PC-based Game Features that Influence Instruction and Learner Motivation

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James Belanich

U. S. Army Research Institute for the Behavioral and Social Sciences

Kara L. Orvis

Consortium Research Fellows Program

U. S. Army Research Institute for the Behavioral and Social Sciences

Daragh E. Sibley

Consortium Research Fellows Program

George Mason University

Abstract

PC-based games are currently being used for training, but the instructional and motivational features of such technology are not well understood. To identify features of training games that influence instruction and motivation, a popular first-person-perspective game with an Army theme was analyzed empirically. Twenty-one participants played the “basic training” portion of the game, which included Army background information, virtual marksmanship training, an obstacle course, virtual weapons familiarization, and an urban terrain training mission. After playing the game, participants answered questions regarding information presented during the game and about motivational aspects of the game. Participants recalled procedures better than facts. Information relevant to the progression of the game was recalled better than information irrelevant to player progression. Graphic images and spoken text were recalled more accurately than printed text. Motivational factors identified by participants as influencing their likelihood to continue playing the game were: challenge (not too hard and not too easy), realism (audio-visual realism and adhering to laws of nature), exploration (opportunity to discover new things), and control (manipulating the virtual environment through keyboard/mouse interface). The results of this research provide useful information to individuals developing training games, desktop simulations, and interactive multimedia courseware.

PC-based Game Features that Influence Instruction and Learner Motivation

PC-based games can be used for training purposes (Garris, Ahlers, & Driskell, 2002; Herz & Macedonia, 2002; Ricci, Salas, & Cannon-Bowers, 1996; Rieber, 1996). Some of this research demonstrated that specific skills can be trained with PC-based games (Prensky, 2001; Rieber, 1996; Sims & Mayer, 2002), while other research showed that training games can teach generalized skills like troubleshooting (Knerr, Simutis, & Johnson, 1979) and visual attention (Gopher, Weil, & Bareket, 1994; Green & Bavelier, 2003). When comparing text-based and PC-based game instruction, Ricci et al. found that skill retention and satisfaction with the training could be improved by converting text-based instruction to a PC-based game format; demonstrating that PC-based games can be effective training tools.

While research has indicated that PC-based games can be effective for instruction, it has not been clear which specific features of games promoted learning or motivation to continue using the game. In a recent experiment, Garris et al. (2002) used a simulation to compare the inclusion of game features such as a high rate of interactivity, scoring, and audio/visual effects against the simulation without such features. They found that the inclusion of these game features improved training outcomes. While Garris et al. identified a set of game features that influence training effectiveness, they did not distinguish between the training impact of each individual feature. The goal of the current research is to determine specific instructional features (how information or concepts are presented and integrated into the game) and motivational features (what keeps users playing the game) that influence the training effectiveness of PC-based games. The focus of the current research is first-person-perspective games, where the player sees on the display what the character would see in the game environment. First-person-perspective games tend to involve high-quality graphics and sound effects providing an immersive feel to players.

Instructional Aspects

Although little research has been conducted on the specific components of PC-based games that influence instructional effectiveness (Garris et al., 2002), there is a broad base of research on interactive multimedia available (Chandler & Sweller, 1992; Clark, 2000; Craig, Gholson, & Driscoll, 2002; Harp & Mayer, 1998; Mayer, Heiser, & Lonn, 2001; Mayer & Moreno, 1998; Moreno & Mayer, 2002; Mousavi, Low, & Sweller, 1995; Schraw, 1998; and Tindall-Ford, Chandler, & Sweller, 1997). Both PC-based games and interactive multimedia share common characteristics, such as audio/visual presentation and user interaction. It is reasonable to assume that results of much of the interactive multimedia research may be applicable to PC-based training games

As shown by Moreno and Mayer (2000), how information is presented can directly impact the learning that takes place. One objective of the current research was to evaluate the instructional value of different forms of information presentation. In the current research, we assessed how information was presented along three different dimensions: (a) type of information, (b) relevance to game play, and (c) mode of presentation.

Type of information. Tulving (1972, 1983), Cohen and Squire (1980), and Squire (1987) classified memories into different types. While their work focused on memory, the same terms can be used for how information is presented in an instructional setting. For this research we focused on three specific types of information: procedural, episodic, and factual. These three types of information coincide with Dale's (1946) continuum of teaching methodologies, which includes doing, observing, and symbolizing.

