

Chinese checkers

A computerized version of the board game. The goal is to move all game pieces to the opposite side of the board. A piece can move a single space, or can "jump" over other pieces (either once, or consecutively until no more jumps can be executed). Players compete against a computer opponent to be the first to move all of their pieces across the board.

Crossword

A computerized crossword puzzle game. From the provided clues, players type in answers based on the number of letter spaces available and any letters already in those spaces from previous answers.

Droplets

Droplets (circles) of different colors are presented in a grid. The player can click four droplets of the same color that form the corners of a rectangle. All droplets within that rectangle are destroyed and points are awarded based on the number of droplets destroyed within a limited amount of time.

Gem swap

Gems of different colors and shapes are presented in a grid. The player can click two adjacent gems to swap their positions. When lines of three or more identical gems are formed through swapping they are destroyed and points are awarded. The goal is to destroy as many gems as possible within a limited amount of time.

Memory

Players view circles that differ in color (red, yellow, green, light blue, dark blue, pink, black). These colors must be memorized; after a brief period of time all colored circles are occluded. At this point, players must click pairs of occluders hiding circles of the same color. As the game progresses the number of circles increases. Points are awarded for correct matches.

My Jong

The game named "My Jong" is a variant of the game Mahjong. Stacked tiles featuring different symbols are presented. The player identifies and removes pairs of tiles with matching symbols, earning points. Only tiles on top of a stack can be matched, and only if they have a free side (i.e., the tile does not have another one immediately adjacent to it at the same height on the left or right). Players make as many matches as possible within a limited amount of time.

Solitaire

A computerized version of Solitaire (Klondike Solitaire specifically). Players must arrange playing cards of the same suit into four piles from Ace (lowest) to King (highest), following rules for how cards can be flipped and moved from one pile to another.

Sudoku

A computerized version of the popular number puzzle game. A 9×9 grid of squares is divided into nine boxes. At the start of each game some squares already have numbers (1–9) in them. The player must determine which numbers go in the remaining squares based on the rule that the numbers 1–9 can only appear in each row, column, and box once.

Tetris

Tetris is a classic video game in which players must arrange falling blocks of different shapes (zoids) to form lines at the bottom of the screen. When a complete line is formed the line disappears and points are awarded. If complete lines are not formed, zoids stack up and the game ends when the zoid stack reaches the top of the screen. As the game progresses the speed with which zoids fall increases, increasing difficulty.

Poker

A computerized version of the card game. This version of poker implemented 5 card draw rules. After placing a bet, cards are dealt, and the player decides which cards to hold, and new cards are dealt if requested. Points are awarded based on the final hand and initial bet.

Word search

The player is presented with a matrix of jumbled letters and a word definition below. The player must find the word corresponding to the definition in the matrix and highlight it. Score is based on the number of words found within a limited amount of time.

Predictor Variables

A variety of cognitive and psychosocial measures were collected at baseline, some of which are used as predictor variables in the current paper. These measures are described in detail by Czaja et al. (2015). The Ten Item Personality Inventory (TIPI) was administered to obtain a brief measure of Agreeableness, Conscientiousness, Emotional Stability, Extraversion, and Openness to Experience (Gosling, Rentfrow, & Swann, 2003). For each of the subscales of the TIPI, higher scores are associated with participants indicating greater agreement that the personality trait describes them (e.g., a higher score on the Conscientiousness subscale corresponds to greater self-reported conscientiousness).

Cognitive measures included: Trails A (Processing Speed) and Trails B (Executive Control; Reitan, 1958), Digit Symbol Substitution (Processing Speed; Wechsler, 1981), Animal Fluency (Verbal Fluency; Rosen, 1980), and the Shipley Institute of Living Scale (Crystallized Intelligence; Zachary, 1986). Briefly, Trails A involves a sheet of paper with numbers within circles printed on it. Participants must use a pen or pencil to connect numbered circles in consecutive order as quickly as possible. Trails B involves numbers and letters within circles, and participants must alternate between connecting numbers and letters (e.g., 1-A-2-B, etc.). Trails A and B scores are based on task completion time, meaning that lower scores correspond to better (faster) performance. For all other cognitive measures, higher scores indicate better performance. Digit Symbol substitution involves matching as many abstract symbols to randomly associated digits within a brief period of time. Animal Fluency requires naming as many animals as possible within 60 s, and the Shipley Institute of Living Scale involves correctly identifying synonyms of a target word.

