

The Difference Between Playing Games With and Without the Computer: A Preliminary View

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ABSTRACT. The authors address the question of whether associations between video games and cognitive and metacognitive variables depend either on the features of the computer or on the content of the game that the computer allows one to play. An experiment to separate these two kinds of effects was carried out by using a traditional version and a computer-supported version of Pegopolis, a solitaire game. The two versions were exactly the same except that they were played by moving pieces either on a real board or on a virtual computer-presented board. The performance levels and strategies followed during the game by the 40 undergraduates who took part in the experiment were not significantly different in the real and virtual conditions. None of the participants transferred playing strategies or practice from one version of the game to the other. Scores were not affected by gender or by the studies pursued by participants, the habit of playing games in the traditional manner or playing video games, or intelligence. Retrospective reports did not support differences in the subjective experience between the two versions. Results showed that video games, when they do not make much use of the computer's special features, produce effects because of the situations they simulate rather than because of features of the computer itself.

Key words: cognitive strategies, individual differences, metacognition, play, practice effects, video games

THE PLAYING OF VIDEO GAMES has increased dramatically over the past 30 years, a fact that has encouraged researchers to study the behavioral, affective, and cognitive characteristics of the players. Video game users tend to prefer competitive activities, challenges, science fiction movies, reading books (McClure & Mears, 1984), and television viewing (Selnow, 1984). The playing of video games has been associated with high levels of aggression (Anderson & Ford,

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1986; Anderson & Morrow, 1995; Cooper & Mackie, 1986; Silvern & Williamson, 1987), hostility (Schutte, Malouff, Post-Gorden, & Rodasta, 1988), impulsivity (Lin & Lepper, 1987), and anger (Mehrabian & Wixen, 1986) and with low levels of prosocial behavior (Chambers & Ascione, 1987; Van Schie & Wiegman, 1997) and tolerance for frustration (Fling, Smith, Rodriguez, & Thornton, 1992). Introverted people expressed a greater preference for video games than did extroverted individuals (Barnett et al., 1997). Video game players scored higher on an *Escape-Solitude Scale* (a scale measuring the tendency to abandon life-roles; Selnow, 1984) than infrequent players. Finally, habitual video game players were found to be brighter (McClure & Mears, 1984), and practiced performance in video games was associated with psychomotor abilities (Yuji, 1996) such as tracking (Bliss, Kennedy, Turnage, & Dunlap, 1991) and with intelligence as measured by IQ tests (Rabbitt, Banerji, & Szymansky, 1989).

However, a crucial question does arise: Do these links between video game playing and psychological dimensions depend—as often claimed (De Kerckhove, 1991; Greenfield, 1994; Herz, 1997; Provenzo, 1991; Turkle, 1984)—on the features of the computer itself (interactivity, multisensory stimulation, immediate feedback, and so on) or on the kind of games the computer allows one to play? For instance, the association between video game playing and preferences for competitive and challenging activities might depend on an inclination to test personal abilities, an inclination that other games or media, not computer supported, might also satisfy. Aggressive traits might lead one to play video games because of their content (which often concerns fights, murders, and so on) rather than because of the *intrinsic features of the computer*.

The distinction between the effects produced by the interaction modalities peculiar to video games and the effects produced by the kind of situations that video games usually present—a distinction that as yet has not been adequately investigated—concerns not only personality and emotional correlates of video game playing but also cognitive and metacognitive skills. In this respect, we may wonder, for example, whether the content of video games (which involves logic or strategic operations) and not the specific computer-based video game interaction format, *might be the reason for the relationship between video games and thinking*.

To understand the peculiar intellectual counterparts of video game use, we need to separate the aspect of the content of a video game from the aspect of the computer-supported nature (the format) of the video game itself. In this study we compared two tasks with the same content experienced in a computer-supported versus a non-computer traditional condition. We examined what happens when a traditional game is played in a computer-supported version, which should allow us to identify possible differences between the traditional and the computer-based version of the game in the strategies followed during the game. We hoped that our experiment might be an interesting benchmark to test the recurrent claim that using computers to play games induces one to activate thinking processes that are peculiar to that tool (De Kerckhove, 1991; Di Sessa, 2000; Herz, 1997;

Provenzo, 1991; Turkle, 1984). This was the main goal of our present study.