For instructional purposes, learners potentially acquire procedural information when they actually perform a task (doing). Learners potentially acquire episodic information when they experience an event as an observer (observing). Learners potentially acquire factual information when they are provided semantic-based (language-based) information (symbolizing). In a PC-based first-person-perspective game a player could learn information conveyed three different ways: a) attempting the task while receiving game feedback (procedural), observing the game environment (episodic), or the player could be provided printed or spoken text (factual). One of the objectives of the current research was to determine the relative training effectiveness related to these types of information in the context of a PC-based first-person-perspective game.

Relevance to game play. During instruction, some of the information presented may be directly relevant to the instructional objectives, while other information may be tangential. The inclusion of non-relevant information, like jokes or non-sequiturs, can make the instruction more interesting, but what is the impact on the training effectiveness?

Research has not been favorable to adding irrelevant information. Lower levels of retention and transfer on important information occurred when interesting but irrelevant information was added to multimedia presentations (Harp & Mayer, 1997, 1998; Mayer et al., 2001). While these researchers illustrated that irrelevant information can distract learners viewing multimedia presentations, no research has investigated the inclusion of irrelevant information in PC-based first-person-perspective games. One of the objectives of the current research was to assess the recall of information that was relevant and was not relevant to player progression through the game.

Mode of presentation. In a PC-based first-person-perspective game environment, players can receive information through both audio and visual modalities. Also, visual information can be presented as text or objects. Training game developers have a broad range of options in how they present material, and one objective of the current research was to assess the impact of how the information was presented.

No research to date has assessed the effect of presentation mode on information recall in the context of PC-based games, while research in multimedia instruction seems to be mixed. Tindall-Ford et al. (1997) and Leahy, Chandler, and Sweller (2003) found that when audio and visual information are complementary to one another they are more effective than either one by itself. Mayer and Moreno (1998) found that students retained identical text from multimedia instructional presentations better through audio channels than through visual channels. Conversely, in some situations, printed text may be superior to audio text. Eberman and McKelvie (2002) found that when asked to visualize the images related to the text, the content of printed text was recalled better than audio information. These differences may be due to the training environment used. The current research further investigated which modes of presentation improve learning in the specific learning environment of a first-person-perspective training game.

Motivational Aspects

The rationale behind training through games is that the act of playing a game will motivate the learners to continue playing, thereby continuing to learn. Training motivated learners is far easier than training non-motivated learners (Prensky, 2001). If information is embedded in the game, than continued playing should result in more material being introduced to the learner. For the current research, the objective was to identify features of a first-person-perspective game that motivate users to continue playing. An understanding of motivating features may allow game designers to keep learners engaged in the training activity for extended periods.

In a series of experiments, Malone (1981) and Malone and Lepper (1987) identified four features of PC-based games that influenced player motivation. The four features were: (a) *challenge* - the activity provides an intermediate level of difficulty; (b) *control* - the ability to determine the outcome of events based on the player's actions; (c) *curiosity* - the belief that the player will uncover something new; and (d) *fantasy* - the feeling that players are engaging in an activity that is not real. In the current research, we identified characteristics of a particular first-person-perspective PC-based game that may influence motivation to continue playing.

Method

Participants

Twenty-one individuals participated in the experiment. The average age of the participants was 20.4 years old, with a range from 17 to 29. While all of the participants had made a commitment to the U.S. Army (newly enlisted or Reserve Officers Training Corps), none had gone through basic training.

Apparatus

The America's Army game was used as the platform for this experiment. The game was developed by the Office of Economic and Manpower Analysis at the United

States Military Academy as a recruiting tool to inform the “recruiting age” public about the U.S. Army. The minimum system requirements for America’s Army include: Microsoft Windows 98/ME/XP/2000, a Pentium III processor running at 700 MHz with 128 MB of RAM, 1.5 GB of hard drive space, and an internet connection.

The game is a PC-based first-person-perspective game where players go through virtual “basic training” and then complete on-line military missions as part of a team. The game has been popular; with over 2 million registered players in just over a year (http://www.americasarmy.com). Based on this volume of usage, players certainly appeared motivated to play America’s Army game, and therefore, was a good platform to identify some features that motivate users to play. Also, given that the game was designed to inform the players about the U.S. Army, the influence of game characteristics on learning could be assessed.

Procedure

Pre-game data collection. Participants were first asked to complete demographic questions and a nine-item multiple-choice questionnaire to measure prior knowledge about the game and the U.S. Army. Each item had five probable answers including an “I don’t know” choice.