In addition to these measures, a demographic survey collected information such as age (in years), gender (dummy coded as -1 for female, 1 for male in analyses), and other individual difference characteristics.

Statistical Analyses

Hypotheses related to whether or not different types of players could be identified within the data set were addressed using cluster analysis. A model-based cluster analysis was conducted in R (version 3.4.1) using package *mclust*. This package simultaneously tests various Gaussian finite mixture models and uses the Bayesian Information Criterion (BIC) for final model selection (Scrucca, Fop, Murphy, & Raftery, 2016). Where k-means clustering requires a number to be specified for k to create clusters, model-based unsupervised learning derives k directly from the data.

Other analyses explored the best predictors of total days of gameplay, as well as predictors of days of play for each individual game using linear regression in JASP 0.8.4 (JASP Team, 2018). Predictors included total system use (days), gender, age, personality factors (Agreeableness, Conscientiousness, Emotional Stability, Extraversion,

Openness to Experience), and cognitive scores (Animal Fluency, Digit Symbol Substitution, Shipley Vocabulary, Trails A, Trails B). Only significant linear regression models are reported.

To answer questions regarding whether game use may have promoted the use of other nongame PRISM features, we first defined weekly nongame use. This was the sum of the number of days a feature *other than the games feature* was accessed in a week. For example, if the E-mail feature was used 5 days in a week, the Calendar feature 2 days, the Community feature 1 day, and no other features were used, nongame use for that week would be 8. Similarly, game-use was computed by summing every day each game was played in a week. If Solitaire was played 6 days, Sudoku 1 day, Word Search 3 days and no other game was played, game use for the week would be 10. In this model the dependent variable was nongame use for the week. Nongame use was predicted with a linear and quadratic term for week number as well as the previous week's nongame use and the previous week's game use. Random effects were fit for the intercept, as well as the linear and quadratic effect of time. Random effects in this case allow individuals to vary on both where they start and how they change. This model was conducted using SPSS 21, which calculates degrees of freedom using the Satterthwaite approximation (Satterthwaite, 1946). Of primary interest is whether previous game use predicts future system use controlling for previous system use.

Results

Would Computer Naive Older Adults Spontaneously Engage in Gameplay?

In total, 131 participants completed 12 months of the PRISM trial. PRISM use is initially quantified as the number of days that participants accessed the PRISM system over a year (max 365). On average use was high but variable ($M = 197$ days, $SD = 107$, $min = 3$, $max = 359$). With respect to video gameplay, older adults played a game on 42% of the days the PRISM system was accessed ($M = 84$ days, $SD = 100$, $min = 0$, $max = 332$). This is consistent with previous reports that games were one of the most used PRISM features after e-mail and Internet (Czaja et al., 2017). Almost half the sample (49%) had the equivalent of one month (30 days) or more of days of gameplay over the course of the year-long trial. Figure 1 (left most plot) illustrates the distribution of days of gameplay in the form of a box-plot.

Which Games Would be Preferred?

Figure 1 also depicts the number of days participants played each game over the year-long study. There was a strong, clear preference for Solitaire, with participants playing on average 54 days ($SD = 88$, $min = 0$, $max = 327$). After Solitaire, there was no clear second choice, and on

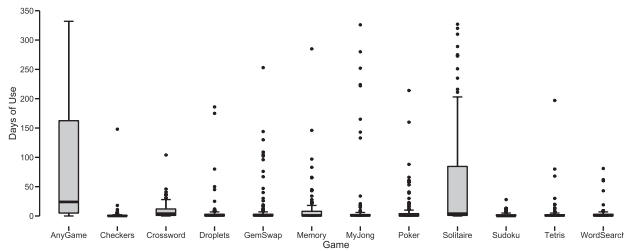


Figure 1. Boxplots of the number days each video game was played, as well as the number of days on which any game was played.

average participants infrequently played the other games. Somewhat surprising in light of reported preferences for puzzle games and games promoting intellectual stimulation among older adults, Sudoku was the least preferred game ($M = 2$ days, $SD = 4$, $min = 0$, $max = 28$). However, aggregate data may mask the fact that individual participants may have engaged in a significant amount of gameplay with games other than Solitaire (see cluster analysis presented later).

