Developmental Differences at Play: Children's Selective Attention and Performance in Video Games

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This study investigated developmental differences in children's performance on a popular video game. Second- and fifth-graders played a video game for ten minutes and then were asked questions about the game features that they paid attention to while playing, and about specific game and attention strategies that they would recommend to a novice player. Older children and children identified as frequent players showed better performance. Post-game responses also indicated developmental differences in references to game features, strategies, and evaluative assessments. Younger children focused more on evaluative assessments. Older children, by comparison, focused more on specific goals for game play, and such a focus predicted better task performance. This study begins to provide additional insight into children's goals and motivation for learning in the context of intrinsically motivating tasks and the implications of that motivation for attention and performance.

To date, the study of children's selective attention while learning has been primarily conducted using contrived tasks. Selective attention is defined as the ability to filter out irrelevant or distracting information from that which is more central or relevant to the task at hand. Typically, researchers have found that children younger than ten years of age are less likely to selectively attend and do not allocate attention as efficiently as older children (Crane & Ross, 1967; Hagen & Hale, 1973; Hale, 1979; Lane & Pearson, 1982). Thus, younger children are less flexible and systematic in their attentional deployment (Miller, 1985), and less efficient in their use of attentional strategies than are older children and adults (DeMarie-Dreblow & Miller, 1988; Miller, 1990; Miller & Seier, 1994).

Much of the current laboratory-based study of children's selective attention and attention strategies has relied on the selective memory task developed by Miller and her

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colleagues (Miller & Weiss, 1981). This task is a derivation of an incidental learning task developed by Hagen (1967) and based within the incidental learning paradigm that was used extensively during the mid-1960s and 1970s to study children's selective attention. The major assumption of this task is that selective attention involves greater learning about relevant information and less learning about the information irrelevant to task solution. More recently, investigators such as Miller and her colleagues have used this task to examine children's selective attention in light of their attention strategies. Specifically, children are presented with a two by six array of pictures representing two categories of information, typically animals and household objects. They are then told to study one category of pictures so that they will be able to later recall their positions within the array. Each picture can only be viewed by lifting a door on which a line drawing indicates the category whose exemplar is depicted underneath. A child's pattern of lifting the doors during the study periods for each trial provides an assessment of attention strategies used. For example, lifting only the doors corresponding to information that is to be recalled later is a better strategy than lifting all doors in a random fashion. Recall of the locations of the category exemplars provides a separate measure of recall for central task information (reflecting selective attention) and of irrelevant task information (reflecting incidental learning).

The findings from this task typically indicate that before the age of 10, children's selective attention is less sophisticated than is demonstrated by their overt strategic behavior. Miller (1990) has referred to the developmental lag between strategy production and its effective use as a utilization deficiency. Questions emerge, however, about the domain specificity of this hypothesis for children's selective attention and patterns of attention, and its applicability to more ecologically valid tasks (Miller & Seier, 1994).

An ecologically valid domain in which children's performance and patterns of attention can be assessed may be represented by self-selected learning situations or "real cognitive activities" (Anderson & Smith, 1984, p.118) posed by media such as film, television, and more recently, the video game. Studies of children's selective attention have, in fact, used media as learning stimuli (Hale, Miller, & Stevenson, 1968; Collins, 1970; Collins, Wellman, Keniston, & Westby, 1978). The participatory nature of the video game (Greenfield & Cocking, 1994), however, may provide a particularly ecologically valid venue in which to investigate the coordination between children's attention and performance.

The prevalence of video games as a form of interactive entertainment among children throughout middle childhood has been duly noted by researchers (Greenfield, 1984; Provenzo, 1991) as well as by the manufacturers who have promoted their use (Herz, 1997). The video game offers an opportunity to master the intricacies of a complex, multicued, rule-governed environment which young children presumably find intrinsically motivating. Malone (1981) had earlier attested to the intrinsically motivating characteristics of the video game's progenitor, the early computer game, in his analysis of those game aspects such as challenge, fantasy, and curiosity that children found most appealing while playing.

