The Effect of Animation on Comprehension and Interest

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애니매이션이 이해와 흥미에 미치는 효과

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Abstract

This study was conducted to investigate the interaction effects of various presentation types of graphics and the individual differences in need for cognition on comprehension, interestingness, and motivation. The depiction of the operation of a bicycle tire pump was presented in one of the following conditions, (a) simultaneous presentation, (b) successive presentation, (c) self-pace presentation, (d) animation. For younger students, animated graphics are rated more enjoyable and motivating only when they are low in NFC. If they are high in NFC, animated graphics are not more effective than static graphics in terms of comprehension, interest, and motivation. On the other hand, for older students, self-paced static graphics are more interesting and enjoyable than the animated graphics regardless of their NFC score. These results suggest that the animated graphics are not always beneficial for learning and motivation.

The effect of animation on learning

As multimedia and computer graphic technology develops and web-based learning system becomes more popular, there has been increased use of animation incorporated into learning materials. Many researchers or educational practitioners have believed that animation would facilitate learning. In general, animation is known to be effective for expressing process or conveying changes in time and space. Animation is also good for showing continuity in transitions, indicating dimensionality in transitions, illustrating changes over time, multiplexing the display, and enriching graphical representations (Nielsen, 1995)

Several studies compared animated graphics with static graphics directly. Some of them showed that students learning from animated graphics outperformed those learning from a static graphics on the concept of speed (Baek & Layne, 1988), on the circulatory system (Large, Beheshti, Breuleux, & Renaud, 1996), on the Newton's law of motion (Rieber, 1990, 1991a, 1991b), or on the electronic circuit (Park & Gittelman, 1992).

However, there have been some controversies on the effectiveness of animation on learning. When Morrison (2000) closely examined the previous research on the animation, she found that the animated graphics include additional information on the details of the microsteps between larger steps which were not available for the static graphics. When she controlled the amount of information between the animated and static graphics, no difference was found. Reed (1985) found that the animated graphics facilitated the learning of the algebra word problems only when students were required to make estimations. Rieber and Hannafin (1988) and Rieber (1989) found no effect of animation in learning Newton's law of motion

There may be potential disadvantages for

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animated graphics over static graphics. For example, animations usually contain more information than static graphics so that students may have more cognitive loads when they process animated graphics. In addition, the salient features of animation such as motion and trajectory may attract involuntary attention reflexively, which can override the voluntary control of attention (cf, Yantis & Jonides, 1990).

The temporal nature of animated presentation may also lead learners to process information passively and overlook some of the important information. In summary, it is possible that all of these characteristics of animation may distract attention and interfere with deeper processing and finally affect the comprehension.

Animation and Interest/Motivation

Although the effect of animated graphics on learning is still controversial, one of the main reasons for the growing popularity on animation seems to be due to the belief that animation is more interesting, aesthetically appealing, and even motivating. Some research showed that animations are much preferred due to its perceptual attractiveness (Perez & White, 1985; Rieber, 1991; Sirikasem & Shebilske, 1991).

However, there are two different types of interest, emotional interest and cognitive interest. According to Kintsch (1980), emotional interest is created by the events which have an arousal function. Cognitive interest, on the other hand, is produced by the relationships of incoming information to background knowledge. Previous research on cognitive interest indicates that interest is generated by the intellectual activity to resolve incongruity such as inference (Kim, 1999; Kintsch, 1980; Mandler, 1982; Schank, 1979). This suggests that static graphics are more likely to increase the cognitive interest than animated graphics because static graphics require for learner to generate more inferences to fill the gap between the graphics than animated graphics. On the other hand, animated graphics are more likely to increase the emotional interest than static graphics because animation may lead to higher arousal level.

Researchers on text processing have used the term seductive details to refer to interesting but irrelevant details that are added to a learning material to make it more interesting (Garner, Brown, Sanders & Menke, 1992; Garner, Gillingham, & white, 1989; Wade & Adams, 1990) Harp and Mayer (1997) found that adding entertaining graphics to a scientific text increase the emotional interest but not cognitive interest. One possible explanation for the non-beneficial effect of seductive details on cognitive interest is that the additional information would distract the reader and thereby divert their attention away from the important information.