Would Gameplay Continue Throughout the Year-long Trial or Would Gameplay Drop off Substantially Over Time?

To examine this question, gameplay was quantified as the average number of days per week a game was played (max 7) over the course of the trial (Figure 2). Although gameplay dropped off slightly over time, there was gaming activity over the course of the entire year. The pattern of game preferences appeared to be relatively stable, with Solitaire being consistently the most played game, and Sudoku consistently the least played game. Even during the last four weeks of the intervention, almost half (49%) of participants played at least one game.

Could Different Types of Gamers be Identified Based on Their Pattern of Gameplay?

Using *mclust*, the three top performing models had clusters of the same shape, variable volume, and orientation equal to the coordinate axes (VEI; Kassambara, 2017). The best model is defined as having a BIC closer to 0 since *mclust* uses BIC maximization and outputs negative BIC values. The BIC values among these top performing models were: $-8,864$ (5 clusters), $-8,874$ (6 clusters), $-8,936$ (7 clusters). Thus, we focus on the 5 cluster solution. Figure 3 depicts the gaming habits of the identified clusters. Table 1 provides more information about their overall game and PRISM usage. This analysis identified one cluster of participants (Cluster 5) that frequently and almost exclusively played Solitaire ($N = 16$). Cluster 4 also engaged almost exclusively in Solitaire play, but played less frequently ($N = 33$). Another cluster (Cluster 2) appeared to be made up of individuals who engaged in diverse gameplay ($N = 18$). This group played My Jong the most, but also played Solitaire,

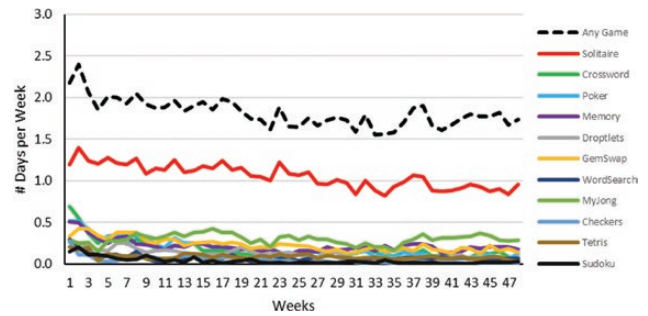


Figure 2. Number of days per week each game was played over the course of the trial. Note that near the end of the trial some participants began transitioning from the PRISM software package to Windows in preparation for the end of the trial and availability of the software. For this reason, data are only depicted for the first 48 weeks.

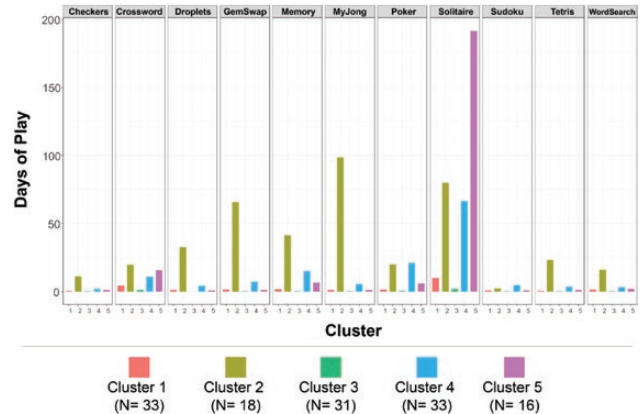


Figure 3. Number of days each game was played as a function of cluster. Clusters 1 and 3 engaged in minimal gameplay (and were less frequent PRISM users), Cluster 2 engaged in diverse gameplay, and Clusters 4 and 5 engaged in almost exclusive Solitaire play, with participants in Cluster 5 being more active gamers than Cluster 4.

Gemswap, Memory, and other games. Clusters 1 ($N = 33$) and 3 ($N = 31$) were fairly similar in that both groups engaged in minimal gameplay and used the PRISM system for fewer days on average compared to other clusters.

Could Individual Difference Characteristics Predict Gameplay and Game Preferences?

Next, we turn to whether gameplay can be predicted by individual difference factors such as gender (coded -1 for female, 1 for male), age, personality (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), and cognition (Animal Fluency, Digit Symbol Substitution, Trails A, Trails B). All analyses control for the number of days participants used the system (if participants did not use the system there is no opportunity to engage in gameplay). Only significant regression models are reported. Please note the exploratory nature of these analyses given the large number of comparisons being made between different games and individual difference measures.