We selected Pegopolis, a game for which both a traditional and a computer version were available. The two versions were the same except for the different formats in which they could be played. That is, such a game can be played either by moving pieces on a real board or by moving pieces on a virtual, computer-presented board. We wanted to verify whether the behavior, the strategies, and the attitudes toward a game are significantly affected by the medium used to play it. In fact, if differences between the real and virtual version of the game emerge, they should be attributed to the intrinsic features of the game setting because the two versions have exactly the same content.

Why should the peculiar features of the virtual version of Pegopolis affect game playing? The computer-based version of Pegopolis provides players with a frontal perspective of the board, a more holistic view: All pieces can be simultaneously considered so that the best moves are easily identified and a general strategic approach is prompted. Furthermore, the load needed by eye-hand coordination processes and by motor control is reduced in computer interaction (players have simply to click on the piece to be moved) compared with the real game, so that mental effort can be better focused on reasoning, and movements do not interfere with cognitive activity.

Constraints (that is, rules about illegal moves) are directly embedded in the virtual Pegopolis, and an immediate feedback to each move is given: This releases players from checking for the admissibility of the moves they perform. Also, because moves are physically irreversible in virtual Pegopolis (i.e., once a move is performed, it is not possible to go back and perform a different move), a reflective attitude should be induced. Finally, the virtual version of the game should enhance motivation because of the curiosity and novelty associated with the use of a technological tool.

Our secondary aims in the experiment were to assess differences between the two versions of the game with reference to possible practice effects along trials and transfer effects from the real to the virtual version of the game and vice versa. We were also interested in studying possible links between performances in the real and virtual game and individual differences (gender, studies pursued, traditional game and video game playing habits). Finally, we investigated the relationships between behavior in the real and virtual Pegopolis and intelligence. We expected that high levels of cognitive ability would lead individuals to activate the most efficient strategies to reach the goal of the game.

Method

Participants

Forty undergraduates (20 men and 20 women) took part voluntarily in the experiment: 45% were students in humanities and 55% were in scientific disci-

plines; 52.5% were game players and 47.5% were nonplayers; 47.5% were habitual video game users and 52.5% were nonusers (the last two distinctions were based on responses given in an interview and on the median of the distribution of rates as the cutoff point).

We assigned the students randomly either to the real–virtual (R–V) or to the virtual–real (V–R) condition so that gender, the kind of course attended, and traditional and video game habits were homogeneously distributed. Mean ages (respectively, 23.1 and 23.4) were approximately the same in the R–V and V–R groups.

Materials

Pegopolis is a board game in which the board is divided into 37 squares; 36 pieces are arranged so that the central square is empty. The goal is to try, by piece jumping, to remove as many pieces from the board as possible. You are only allowed to move a piece from an occupied square to an unoccupied square, directly opposite, jumping over a piece to capture it. Only vertical and horizontal jumping is allowed. Pieces can be moved only by jumping over another piece. The captured pieces are removed from the board. The game is over when there are no more jumps available. It is not possible to modify an already performed jump.

In the real version, the game is played on a wooden board in which the 37 squares are delimited by horizontal and vertical lines; within each square there is a hole in which a small peg is fitted. In the virtual version, the game is presented on a computer screen reproducing the board with the pieces (from an aerial perspective); by means of the computer mouse it is possible to select a piece and to drag it to an empty square by jumping over an adjacent piece.

Procedure

We asked potential participants to take part in an experiment about differences in playing a solitaire game performed on a traditional and on a computer-supported board. Participants were shown the board of the game and were asked whether they knew that game; those who did were excluded from the study. We preceded the trial session (which lasted about an hour) by individual interviews with the participants concerning their leisure time activities. We asked them to rate on a 5-point-scale how frequently and for what purposes they used a computer; they were also asked to rate how frequently they played video games; finally, we asked them to rate how frequently they spent time playing traditional games (cards, chess, checkers, and so on).

Afterward they were presented instructions for Pegopolis. Four successive trials were played according to the condition assigned: In the R–V condition, participants played two Pegopolis trials with the real version and then two trials with the virtual version; in the V–R condition, participants played the first two trials with the virtual version and then two trials with the real version. There was no time limit.