Play game. Participants played the first four sections of the game: a) marksmanship training, b) an obstacle course, c) weapons familiarization, and d) a MOUT (military operations in urban terrain) training mission. The marksmanship section began with a printed text description, followed by instructions on tasks like loading the gun and the number of targets they needed to hit to qualify with their weapon. The practice and qualification rounds were repeated until the participant qualified (at least 23 out of 40 targets with 40 rounds). The obstacle course began some printed text followed by instructions for player movement given verbally by the virtual drill instructor while the player completed the course on a practice run. The obstacle course included obstacles like climbing over a wall, running over a balance beam, and low crawling under barbwire. Each player repeated this until they met the time limit of 90 seconds. The weapons familiarization section provided the players with the opportunity to use four different weapons: a machine gun, a rifle with a grenade launcher, fragmentation grenades, and smoke grenades on a firing range. The MOUT training section required players to navigate through a building and various tunnels while shooting at stationary silhouettes of combatants, distinguishing them from the silhouettes of innocent bystanders. This section introduced “rules of engagement”, which dictated that one was to only shoot “hostile” targets, while not shooting “noncombatant” targets.

Post-game data collection. Upon completion of “Basic Training” each participant completed a 35-item multiple-choice questionnaire on information presented during the game. As with the pre-game questionnaire, each multiple-choice question had five possible answers. Nine of the multiple-choice questions were repeated from the pre-game questionnaire, so the remaining 26 were used to assess instructional features. Also included were four open-ended questions, which were used to assess game characteristics that influenced motivation. The questions covered what the players liked and disliked about the game and what would keep them playing the game.

The 26 multiple-choice questions appearing only in the post-game questionnaire were classified along three instructional characteristics: type of information, relevance of information to game play, and mode of presentation. Items were classified as belonging to different subsets of information type using the following definitions: (a) procedural – cognitive or motor skills and activities; (b) episodic – experiential memories of sensation, perception, and past events; and (c) factual - facts and concepts represented by text and symbols. For relevance to game play, items were classified as belonging to the subsets defined as: (a) relevant – information that is required or helpful to progress in the game and (b) irrelevant – information that does not impact on progress in the game. Finally, items were classified by their mode of presentation using the following subset definitions: (a) spoken text – narrated information, (b) printed text – printed information, and (c) graphic images. Five questions on the post-game questionnaire assessed information that was presented through more than one modality, so only 21 questions were used in the assessment of the effect of presentation modality.

Two of the researchers separately classified each of the items into their appropriate information type, relevance, and presentation mode categories. The initial inter-rater agreement [agreements/(agreements + disagreements)] for the characteristics of information type, relevance to game play, and mode of presentation were deemed acceptable at .91, .89, and 1.0, respectively. The items that authors disagreed on initially were then discussed until a mutual consensus for categorization was reached.

To assess motivation, responses from the open-ended questions were grouped into four categories based on previous research (Malone, 1981; Malone & Lepper, 1987) and the terms used by the participants in their responses. These categories were: challenge, control, realism, and exploration. Challenge was defined as a response that discussed accomplishing required tasks or goal achievement (e.g., “it was fun trying to complete the obstacle course in only 90 seconds”). Control was defined as a response regarding the interaction of the player with the game environment (e.g., “I enjoyed seeing the targets fall when I shot them”). Realism was defined as responses about elements that made the game experience more representative of a real-life experience. This category included comments about the games high visual and audio fidelity, as well as responses about realistic weapons and procedures. Exploration was defined as responses that mentioned the process of discovery and novel sensory stimulation (e.g., seeing a new weapon or participating in a new activity like MOUT).

Two researchers independently coded all responses to the open-ended questions, and the inter-rater agreement for questions about what motivated participants to continue playing and questions about what failed to motivate were deemed acceptable at .81 and .87, respectively. The responses that coders initially disagreed on were then discussed until consensus was reached.

Results

Pre-game data

The nine pre-game questionnaire items were used to determine whether participants were naïve to the information presented during the game. The mean score for the pre-game questionnaire was 19.6% with a standard deviation of 16.4% (range = 0-56%), indicating that participants were not familiar with much of the information.