This notion of seductive details can also be applied to the presentation of graphic information with narration. Since animated graphics always have more information about the movement over static graphics, the detailed movement in the animated graphics may distract the learner from making sense out of the learning material. Therefore, animated graphics, in essence, have seductive details so that they would increase emotional interest but not cognitive interest.

Another important aspect on learner's motivation and interest is controllability or interactivity. One strategy for enhancing the learner's motivation is to increase the learner's sense of control and self-determination by providing choice or locus of control (e.g., Deci & Ryan, 1985; Nuttin, 1973). It has been well documented that individuals offered choice would show more enjoyment, better performance, and greater persistent at a variety of activities (e.g., Langer & Rodin, 1976; Malone & Leeper, 1987; Perlmuter & Monty, 1977). Cordova and Leeper (1996) demonstrated that provision of choice in the multimedia learning material enhanced students' intrinsic motivation. In this study, the mode of static graphics was varied including the condition of self-paced presentation of static graphics.

Individual differences

The effect of animation on learning and motivation may vary depending on individual differences in the spatial ability and need for cognition.

Spatial Ability

Although the learning from graphics depends on spatial abilities such as the ability to visualize and mentally rotate objects in two or three dimensions, it is controversial which spatial ability

group, low-spatial ability learners or high-spatial ability learners, would benefit the most from animated graphics. Mayer and Sims (1994) proposed ability-as-enhancer hypothesis, which predicts that animation should benefit the high-spatial ability learners more than low-spatial ability learners. According to ability-as-enhancer hypothesis, low-spatial ability learners would expend their cognitive resources on constructing visual representational connection and therefore would have fewer resources available for the construction of referential connection whereas high-spatial ability learners would expend their resources on constructing referential connection. When narration was presented concurrently with animation, high-spatial ability learners outperformed their low spatial ability learners (Mayer & Sims, 1994; Morrison, 2000).

Alternatively, Hays (1996) proposed ability-as-compensator hypothesis, which predicts animation should benefit the low-spatial ability learners more than high-spatial ability learners. According to ability-as-compensator hypothesis, low-spatial ability learners would not be able to construct their own visualization and therefore would gain greater benefits from the animated graphics whereas high-spatial ability learners would be able to construct their own visualization and would get no benefit.

Since the relationship between individual differences in spatial ability and animation is still controversial, the spatial ability is used as just a covariate in the present study.

Need for Cognition (NFC)

Kim (1999) found that cognitive interest is a function of bridging inference. Iran-Najad (1987) also argues that cognitive interest is generated by intellectual activity of the individual. This suggests that there might be individual differences in cognitive interests depending on the desire to engage in intellectual activity. One such an individual dispositional factor might be the need for cognition. Need for cognition (NFC) refers to an individual's tendency to engage in and enjoy effortful cognitive endeavors (Cacioppo & Petty, 1982; Petty & Cacioppo, 1986). Previous research has shown that individual differences in the need for cognition affect persuasion and attitude (Cacioppo, Petty, & Morris, 1983; Haugtvedt, Petty, & Cacioppo, 1992). It is highly plausible to hypothesize that the individual differences in NFC would influence the effectiveness of and the preference for the animation. That is, high-NFC learners would prefer static graphics to animated graphics because they would generate inferences to fill in the gaps between the static graphics. In contrast, low-NFC learners would prefer animated graphics to static graphics.

Ages

Individual differences in NFC may interact with ages because there might be developmental differences in inferential processing. For example, older students (6th graders) with static graphic presentation are able to generate inferences while younger students (4th graders) might be able to generate inferences only when they are high-NFC. Thus, it is hypothesized that younger students are more likely to prefer animated graphics to static graphics whereas there might be no differences between animated graphics and static graphics for older students.

This study was conducted to investigate the interaction effects of various presentation types of graphics and the individual differences in need for cognition on comprehension, interestingness, and motivation.

In summary, there were three research questions to answer in this study. First, does animated graphics facilitate comprehension, interestingness, motivation? Second, is there any interaction effect between presentation type of the graphic learning material and need for cognition of the learner? Third, is there any developmental difference in comprehension, interestingness, and motivation for various types of presentation?