After the experiment, we asked participants to describe the strategies they had used in playing Pegopolis and their opinions about possible differences they found between the real and the virtual version of the game. Finally, participants were administered the Progressive Matrices (PM38) by Raven (1938), a culture-free intelligence test, according to the standard procedure devised for this instrument.

Results

We measured (in seconds) and recorded the time spent in each trial. During the game we observed each participant and recorded each move. Moves were classified either as *central jumping* or as *peripheral jumping*. Central jumping was moving a piece so that it occupied an empty square situated in the 3×3 central area of the board; peripheral jumping was moving a piece so that it occupied an empty square outside such an area. At the end of each trial we counted the number of pieces remaining on the board; they were classified either as *central residuals* if they were located in the 3×3 central area of the board or as *peripheral residuals* if they were located outside this area.

Obviously, central moves are associated with a higher probability of success than peripheral moves because the former and not the latter prevent pieces from being isolated along the perimeter area of the board. Thus, relatively high numbers of central residuals and low numbers of peripheral residuals indicate a better strategic approach because they avoid the isolation of pieces which can never again be moved.

Table 1 contains the values of the dependent variables (computed by summing scores in each couple of trials) in the real and virtual versions of the game. We carried out this analysis by including in the real version set of data the first two trials of the R-V group and the third and fourth trials of the V-R group and by including in the virtual version set of data the third and fourth trials of the R-V group and the first and second trials of the V-R group. (This was possible because of the lack of order effects.) The only significant difference between the two versions was the time used to play the game; the virtual version was played faster.

We analyzed order effects by assuming the number of trials as a within-subject independent variable and the time spent, the number of jumps (total, central, and peripheral), and the number of residuals (total, central, and peripheral) as dependent variables. A repeated-measure model of analysis of variance revealed no significant differences among the first, second, third, and fourth trials. No differences in the strategies undertaken between the two trials of the same (real or virtual) couple emerged. Finally, analyses revealed no transfer effects from the real game (by summing scores of the first two trials of the R-V group) to the virtual game (by summing scores of the third and fourth trials of the R-V group) and vice versa (by summing, respectively, scores of the first and second trials of the V-R group and the third and fourth trials of the V-R group).

TABLE 1. Measures of Performance in the Pegopolis Game Under the Real and Virtual Conditions

Performance totals	Condition				<i>t</i> (39)
	Real		Virtual		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Time (seconds)	410.32	217.23	341.64	159.92	2.44*
Number of jumps	55.12	3.99	53.86	5.02	1.18
Number of central jumps	18.00	2.87	17.83	2.41	0.56
Number of peripheral jumps	39.07	4.15	38.52	4.40	0.91
Number of residuals	13.99	3.63	15.07	4.14	-1.55
Number of central residuals	4.03	1.98	3.85	1.78	0.62
Number of peripheral residuals	11.03	3.12	12.65	2.89	-1.01

* $p < .01$.

Performances in Pegopolis were not significantly affected by gender [time: $t(38) = 0.32, p = .75$; number of central jumps: $t(38) = 1.80, p = .08$; number of peripheral jumps: $t(38) = 1.91, p = .06$; number of central residuals: $t(38) = 0.86, p = .39$; number of peripheral residuals: $t(38) = 0.78, p = .44$], course of study [time: $t(38) = 1.05, p = .30$; number of central jumps: $t(38) = 0.68, p = .50$; number of peripheral jumps: $t(38) = 0.60, p = .55$; number of central residuals: $t(38) = 0.71, p = .48$; number of peripheral residuals: $t(38) = 0.89, p = .38$]; habits concerning playing traditional games [time: $t(38) = 1.55, p = .13$; number of central jumps: $t(38) = .52, p = .60$; number of peripheral jumps: $t(38) = 0.35, p = .73$; number of central residuals: $t(38) = 0.26, p = .80$; number of peripheral residuals: $t(38) = 0.17, p = .86$]; and habits concerning playing video games [time: $t(38) = 1.41, p = .17$; number of central jumps: $t(38) = 0.09, p = .93$; number of peripheral jumps: $t(38) = 0.35, p = .73$; number of central residuals: $t(38) = 1.22, p = .23$; number of peripheral residuals: $t(38) = 1.42, p = .16$].