Information Type

Three types of information were assessed through the post-game questionnaire: procedural, episodic, and factual. Of the 26 items used to assess information type, 6 were classified as procedural, 8 as episodic, and 12 as factual. The percentage of questions answered correctly for each subset of information type are displayed in Figure 1. The Ibars indicate the standard error. For procedural information, across all participants the mean percentage correct was 77.9% with a standard error of 5.3%. For episodic information, the mean was 70.5% with a standard error of 3.1%. For factual information, the mean was 62.9% with a standard error of 4.3%. The difference between the mean accuracy scores was significantly different (one-way ANOVA, F=4.0, p= .026). A Tukey pairwise comparison found a significant difference between the procedural and factual means (p< .05). Using Cohen's d [Cohen's d = (Mean$_1$-Mean$_2$)/standard deviation $_{\text{pooled}}$], the effect size between procedural and factual was .73. The effect size between episodic and factual was .37, and the effect size between procedural and episodic was .36.

Relevance to Game Play

Questions from the post-game questionnaire were categorized as either relevant or irrelevant to player progress through the game. Of the 26 questionnaire items, 16 were classified as relevant, while the remaining 10 were classified as irrelevant.

The percentage of questions answered correctly for each relevance category is displayed in Figure 2. For relevant information, the mean accuracy score was 72.3% with a standard error of 3.6%. For irrelevant information, the mean was 58.7% with a standard error of 4.8%. Relevant information was recalled at a statistically significant higher level than irrelevant information (paired sample t-test, t=2.29, p>.01). Using Cohen's d, the effect size between relevant and irrelevant was .65.

Presentation Modality

Of the 21 questions used to assess presentation modality, 6 were classified as graphic images, 4 as spoken text, and 11 as printed text. Five questions were not used in the analysis of this variable, because the information was presented in more than one modality. The percentage of questions answered correctly for each category of presentation modality is displayed in Figure 3. For graphic images, the mean was 79.1% with a standard error of 3.4%. For spoken text, the mean was 73.8% with a standard error of 5.0%. For printed text, the mean was 57.1% with a standard error of 4.3%. The difference between the mean scores based on modality of presentation was significantly different (one-way ANOVA, F=9.3, p<.01). A Tukey's pairwise comparison identified a significant difference between graphic images and printed text (p<.01) and a difference between spoken text and printed text (p<.05). Using Cohen's d, the effect size of the difference between graphics and printed text was 1.02, while the effect size for spoken text verses printed text was .77. The effect size for the difference between graphics and spoken text was .25.

Motivation

Features that motivate. There were 25 responses to the two open-ended questions assessing the motivational features of the game. Not all participants responded to the questions used to assess motivation, and some participants wrote more than one response. Twenty of the responses were coded into one of four categories; nine mentioned realism, six mentioned challenge, three mentioned exploration, and two mentioned control over the game environment. Additionally, there were five responses that did not clearly express a reason why the game was motivating; they were either tautological (i.e., "I liked it because it was fun") or statements that they found no part of the game motivating.

Features that did not motivate. There were 25 responses to the two open-ended questions assessing the non-motivational aspects of the game. Eighteen of the responses were coded into one of the following categories, eight responses mentioned a lack of control, five mentioned the game not being challenging enough, three stated that the game was too challenging, and two mentioned a lack of realism. Seven responses did not clearly express reasons the game was not motivating.

Discussion

Instructional Characteristics

Information type. In the current experiment, subjects recalled procedural information at a higher rate than factual information. This suggests that in the context of PC-based first-person-perspective games, procedural information was learned better than factual information. The current research supports Dale's (1946) guidelines that what is done (procedural) is learned best, followed by what is observed (episodic), and symbolic information (factual) is least likely to be learned.

While participants performed better on procedural and episodic questions, factual information was still recalled. Some instructional information will be naturally structured as factual information; therefore, factual information should not be disregarded completely but should be used in a targeted manner.

Relevance. In the current experiment, information that was relevant to the progression of the game was recalled more accurately than information tangential to player progression. This suggests that training game developers should incorporate learning objectives into the storyline of the game. If the training objectives are not part of the game's storyline, the player may remember how to play the game instead of learning the training objectives.

Beyond the beneficial effect that relevant information may have, there may also be a damaging effect of having information that is not relevant to the topic of instruction.

It has been demonstrated in multimedia instruction research that the inclusion of non-relevant details can be distracting and have detrimental effects on learning (Harp & Mayer, 1997, 1998; Mayer et al., 2001). This suggests that the inclusion of irrelevant information may impede the learning of the relevant information.

Mode of presentation. Findings indicate that spoken text and graphic images were recalled more accurately than printed text. This extends previous findings of Mayer and Moreno (1998) to a first-person-perspective game, where they found that students retained text from multimedia instructional presentations better through audio channels than through visual channels.