Experiment 1: 4th Grade

Method

Participants and Design. The participants were 101 fourth-grade students from the elementary school in Seoul. Based on NFC scores, 53 students were classified as low NFC students and 48 students were classified as high NFC students. They were randomly assigned to one of four presentation conditions in a 2 x 4 between-subject factorial design: (a) simultaneous static-graphic presentation (low NFC = 15, high

NFC = 11), (b) successive static-graphic presentation (low NFC = 13, high NFC = 12), (c) self-paced static-graphic presentation (low NFC = 12, high NFC = 13), (d) animated-graphic presentation (low NFC = 13, high NFC = 12).

Materials. The experimental materials consisted of four programs which differ only in the type of presentation of identical learning material, bicycle pump: (a) simultaneous presentation of static graphics – presenting eight static graphics simultaneously on a screen and the moving frame was used in order to indicate the change of the graphic, (b) successive presentation of static graphics – presenting each static graphic at a time with slide show style and one second pause between graphics, (c) self-paced presentation of static graphics – presenting each static graphic at a time by self-paced style, (d) animated presentation of graphics – presenting continuously animated graphics.

The static version of experimental material was adapted from the static illustration in *The World Book Encyclopedia* (1991) on the operation of a bicycle tire pump. The static graphics consisted of eight black-and-white line-drawings. Figure1 presents frames from an animated depiction of how a bicycle tire pump works, along with words from accompanying narration adapted from Mayer and Anderson (1991). The animated version was identical to the one used in the previous studies by Mayer & his colleagues (e.g., Mayer & Anderson, 1991, 1992; Mayer & Sims, 1994).

Each program was coordinated with the narration lasting approximately 30 s. The narration consisted of an approximately 50-word description spoken in a male voice. All conditions were created with Macromedia Director.

Spatial Ability Test

Vandenberg Mental Rotation Test (1979) was used to measure students' spatial abilities. The test consists of twenty items to identify two rotated versions of a target three-dimensional block figure. Since spatial ability may affect the comprehension and interestingness of the learning material, spatial ability test scores were used as a covariate.

Need for Cognition (NFC) Scale

The abbreviated version of need for cognition scale was used to assess the degree to which each student engage in effortful cognitive process (Cacioppo, Petty, & Kao, 1984). The scale consists of 18 items which contain statements about situations that require self-ratings to demand for cognitive effort.

Comprehension Test

The comprehension test consisted of 20 true-false questions to assess to students' understanding and knowledge both of the structure and the function of the bicycle tire pump.

Attitudinal Questionnaire

The attitudinal questionnaire consisted of following four questions with 5-point scale designed to assess students' general interest, emotional interest, comprehensibility, and motivation.

1. "How interesting is this learning material?"
2. "How much do you think you enjoyed this learning material?"
3. "How much do you think you understand the learning material?"
4. "How willing would you study other learning material in this type of presentation medium?"

Procedure.

Participants were given 6 minutes to complete the Vandenberg Mental Rotation Test. After completing the spatial ability test, participants were administered the Need for Cognition scale. Participants who scored above the median on NFC score were classified as high NFC and those who scored below the mean were classified as low NFC. After being randomly assigned to one of the four presentation conditions, participants viewed the learning material three times. The onset of each presentation was controlled by the participant. When the participants had completed viewing the presentation, they were asked to answer 4 attitudinal questionnaires on interestingness, enjoyment, motivation, and comprehensibility using 5-point scale. Then, 20 True-False comprehension questions were given.

Results

The Separate 2 x 4 analyses of covariance (ANCOVA) were conducted on five dependent measures (Interestingness, Enjoyment, Motivation, Comprehensibility, Comprehension test score) with the Vandenberg mental rotation test score as the covariate. The mean rating or test scores and standard deviations for 6 dependent measures appear in Table 1.

Effects on Interests

Interestingness. A significant main effect was found for presentation type, $F(3, 92) = 9.42$, $MSE = .819$, $p < .001$. Subsequent LSD tests (based on an alpha of .05) indicated that the simultaneous condition was rated significantly less interesting than any other conditions, which did not differ significantly from one another. A significant main effect was also found for NFC, $F(1, 92) = 3.69$, $p = .058$, with high NFC students rating each condition more interesting than low NFC students. The interaction effect of presentation type and NFC was not significant.