No significant differences (as assessed by t tests not reported here for reasons of space) emerged in the scores computed separately for each trial and those computed by summing the scores, respectively, in the two real and in the two virtual trials. Analyses revealed that general intelligence levels were not significantly different in men and women [$t(38) = 1.59, p = .12$], by humanities or scientific courses of study [$t(38) = 0.00, p = 1.00$], or for the traditional game [$t(38) = 1.76, p = .09$] or the video game [$t(38) = 1.86, p = .07$] players and nonplayers.

We divided the participants into two subsamples according to their performances on the progressive matrices. We considered both the total score and the

TABLE 2. Correlations (Spearman's ρ Coefficients) Between Measures of the Performance in Pegopolis Game

Measure	Number of jumps	Number of central jumps	Number of peripheral jumps	Number of residuals	Number of central residuals	Number of peripheral residuals	PM38 score
Time	.19	-.09	.17	-.21	-.21	-.11	.33
Number of jumps		.24	.75*	-.34	-.27	-.81*	-.01
Number of central jumps			.02	-.01	-.30	.13	.12
Number of peripheral jumps				-.61*	.11	-.72*	.10
Number of residuals					.17	.68*	-.02
Number of central residuals						-.09	.05
Number of peripheral residuals							.23

Note. PM38 = Progressive Matrices

* $p < .01$.

partial score in the series E of the test (that is, the most discriminative subscale). According to each score, students were classified as of low or high intelligence by assuming the median of the distribution of the scores as the cutoff point (respectively, scores 52 and 7). Low and high intelligence participants—identified on the basis of the total progressive matrices scores—were not different either in the overall measures computed by considering the four trials [time: $t(38) = 0.60$, $p = .55$; number of central jumps: $t(38) = 1.98$, $p = .06$; number of peripheral jumps: $t(38) = 1.55$, $p = .13$; number of central residuals: $t(38) = 1.17$, $p = .25$; number of peripheral residuals: $t(38) = 0.90$, $p = .33$] or in any of the measures recorded separately for the real and virtual version of the game. The same was true when we classified the students as low or high in intelligence on the basis of the scores recorded in the series E of the test.

No clear pattern of correlations between measures of the performance in the game emerged (see Table 2), except for the fact that the number of moves was, as is obvious, negatively associated with the number of residuals. Correlation matrices (not reported) computed by considering separately the real and virtual trials were approximately the same and did not differ from the matrix of scores computed by considering all trials.

In the final interview, students reported that they had used the following strategies: (a) playing without planning how to move the piece, (b) trying to clear the corners of the board, and (c) trying to move the pieces toward the center of the board. A few participants described other strategies (e.g., trying to put pieces in adjacent positions). Frequencies of participants who followed each of these strategies were not significantly associated with their performances in the Pegopolis game, either with the version (real or virtual) of the game or with individual differences (gender, course of study, habitual playing of traditional games or video games).

When asked to identify possible differences between the real and virtual versions of the game, students reported, irrespective of the condition (R-V or V-R) they were assigned to, that playing the game by means of the computer was easier (35% of the respondents) and faster (30%) than playing it on the wood board and that the view offered by the computer was better (40%). No differences in the emotional impact of the two versions of Pegopolis were reported.

Discussion

Results showed that no significant difference between the real and virtual versions of Pegopolis emerged, except for the fact that playing the game with the computer was faster and easier than playing it on the wooden board. Because performances were analyzed using a within-subject experimental design, no effects of individual characteristics should influence their performance in the game. For instance, participants who were good at playing Pegopolis or who carried out moves very quickly could show their skills in both the real and the virtual version of the game.

The numbers of jumps and of residuals were approximately the same in the two conditions, and also the kind of jumping preferred by participants (central or peripheral) was similar in the real and in the virtual game. Thus, our detailed analysis of the participants' behavior during the game did not support the notion that playing a game with the computer involves any differences compared with the traditional, non-computer-supported setting, except for the fact that the computer version reduced the time for moving the pieces.