Total days of gameplay (any game)

The number of days on which any game was played could successfully be predicted with these variables ($F[13, 116] = 6.35, p < .001$). Table 2 depicts the results of this model, which accounted for 42% of the variance in gameplay. Not surprisingly, the total number of days participants used the system was the strongest predictor of game use. However, a number of other predictors were also significant. Women played games more often than men did, and individuals who scored higher on Animal Fluency, a measure of verbal fluency, were more likely to play. In terms of personality, individuals who scored lower in Openness to Experience were more likely to play. Perhaps games were among the most familiar elements of the system, resulting

in individuals less open to new experiences gravitating toward something more familiar.

Days of crossword play

The number of days on which Crossword was played could successfully be predicted ($F[13, 116] = 2.27, p < .05$). Table 3 depicts the results of this model, which accounted for 20% of the variance in Crossword play. Not surprisingly, the total number of days participants used the system was the strongest predictor. Older participants and more emotionally stable participants were more likely to play Crossword. Although speculative, older players may be more drawn to Crossword play because it capitalizes on their greater experience and is a game where older

Table 1. Results of the Cluster Analysis Performed on PRISM Game Data

Descriptive statistics										
Cluster	Days game use					Days system use				
	1	2	3	4	5	1	2	3	4	5
N	33	18	31	33	16	33	18	31	33	16
Mean	15.6	222.5	3.7	97.6	194.3	165.7	272.4	143.9	211.5	252.3
SD	17.5	70.4	4.6	87.0	66.3	110.4	70.2	112.4	95.7	63.92
Minimum	2	99	0	19	66	6	126	3	64	73
Maximum	88	332	23	330	320	344	358	348	350	359

Note: Five clusters of participants were identified, and the table characterizes each cluster with respect to total number of days of gameplay as well as total days of PRISM system use. In general, Clusters 1 and 3 engaged in minimal gameplay (and were less frequent PRISM users), Cluster 2 engaged in diverse gameplay, and Clusters 4 and 5 engaged in almost exclusive Solitaire play, with participants in Cluster 5 being more active gamers than Cluster 4. N = Number of participants; SD = Standard deviation.

Table 2. Regression Analysis Predicting Days of Gameplay With Demographic, Personality, and Cognitive Variables, Controlling for System Use

Days of gameplay (any game)						
Model		Unstandardized	SE	Standardized	t	P
1	(Intercept)	71.482	125.584		0.569	.570
	Age	-0.412	1.176	-0.027	-0.350	.727
	Gender	-21.200	9.686	-0.172	-2.189	.031
	Agreeableness	-3.642	4.335	-0.070	-0.840	.403
	Conscientiousness	1.131	3.517	0.025	0.322	.748
	Emotional Stability	1.006	3.260	0.027	0.309	.758
	Extraversion	-2.954	2.860	-0.079	-1.033	.304
	Openness to Experience	-6.525	3.157	-0.164	-2.067	.041
	Animal Fluency	3.581	1.699	0.171	2.108	.037
	Digit Symbol Substitution	-1.323	0.785	-0.168	-1.685	.095
	Trails A	-7.800e-4	0.356	-2.114e-4	-0.002	.998
	Trails B	0.126	0.104	0.124	1.211	.228
	Shipley Vocabulary	0.288	1.412	0.019	0.204	.839
	Total System Use	0.545	0.072	0.580	7.612	<.001

Note: Gender was dummy coded with female as -1 and male as 1. Trails A and Digit Symbol Substitution measured processing speed; Trails B measured executive control; Animal Fluency measured verbal fluency; Shipley Vocabulary corresponded to the Shipley Institute of Living Scale which measured crystallized intelligence. Trails A and B were timed measures, meaning that lower scores corresponded to better (faster) performance. For all other cognitive measures, higher scores indicated better performance. Personality variables (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), Total System Use, and Age (years) were coded such that higher values corresponded to greater quantity.