Enjoyment. The results of a 2 x 4 ANCOVA yielded significant main effect for NFC, $F(1, 92) = 5.68$, $MSE = .669$, $p < .05$, indicating that high NFC students rated each condition more enjoyable than low NFC students. The significant main effect of presentation type, $F(3, 92) = 4.26$, $p < .05$, is better understood in the context of the interaction of presentation type and NFC, $F(3, 92) = 2.27$, $p = .086$. LSD tests indicated that animated condition was rated significantly more enjoyable than any other condition for low NFC students whereas there was no significant difference on enjoyment rating among conditions for high NFC students.

Effects on Intrinsic Motivation

Motivation. The main effect of presentation type on the motivation was significant, $F(3, 92) = 9.30$, $MSE = .664$, $p < .001$. Although the main effect of NFC was not significant, the interaction effect of presentation type and NFC was significant, $F(3, 92) = 2.89$, $p < .05$. LSD tests indicated that low NFC students in the animated condition reported significantly higher motivation than in the simultaneous condition. On the other hand, high NFC students in the simultaneous condition reported significantly lower motivation than those in any other condition and high NFC students in the self-paced condition showed higher motivation than those in the successive condition.

Effects on comprehension

Comprehensibility. A 2 x 4 ANCOVA revealed a significant main effect of presentation type on perceived comprehensibility, $F(3, 92) = 6.94$, $MSE = .770$, $p < .001$. Although the main effect of NFC was not significant, the interaction effect of presentation type and NFC was significant, $F(3, 92) = 3.49$, $p < .05$. LSD tests indicated that low NFC students in the animated condition reported the learning material significantly more comprehensible than those in any other condition whereas the high NFC students in three static graphic conditions reported the equal comprehensibility of the learning material, which rated the learning material significantly more comprehensible than those in the simultaneous condition.

Comprehension test score. There were neither significant main effects nor interaction effect on comprehension test score.

Experiment 2: 6th Grade

Method

Participants and Design. The participants were 107 sixth-grade students from the elementary school in Seoul. They were randomly assigned to one of four presentation conditions in a 2 x 4

Table 1. Mean rating or test scores for interest, motivation, and comprehension in Experiment 1

	simultaneous		static		self-pace		animation	
	Low NFC	High NFC	Low NFC	High NFC	Low NFC	High NFC	Low NFC	High NFC
Interestingness	3.0	3.0	3.6	4.3	3.6	3.9	4.3	4.3
Enjoyment	3.6	3.6	3.5	4.0	3.4	4.0	4.4	4.0
Motivation	3.6	3.2	3.9	4.2	4.0	4.3	4.5	4.6
Comprehension	3.4	2.9	3.5	4.1	3.6	4.1	4.5	4.3
Test score	10.8	10.3	10.8	10.6	10.0	10.4	11.9	10.9

between-subject factorial design. Based on NFC scores, 50 students were classified as low NFC students and 57 students were classified as high NFC students. The total number of participants were as follows: (a) simultaneous static-graphic presentation (low NFC = 17, high NFC = 9), (b) successive static-graphic presentation (low NFC = 11, high NFC = 19), (c) self-paced static-graphic presentation (low NFC = 9, high NFC = 12), (d) animated-graphic presentation (low NFC = 13, high NFC = 17).

Materials. The design and materials were identical to Experiment 1.

Procedure. The procedure was identical to that of Experiment 1.

Results

The Separate 2 x 4 analyses of covariance (ANCOVA) were conducted on five dependent measures (Interestingness, Enjoyment, Motivation, Comprehensibility, Comprehension test score) with the Vandenberg mental rotation test score as the covariate. The mean rating or test scores and standard deviations for 6 dependent measures appear in Table 2.

Effects on Interests

Interestingness. The main effect of presentation type approached the significance level, $F(3, 98) = 2.51$, $MSE = .634$, $p = .063$. Subsequent LSD tests (based on an alpha of .05) indicated that the students in the self-pace condition reported significantly higher interestingness than those in each of the other conditions, which did not differ significantly from one another. A significant main effect was also found for NFC, $F(1, 98) = 4.13$, $p < .05$, with the high NFC students reporting more interestingness than the low NFC students. The interaction effect of presentation type and NFC was not significant.