No effect emerged that might have been a result of the repeated experience with the game across trials. We found no significant improvements or changes in strategy when comparing performances in the four trials, performances within each couple of trials carried out with the same version of the game (real or virtual), or performances in the first two trials (real or virtual) and in the second two trials (virtual or real). Performance in Pegopolis does not seem to be affected by practice, and no transfer from the real to the virtual game or vice versa occurred. It is possible that, over the four trials, detrimental effects arose, such as a lack of interest or of motivation in the last trials because of repeated exposure to the same game.

However, we noticed that none of the participants reached the goal of the game in any of the trials, so that they were always motivated to achieve better results in the subsequent trials. Also, we were induced to exclude possible effects of this kind on the basis of our observation of participants' behavior. No students asked to stop the trials, appeared to get bored, or showed reduced interest in playing Pegopolis; on the contrary, the challenging features of the game were appreciated, and at the end of the experimental session several participants asked whether it was possible to carry out further trials.

The lack of a significant relationship between Pegopolis scores and individual differences was supported by the wide set of analyses carried out. No variable that we investigated (gender, course of study, or the habitual playing of traditional games and video games) affected performance. Pegopolis appears to be a game in which previous experience with other games and video games has no role. However, because of the design of this experiment, in which we used participants who had never played Pegopolis before, we could not assess the influence that the specific previous experience in playing Pegopolis might exert. Nevertheless, Pegopolis seemed to be particularly relevant in highlighting possible effects because of the specific format (traditional or computer supported) in which the game is presented.

Intelligence, as measured by Raven's (1938) Progressive Matrices, was not linked to Pegopolis. More precisely, no distinct pattern of association between the cognitive level of the participant and game performance emerged when we considered the real and the virtual versions separately. This finding leads us to suspect that the relationship between intelligence and video game playing reported in the literature depends on the content of the game (which involves—like many other, non-computer-supported games—thinking skills such as analyzing, planning, comparing) rather than on the computer setting.

There might be questions about the power of the statistical tests we used to assess the significance of the differences recorded in the study. We computed power statistics for each *t* test that we carried out both to compare mean scores in the real and virtual conditions (paired samples) and to identify possible effects of gender, course of study, traditional and video game habits, and intelligence level (independent samples). We obtained values ranging from .41 to .73. These values, though not very high, seem to be quite good. Thus, we maintain that the lack of significant differences that we found was not due to the failure of statistical tests.

Finally, the experiment casts doubt about the grounds of some links between video game playing and thinking. In fact, a pure "computer effect" did not emerge. Playing a game with the computer and playing the same game with traditional materials produced no differences either in the performance levels or in the reasoning strategies that were followed. This lack of differences was also supported by retrospective reports by participants who did not notice relevant changes in their experience when they moved from the real to the virtual version of the game or vice versa.

Thus, converging evidence suggests that the relationships between video games and intellectual variables do not depend on the characteristics of the computer itself but on the features of the situations that the computer simulates. However, we must not forget that this conclusion is grounded in the analysis of only one kind of computer game; thus, it is possible that other video games would give different results. Further studies might allow us to generalize the present findings.

A second limitation of the experiment concerns features of the game we used. The virtual version of Pegopolis does not take advantage of many opportunities that the computer offers. To the extent that a video game does not benefit from the most interesting and innovative features of the computer, it appears to be of secondary importance to study the psychological changes that playing a video game on the computer brings about. However, to the extent that a video game shares unique features of the computer, it is difficult—perhaps impossible—to find an equivalent comparison condition useful to assess how the computer specifically influences cognitive processes.

This is a dilemma that cannot be easily solved. We chose the equivalence of conditions over the loss of the completeness and salience of the computer features. We argue that this choice was useful to acquire some preliminary results that lead us to conjecture that differences in cognitive and metacognitive processes are produced by the computer only if it opens opportunities that are completely different from traditional media, for instance by permitting one to perform actions and transformations which cannot be carried out in the physical world (Antonietti & Cantoia, 2000); otherwise, as the literature about learning suggests (Clark, 1983), it is unlikely that the computer experience will lead people to think in qualitatively new ways.

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