Given our findings, one may think that only graphic images or spoken text, and not written text, should be used for instruction in this medium. However, for several reasons, this may not be the case. First, a casual observation during the experiment indicated that some participants skimmed or ignored full pages of text by merely clicking on “next” to proceed to the next page without ample reading time. This suggests that large blocks of written text may be ignored by some players and may account for these findings. For the spoken text, the players did not have the ability to skip past the information. The differences may be influenced by whether or not participants received the information rather than how it was displayed. Future research should investigate this difference. Secondly, previous research has shown that when audio and visual information are complementary to one another they are more effective than either one by itself (Leahy et al., 2003; Tindall-Ford et al., 1997). Therefore, the combination of text and graphic images, whereby one complements the other, may be an effective way to provide instruction.

Motivation Features

Based on the responses of the participants to the open-ended questions, there were four game features that influenced motivation to continue playing: challenge, realism, control, and exploration. These four categories are similar to those presented by Malone (1981) and Malone and Lepper (1987), which were: challenge, fantasy, control and curiosity.

Challenge. Across features that positively and negatively affected motivation, challenge was the most frequently mentioned. This indicates the potential importance of attaining an optimal level of difficulty so as to motivate participants, a finding that is in line with Malone (1981) and Malone and Lepper (1987). Malone stated that an optimal level is reached when a participant finds an activity difficult, without finding it overwhelming. If the task is too simple and the person is guaranteed success, it may be perceived as boring, and if it is too difficult, the individual may become frustrated (Rieber, Davis, Matzko, & Grant, 2001).

Control. In this experiment, only a few responses mentioned control as a motivating feature (2), while a larger number of responses (8) identified a lack-of-control as being a negative feature and potentially non-motivational. The prevalence of negative remarks relative to positive remarks suggests that either a sense of control was more frequently absent than present in the game or that subjects have a tendency to notice the absence of control more then its presence. In either case, the data suggest that training designers should provide players with a sense of control over the game environment.

Malone and Lepper (1987) suggested that controlling one’s environment is a motivating factor contributing to enjoyment of PC-based games. For instructional purposes, the motivation to continue playing might translate into completion rates. Previous research found that students who felt more in control of their environment had higher completion rates of courses than individuals who did not feel in control (Dille & Mezack, 1991; Parker, 2003). Therefore, it is likely that individuals may be more willing to persist in a training game if it endows them with feelings of control. Additionally, research has shown that control in virtual environments leads to increased learning about objects in that environment (James, Humphery, Vilis, Corrie, Baddour, & Goodale, 2002).

Realism. Realism was the most commonly mentioned reason to continue playing the game. Some participants also mentioned that a lack of realism was a reason that they did not find parts of the game motivating, suggesting that realism is an important feature of first-person-perspective games. It could be argued that the realistic nature of the game promoted the immersive feeling that individuals were engaged in something beyond just playing a game. The immersive nature of the game could be motivational in a training game because it provides a context for the learning activity that provides experiences not otherwise readily available to an individual (e.g., qualifying with a rifle, throwing a grenade, or completing an obstacle course), all while sitting in front of a computer.

In addition to motivational benefits, realistic training environments have been linked with increased transfer of training (Auffrey, Mirabella, & Siebold, 2001; Detterman, 1993; Thorndike & Woodworth, 1901). Given that the purpose of training games are to improve performance on an actual task, the games should realistically represent the elements of the real-world environment that are pertinent to the instructional objectives of the training game.

While realism may be beneficial, training game developers should be wary of overly investing resources in graphics and audio realism. High fidelity graphics and audio can be expensive to produce, and it appears that there are diminishing educational returns from high fidelity systems (Baum, Riedel, Hays, & Mirabella, 1982; Freda & Ozkaptan, 1980; Morris & Tarr, 2002). For example, Morris and Tarr (2002) found that quality of decision-making actually decreased with higher levels of graphics. This suggests that while realism is a feature that may motivate players, there is a limit where greater levels of realism may no longer increase the effectiveness of a training game.

Exploration. Proper use of exploration was mentioned as motivational, but was not mentioned as un-motivational. There are two possible explanations for this finding. First, this particular game could have stimulated adequate levels of exploration for all individuals. The second possible reason is that individuals might not readily notice inadequate levels of exploration; therefore they would not report the absence of exploration. Whatever the reason, future research should investigate the role of exploration in learner motivation.

The feature of exploration is similar to Malone's (1981) curiosity. Malone considers curiosity to occur when an individual searches out knowledge gaps. Researchers have suggested that curiosity is a fundamental and powerful human drive to acquire novel information, for no immediate external purpose and thus for no immediate external reward (Kashdan & Fincham, 2002). Thus, this particular motivational element in a PC-based game is naturally entwined with the learning process and may be harnessed for instructional purposes.