Table 3. Regression Analysis Predicting Days of Crossword Gameplay With Demographic, Personality, and Cognitive Variables, Controlling for System Use

Days of crossword play						
Model		Unstandardized	SE	Standardized	<i>t</i>	<i>p</i>
1	(Intercept)	-15.728	18.755		-0.839	.403
	Age	0.390	0.176	0.201	2.219	.028
	Gender	-1.383	1.447	-0.088	-0.956	.341
	Agreeableness	-0.424	0.647	-0.064	-0.656	.513
	Conscientiousness	-0.476	0.525	-0.081	-0.906	.367
	Emotional Stability	0.977	0.487	0.202	2.007	.047
	Extraversion	-0.448	0.427	-0.093	-1.050	.296
	Openness to Experience	-0.823	0.471	-0.162	-1.745	.084
	Animal Fluency	0.472	0.254	0.176	1.859	.066
	Digit Symbol Substitution	0.001	0.117	0.001	0.011	.991
	Trails A	-0.028	0.053	-0.059	-0.527	.599
	Trails B	1.449e-4	0.016	0.001	0.009	.993
	Shipley Vocabulary	-0.188	0.211	-0.099	-0.893	.374
	Total System Use	0.031	0.011	0.260	2.927	.004

Note: Gender was dummy coded with female as -1 and male as 1. Trails A and Digit Symbol Substitution measured processing speed; Trails B measured executive control; Animal Fluency measured verbal fluency; Shipley Vocabulary corresponded to the Shipley Institute of Living Scale which measured crystallized intelligence. Trails A and B were timed measures, meaning that lower scores corresponded to better (faster) performance. For all other cognitive measures, higher scores indicated better performance. Personality variables (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), Total System Use, and Age (years) were coded such that higher values corresponded to greater quantity. Bolding indicates statistical significance ($P < .05$).

adults often excel relative to younger adults (Hambrick, Salthouse, & Meinz, 1999).

Days of Solitaire play

The number of days on which Solitaire was played could successfully be predicted ($F[13, 116] = 3.60, p < .001$). Table 4 depicts the results of this model, which accounted for 29% of the variance in Solitaire play. The total number of days of system use was the only significant predictor.

Days of Tetris play

The number of days on which Tetris was played could successfully be predicted ($F[13, 116] = 2.37, p < .01$). Table 5 depicts the results of this model, which accounted for 21% of the variance in Tetris play. Greater introversion (less extraversion) and higher verbal fluency (as measured by Animal Fluency) were both associated with more Tetris play.

Days of Poker play

The number of days on which Poker was played could successfully be predicted ($F[13, 116] = 2.55, p < .01$). Table 6 depicts the results of this model, which accounted for 22% of the variance in Poker play. Total days of system use was the strongest predictor of Poker play. Better performance on Trails A, a measure of processing speed, was predictive of Poker play. Less emotionally stable individuals were also more likely to play Poker.

In sum, although 20%–42% of the variance in gameplay could be predicted, most of the predictive power of

each model was realized through the association between game use and system use, with age, gender, cognition, and personality playing comparatively small roles. Few variables consistently or strongly predicted gameplay.

Would Gameplay Encourage PRISM System Use?

To address this question, we examined how frequently nongame features were used in a week, and whether game use the previous week predicted nongame feature use the following week. This analysis can provide initial support for the idea that game use can encourage the future use of other PRISM features.

Table 7 gives complete results for the random effects model predicting weekly nongame use with nongame use and game use from the previous week. All effects were strongly significant. Not surprisingly, the previous week's nongame use was the best predictor of nongame use the following week, $t(5619.08) = 27.25, p < .001$. Use decreased with time, $t(134.02) = -11.66, p < .001$, with this decrease decelerating over time, $t(126.50) = 6.82, p < .001$. Most importantly for the purposes of the current question, game use the previous week positively predicted nongame system use the following week, $t(4776.57) = 5.09, p < .001$. This result suggests that playing games increased the use of other system features even above previous use of those same features.