Enjoyment. The results of a 2 x 4 ANCOVA yielded significant main effect for NFC, $F(1, 98) = 3.60$, $MSE = .493$, $p = .061$, indicating that high NFC students reported more enjoyment than low NFC students. The main effect of presentation type approached significance level, $F(3, 98) = 2.26$, $p = .086$. LSD tests indicated that self-pace condition was rated significantly more enjoyable than both animated and simultaneous condition. There was no significant interaction effect of presentation type and NFC.

Effects on Intrinsic Motivation

Motivation. ANCOVA revealed that there were neither significant main effects nor interaction effect on motivation. Neither significant main effect nor interaction effect was found.

Effects on comprehension

Comprehensibility. An ANCOVA revealed that there were neither significant main effects nor interaction effect on comprehensibility ratings. Neither significant main effect nor interaction effect was found.

Comprehension test score. The main effect of presentation type on the comprehension test scores was significant, $F(3, 98) = 3.15$, $MSE = 3.87$, $p < .05$. LSD tests indicated that simultaneous condition performed more poorly than each of the other three conditions, which did not differ significantly from one another.

General Discussion

The main finding from this study was the developmental differences in the effect of animation on comprehension, interest, and

Table 2. Mean rating or test scores for interest, motivation, and comprehension in Experiment 2

	simultaneous		static		self-pace		animation	
	Low NFC	High NFC	Low NFC	High NFC	Low NFC	High NFC	Low NFC	High NFC
Interestingness	3.4	3.1	3.2	3.5	3.5	3.9	3.1	3.8
Enjoyment	3.2	3.3	3.5	3.4	3.5	3.9	3.0	3.6
Motivation	3.6	3.9	4.3	3.7	4.0	4.4	3.7	4.3
Comprehension	3.8	3.8	4.2	4.0	3.9	4.5	4.0	4.2
Test score	11.0	9.9	11.4	11.9	12.2	11.2	11.6	11.4

motivation. For 4th graders, it was found that there was interaction effect on enjoyment, motivation, and comprehensibility between presentation type and NFC. However, for 6th graders, there was no interaction effect. These results suggest that the animated graphics are not always beneficial for learning and motivation. For younger students, animated graphics are rated more enjoyable and motivating only when they are low in NFC. If they are high in NFC, animated graphics are not more effective than static graphics in terms of comprehension, interest, and motivation. On the other hand, for older students, self-paced static graphics are more interesting and enjoyable than the animated graphics regardless of their NFC score.

One possible explanation for this finding is that low NFC 4th graders might not be able to generate inferences while they were watching the static graphics whereas high NFC 4th graders might be able to generate inferences. As a result of differential inferential processing, low NFC 4th graders felt the animated graphics more interesting and enjoyable than the static graphics whereas high NFC 4th graders felt the same level of interestingness and enjoyment for both the animated and the static graphics.

In terms of comprehension, all three conditions except simultaneous presentation condition reached the same level of comprehension. The simultaneous presentation condition produced the lowest comprehension score. This suggests that simultaneous presentation of the learning material (graphics) distracts learners' attention so that their comprehension was interfered.

The comparison between successive condition and self-pace condition indicate that the latter condition was rated more motivating than for high NFC students whereas there was no difference between self-pace presentation and successive presentation for low NFC students. This suggests that high NFC students prefer interactivity or controllability. The main effects of NFC on interest and motivation also suggest that high NFC students show more interests in the learning materials and motivation to learn than low NFC students.

Based on the findings from this study, some implications can be drawn for designing multimedia learning materials. For example, it is not necessary to make learning material (graphics) animated especially for older students or high NFC students regardless of ages. Rather, it would be more beneficial for them to make the learning material controllable. Since it costs a lot to make a dynamic animation, the cost and benefit of constructing such an expensive and seemingly attractive multimedia learning material should be seriously considered.

One of the limitations in this study was that the number of subjects per condition was not equal, resulting in less than 10 in some condition, and thereby decreased the statistical power. Also it would be interesting to examine the data from college students to compare a developmental preference or motivation for the animated learning material. In future study, it would be essential to investigate not only the effect of expository animation such as animated graphics for scientific information but also the motivational and cognitive effect of narrative animation.

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