Optimal levels of game features. Of the four motivational features mentioned as reasons for continuing to play the game, three of those features were also mentioned as reasons for not continuing to play the game. This indicates that not all of the four motivational features were at optimal levels. For example, with regards to challenge, some individuals identified sections of the game as too difficult, while others identified sections as too easy. An attempt to identify a single optimal level of any one of these features would be difficult because preference varies across individuals. Differences in individual preference for control, realism, exploration and challenge could originate from a myriad of sources, such as culture, current mood, hand-eye coordination, past play experiences and visual preferences. Because of individual differences and specific training requirements, a system that allows for the variation of these levels may be beneficial to learner motivation.

The variation of these systems may take many forms. One option is to allow the player to set the level of the particular game feature. A second option is where an instructor would select the level based on the instructional objectives. A third mechanism would be to have an automated system that attempts to identify the appropriate level for a player based on their performance. A combination of these features may be appropriate. For example, the game designer/instructor might select the level of realism based on the training objectives, the player might select the level of exploration and control, while the game might regulate the level of challenge based on the player's performance.

Conclusions

In the current research, features of a PC-based training game were assessed in an attempt to identify aspects of a first-person-perspective game that would influence both the learning of content and player motivation to continue using the game. For the current research, the findings related to the instructional characteristics (information type, relevance of information, and presentation modality) may be limited to the PC-based first-person-perspective game used. However, the findings mirrored previous findings from research using interactive multimedia instruction. Likewise, the findings regarding motivation in this game confirmed previous research on motivational aspects of other types of games.

The assessment of instructional features suggest that PC-based training games would be more effective for learning procedures than for learning facts. Additional research would be needed to determine if types of skills and procedures influence the effectiveness of using games for training, or if the type of game influences the effectiveness of the training.

The findings also suggest that instructional objectives should be integrated into the game's storyline so that the training material is relevant to the progression of the game. If the training objectives are part of the storyline of the game, the training effectiveness of the game may be increased. If the training objectives are not part of the storyline, then players/students may only learn how to play the game and not the training objectives. The relevance of the training objectives also overlaps with the motivational feature of realism, which should increase the likelihood of skill transfer from the game to the application of the skill trained.

Spoken text and visual images were found to be more effective presentation modalities than printed text, suggesting that course developers should focus on these modes of presentation. It does not mean that printed text should be abandoned completely, only that it should be limited during game play. Casual observation of the participants in this research showed that players might skip large portions of text.

The assessment of motivational features suggest that PC-based training games should be designed with attention to challenge, realism, control, and opportunities for exploration, which may make the learner's experience more positive and motivate them to continue using the game. While the inclusion of all of these features does not guarantee that users will play the game for hours on end, they are features that should be considered while developing a training game.

For a training game to be effective, it should be both instructional and motivational. Additionally, some of the instructional features identified may influence motivation, and some of the motivational features identified may influence instruction. More research is needed to develop a better understanding of the interaction of instructional and motivational influence on the training effectiveness of first-person-perspective games.