Reversing the direction so that previous nongame PRISM use predicted current game use, controlling for previous game use demonstrated a similar pattern. The

Table 4. Regression Analysis Predicting Days of Solitaire Gameplay With Demographic, Personality, and Cognitive Variables, Controlling for System Use

Days of Solitaire play						
Model		Unstandardized	SE	Standardized	<i>t</i>	<i>P</i>
1	(Intercept)	-54.066	121.859		-0.444	.658
	Age	1.529	1.141	0.115	1.340	.183
	Gender	-8.220	9.399	-0.076	-0.875	.384
	Agreeableness	-5.674	4.206	-0.124	-1.349	.180
	Conscientiousness	1.224	3.413	0.030	0.359	.721
	Emotional Stability	1.613	3.163	0.048	0.510	.611
	Extraversion	1.595	2.775	0.048	0.575	.567
	Openness to Experience	-4.847	3.063	-0.139	-1.582	.116
	Animal Fluency	0.256	1.648	0.014	0.155	.877
	Digit Symbol Substitution	-0.916	0.762	-0.133	-1.203	.232
	Trails A	-0.060	0.345	-0.019	-0.174	.862
	Trails B	0.066	0.101	0.074	0.654	.514
	Shipley Vocabulary	0.396	1.370	0.030	0.289	.773
	Total System Use	0.369	0.069	0.447	5.313	<.001

Note: Gender was dummy coded with female as -1 and male as 1. Trails A and Digit Symbol Substitution measured processing speed; Trails B measured executive control; Animal Fluency measured verbal fluency; Shipley Vocabulary corresponded to the Shipley Institute of Living Scale which measured crystallized intelligence. Trails A and B were timed measures, meaning that lower scores corresponded to better (faster) performance. For all other cognitive measures, higher scores indicated better performance. Personality variables (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), Total System Use, and Age (years) were coded such that higher values corresponded to greater quantity. Bolding indicates statistical significance ($P < .05$).

Table 5. Regression Analysis Predicting Days of Tetris Gameplay With Demographic, Personality, and Cognitive Variables, Controlling for System Use

Days of Tetris play						
Model		Unstandardized	SE	Standardized	<i>t</i>	<i>p</i>
1	(Intercept)	2.946	28.576		0.103	.918
	Age	-0.354	0.268	-0.119	-1.321	.189
	Gender	-3.615	2.204	-0.150	-1.640	.104
	Agreeableness	0.237	0.986	0.023	0.241	.810
	Conscientiousness	0.805	0.800	0.090	1.006	.317
	Emotional Stability	0.300	0.742	0.040	0.404	.687
	Extraversion	-2.334	0.651	-0.318	-3.586	<.001
	Openness to Experience	-0.826	0.718	-0.106	-1.150	.252
	Animal Fluency	1.192	0.387	0.290	3.084	.003
	Digit Symbol Substitution	0.026	0.179	0.017	0.146	.884
	Trails A	0.028	0.081	0.039	0.346	.730
	Trails B	0.023	0.024	0.117	0.988	.325
	Shipley Vocabulary	0.250	0.321	0.086	0.777	.439
	Total System Use	0.029	0.016	0.160	1.808	.073

Note: Gender was dummy coded with female as -1 and male as 1. Trails A and Digit Symbol Substitution measured processing speed; Trails B measured executive control; Animal Fluency measured verbal fluency; Shipley Vocabulary corresponded to the Shipley Institute of Living Scale which measured crystallized intelligence. Trails A and B were timed measures, meaning that lower scores corresponded to better (faster) performance. For all other cognitive measures, higher scores indicated better performance. Personality variables (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), Total System Use, and Age (years) were coded such that higher values corresponded to greater quantity. Bolding indicates statistical significance ($P < .05$).

previous week’s game use strongly predicted current game use $t(4888.32) = 36.48, p < .001$. Use decreased with time $t(125.42) = -4.13, p < .001$, with this decrease decelerating over time $t(123.41) = 2.03, p = .04$. And previous nongame use also positively predicted current game use

$t(5220.66) = 2.61, p = .01$. This result suggest a mutually beneficial process whereby greater engagement in other activities also supports greater gameplay. Table 8 shows additional statistics for this analysis including the random effects.

Table 6. Regression Analysis Predicting Days of Poker Gameplay With Demographic, Personality, and Cognitive Variables, Controlling for System Use

Days of Poker play						
Model		Unstandardized	SE	Standardized	<i>t</i>	<i>p</i>
1	(Intercept)	37.639	39.345		0.957	.341
	Age	-0.440	0.369	-0.107	-1.195	.235
	Gender	1.986	3.035	0.059	0.654	.514
	Agreeableness	-0.117	1.358	-0.008	-0.086	.931
	Conscientiousness	-0.801	1.102	-0.064	-0.727	.469
	Emotional Stability	-3.103	1.021	-0.301	-3.038	.003
	Extraversion	1.360	0.896	0.134	1.518	.132
	Openness to Experience	1.037	0.989	0.096	1.048	.297
	Animal Fluency	0.561	0.532	0.098	1.054	.294
	Digit Symbol Substitution	-0.236	0.246	-0.110	-0.959	.340
	Trails A	0.221	0.112	0.221	1.985	.049
	Trails B	0.015	0.033	0.054	0.459	.647
	Shipley Vocabulary	-0.115	0.442	-0.028	-0.259	.796
	Total System Use	0.084	0.022	0.330	3.761	<.001

Note: Gender was dummy coded with female as -1 and male as 1. Trails A and Digit Symbol Substitution measured processing speed; Trails B measured executive control; Animal Fluency measured verbal fluency; Shipley Vocabulary corresponded to the Shipley Institute of Living Scale which measured crystallized intelligence. Trails A and B were timed measures, meaning that lower scores corresponded to better (faster) performance. For all other cognitive measures, higher scores indicated better performance. Personality variables (Agreeableness, Conscientiousness, Emotional Stability, Extraversion, Openness to Experience), Total System Use, and Age (years) were coded such that higher values corresponded to greater quantity. Bolding indicates statistical significance ($P < .05$).

Table 7. Mixed Effects Model Predicting Nongame System Use From Previous Week Nongame System Use and Previous Week Game-use

Fixed effects	B	SE	<i>P</i>
Previous Nongame Use	0.34	0.01	<.001
Previous Game Use	0.10	0.02	<.001
Week	-0.07	0.01	<.001
Week Quadratic	0.002	<0.001	<.001
Random Effects			
Subject	8.85	1.23	<.001
Week	0.003	<0.001	<.001
Quadratic Week	<0.001	<0.001	<.001

Table 8. Mixed Effects Model Predicting Game Use From Previous Week Nongame System Use and Previous Week Game-use

Fixed effects	B	SE	<i>P</i>
Previous Nongame Use	0.03	0.01	.01
Previous Game Use	0.44	0.01	<.001
Week	-0.06	0.01	<.001
Week Quadratic	0.02	<0.001	.04
Random Effects			
Subject	3.35	0.47	<.001
Week	0.002	<0.001	<.001
Quadratic Week	<0.001	<0.001	<.001

Discussion

The PRISM trial offered the opportunity to study the gaming behaviors of older adults with minimal computer experience and proficiency in their own homes. After receiving the PRISM system and training, participants were not explicitly told to engage in video gameplay. In answer to the question “Would computer naive older adults spontaneously engage in gameplay?” many participants engaged in gameplay that ranged from casual, low-intensity gaming to frequent and active gameplay. Results suggest that with adequate training and support, even older adults with minimal technology experience can become active gamers. A significant percentage of the participants included in our analyses of gameplay (over 33%) were 80 years of age or older, thus gameplay was not restricted to younger older adults.

Which games were preferred? By far the most popular game was Solitaire. A preference for Solitaire is consistent with a general preference for easy-to-learn casual games (Blocker et al., 2014; de Schutter, 2011). The popularity of Solitaire may relate to the game’s familiarity and shallow learning curve and its inclusion of familiar materials (i.e., cards; Cota and Ishitani, 2014). Many participants may have been familiar with the rules of the classic card game already, consistent with the idea that older gamers may gravitate toward board and card games they learned in childhood (Brown, 2014). Although current computer use was minimal for study participants, any participant with prior computer experience may have been exposed to Solitaire since it was a common feature of many Windows PCs. For example, participants may have been exposed to this game on a computer at work. Solitaire was also one of the games that was demonstrated to participants when

the game feature was first introduced during training precisely because it was predicted to be familiar to many participants. Although this training likely played a role in the game's popularity, it is unlikely to be the only reason. Chinese Checkers was also introduced to participants during training, yet participants played it minimally. Somewhat surprising in light of previously reported preferences for intellectually stimulating games (e.g., Pearce, 2008), Sudoku and Memory were not frequently played games. Perhaps the greater complexity of performing Sudoku with a computer, compared to using paper and a pencil, may have discouraged gameplay.