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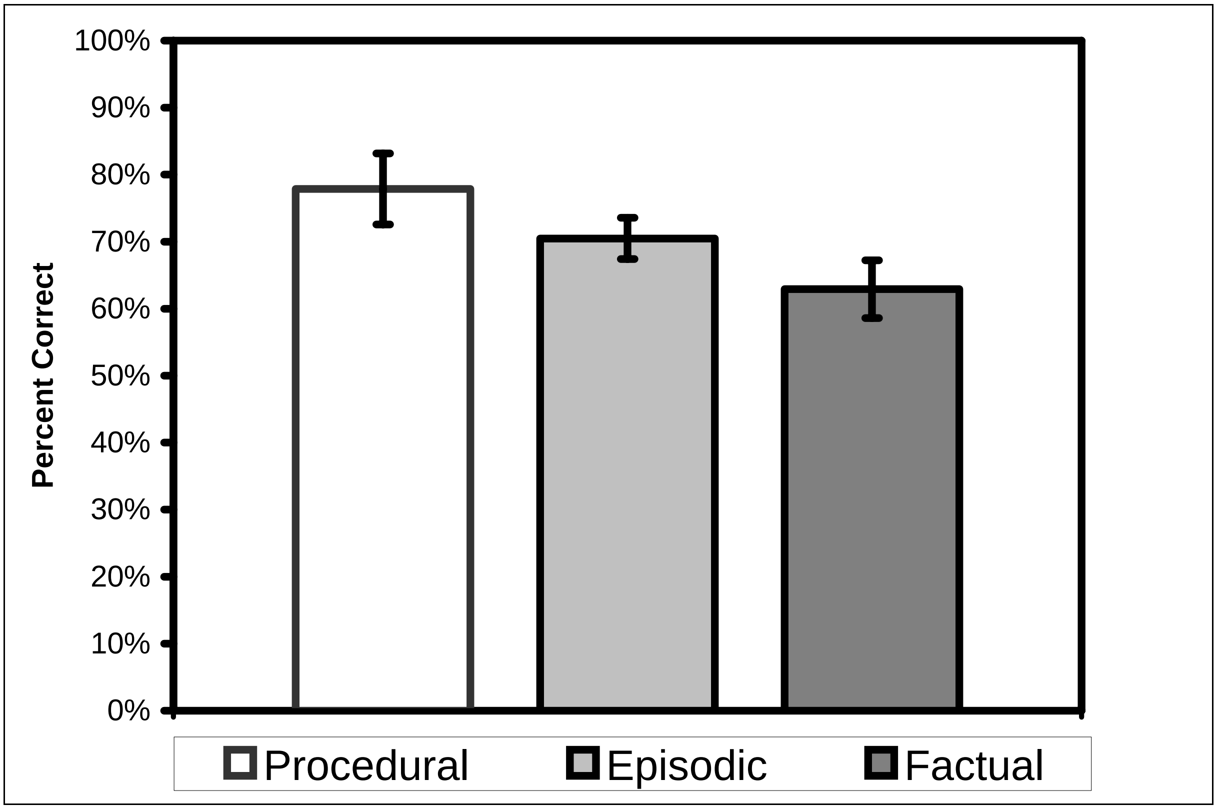

Figure 1. The mean percentage correct for questions involving the three different types of information (procedural, episodic, and factual).