Would gameplay continue throughout the year-long trial or would gameplay drop off substantially over time? Data indicated that many participants continued to play throughout the entire trial with only a moderate drop-off over time, and that patterns of game preference were relatively stable. However, in answer to the question "Could individual difference characteristics predict gameplay and game preferences?" few predictors were strongly and consistently predictive of gaming behaviors.

Could different types of gamers be identified based on their pattern of gameplay? While overall participants preferred Solitaire, there were clusters of participants with different patterns of gameplay, and individuals within these clusters with idiosyncratic gameplay behaviors (e.g., one participant played Memory on 285 days, Word Search on 61 days, Crossword on 41 days, and little else; another participant played Droplets for 186 days and almost nothing else). These varying patterns of game preference are possibly related to individual differences in motives for gameplay, which we did not assess. De Schutter and Malliet (2014) make the distinction between *contentually* motivated players who play to satisfy cognitive and affective needs, compared to *contextually* motivated players who enjoy games because they enable escapism and distraction. Game motivation may be a much stronger predictor of gameplay and preference than the individual difference variables measured here.

Would gameplay encourage PRISM system use? Data were consistent with games encouraging participants to explore other system features. One intriguing possibility, given the popularity of the games feature within the PRISM system, is that video games might be used as a means to encourage adherence to technology-based interventions (e.g., social support systems such as PRISM, or even telehealth systems). The presence of games may keep participants returning to a system, which may encourage exploration of other features, and might even increase skill and comfort with the system overall (e.g., Solitaire may have provided practice using the mouse, which many of our participants struggled with initially). This idea is consistent with analyses demonstrating that gameplay predicted future nongame feature use. These ideas deserve further investigation (e.g., by explicitly manipulating the availability of system games). The content of an intervention itself might even be gamified

(Seaborn & Fels, 2015), with the type of gamification being based on a participants' game preferences. However, we found it difficult to predict game preferences based on individual difference characteristics. Gender, age, personality, and cognition accounted for little variance with respect to predicting gameplay overall or game preferences.

While results provide some initial insight into the gaming preferences and habits of computer-naive older adults, there are also important study limitations to consider. Older adults were provided a fairly limited set of games, mostly based on classic board and card games. These games do not represent the full diversity of games available, some of which older adults might have found more enjoyable compared to the games available as part of the PRISM system, and many of which they might have found less enjoyable based on the aging and gaming literature. Popular game genres including action, shooter, strategy, role-play, and sports games were not represented, and a lack of game diversity might have limited our ability to detect individual difference predictors of gameplay and game preferences. However, these generally popular game genres (e.g., action games, first-person shooters) may appeal less to older adults because they require quick processing speed which declines substantially with age.

With respect to the design of the PRISM system itself, our primary goal was to support social connectivity (Czaja et al., 2017). Now that we have confirmed that games are a popular feature of the system, this opens up a new and promising avenue to promote social interaction. All games previously available were single-player games, which is consistent with the types of games many older adults report playing (Salmon et al., 2017). Nevertheless, multiplayer games might provide another opportunity for social interaction and support (e.g., Domahidi, Festl, & Quandt, 2014; O'Connor et al., 2015), in addition to more traditional communication tools included as part of the PRISM system. An exciting and emerging area of research is investigating multigenerational gaming, and whether multiplayer games can enhance social bonds between younger and older family members (Comunello & Mulargia, 2017; Osmanovic & Pecchioni, 2016). Meaningful experiences may be gained when young children play games with their parents or grandparents. Gaming might continue to be a valuable parent-child shared activity across the life course, as children grow older and parents age into middle and later adulthood (Brown, 2012). Future studies should investigate whether multiplayer games can help achieve the aims of strengthening multigenerational relationships, reducing isolation and loneliness, and boosting the social support of older adults at risk for social isolation. Future variants of the PRISM system might also include exergames to promote both social interaction and physical health (Loos, 2017).

In conclusion, although a substantial digital divide with respect to aging and gaming persists, the PRISM trial illustrates that this divide can be narrowed under the right circumstances. Minimally computer proficient older adults

were motivated to engage in gameplay, and many played frequently. Critically, the PRISM trial included a number of components to reduce barriers to computer and gameplay adoption. The trial provided the technology needed to engage in video gameplay, technology training, and multiple casual games to choose from, some of which were already familiar to participants and could take advantage of previous knowledge. When barriers to adoption were minimized, many older adults became habitual gamers.

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Conflict of Interest

None reported.

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