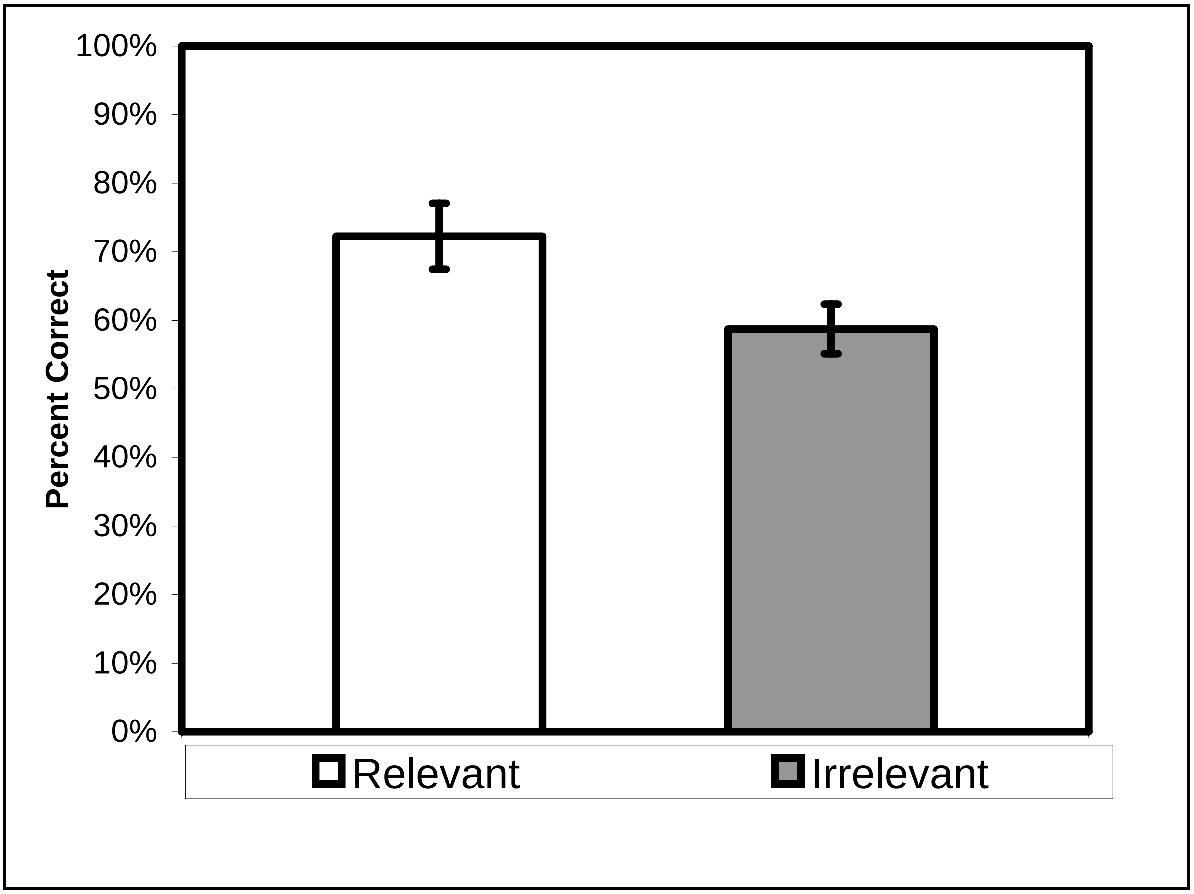

Figure 2. The mean percentage correct for questions involving relevant and irrelevant information.

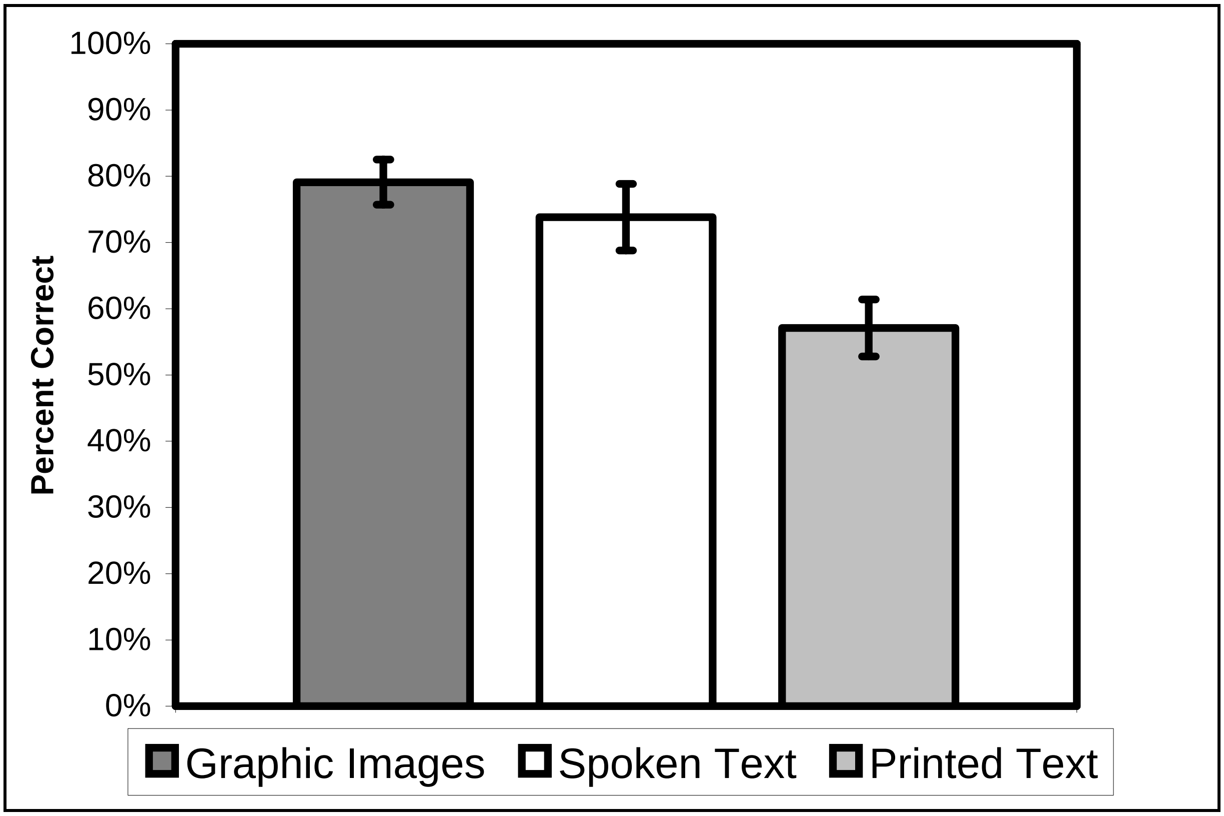

Figure 3. The mean percentage correct for questions involving the three different types presentation formats of information.