The use of video games in the study of children's cognitive development is not without precedent (Greenfield & Cocking, 1994; Kafai, 1996; Okagaki & French, 1994; Subrahmanyam & Greenfield, 1994). However, extant work on attention which has used video games has addressed divided attention (Greenfield, deWinstanley, Kilpatrick, & Kaye, 1994), which is concerned with vigilance and monitoring of different sources of task infor-

mation. The ability to discern relevant game cues and to incorporate them within a strategy to facilitate performance, which is most characteristic of selective attention, was of concern in the present study. Specifically, second- and fifth-grade students were asked to play a popular children's video game and to then comment on the types of learning goals, game features, and strategies that they used while playing the game. These verbal protocols were intended to provide information about children's goals for playing the game, and their perceptions of relevant task cues and their strategies or patterns of attention, while playing. The latter type of information was elicited by having children specify task information that would be useful for a novice player. Blumberg (1988) used a variation of this metacognitive technique when investigating how children's understanding of attention mediated their performance while learning a new task. The present study also sought to investigate how children's reference to task goals and cues corresponded to actual game performance, and the extent to which the relationship between the two showed developmental differences.

METHOD

Subjects

The participants included in the study were 46 second grade (20 girls and 26 boys, mean age = 7.4; range = 6.9 – 10.3 years) and 58 fifth grade (23 girls and 35 boys, mean age = 10.5; range = 7.8 – 11.8 years) children attending an urban public elementary school in an ethnically diverse, middle-class neighborhood in New York City. Six students with limited English proficiency were excluded from the study because of their inability to answer the post-game questions.

Materials and Apparatus

A Sega Game Gear color portable video game system was used to present Sega's *Sonic the Hedgehog 2* video game, which was selected for its popularity with elementary school children, its visual complexity, and its relatively nonviolent focus as compared to other video games played by first- through sixth-grade students. A Panasonic RN-122 microcassette recorder was used to tape children's responses to post-game questions.

Procedure

Each child was tested individually in a quiet area provided by the participating school. After the experimenter (a White female) introduced herself and explained to the student that portions of the student's work would be tape-recorded, the child was asked to play a video game on the Game Gear. After 10 minutes of continuous play, each child was asked three questions about his or her experience with the game:

1. What were you thinking about as you were playing the game?
2. Suppose you were going to tell someone else who has never played the game before how to play it. Are there any special secrets or rules that you would tell them about?
3. Is there anything that you would tell them to pay attention to?

Immediately following the last response, the child was thanked and asked to return to class.

Coding Scheme for the Post-Game Questions

A coding scheme was devised to examine the types of information that subjects provided in response to the three post-game questions. All coding was done using transcripts of subjects' responses prepared from their tape-recorded comments during the experimental session. All transcripts were checked by a second transcriber. The few minor discrepancies were reconciled in new transcripts that were then used for analyzing children's post-game question responses.

Two independent raters then coded the responses to each question for references to particular categories of comments. For the most part, these categories were question-specific and not mutually exclusive. Inter-rater reliability, based on Cohen's kappa, ranged from excellent to good for nearly all categories of response, according to Fliess' (1981) general guidelines. Only one category, non-focused for question 3, had a kappa which bordered on fair ($K = .39$). Descriptions of the categories are presented below.

Goal-Oriented Comments. This category of comments referred to the subject's perceived goals for playing the game. These comments were further classified as *general goal references*, which pertained to the subject's mention of overriding or general goals for playing the game (e.g, "To win the game" or "Just to get to the end"), and *specific goal references*, which pertained to particular or personal goals for mastering the game, and to completing a particular level or move within the context of the game (e.g, " I was thinking that I'd really like to beat the third board" or "The moves that I make"). This category was used to code responses to question 1 only.

Strategy-Based Comments. Subjects' remarks in this category referred to strategies or approaches that could be used while playing the game. These comments were further classified as *attention strategy references*, which concerned how and what to monitor while playing, and how to avoid distractions (e.g, "Keep your eyes where the monsters are, whatever those things are" or "I would just tell 'em to concentrate and look what they're gonna do"), and *game strategy references*, which described how to enact a move or the consequences of an action or inaction (e.g, "There's one where you have to jump on the thing and you have to push the backwards button and you go up and you have a little machine and then get the box that has the small coins"). This category was used to code responses to questions 2 and 3.

Game-Oriented Comments. This category of comments referred to specific aspects of the game. These comments were further classified into two types of references: *game mechanics references*, which concerned the operation of the game such as the controls or the codes that could be used to set the game parameters, such as the number of "lives" allotted per game (e.g, "You gotta press that button to jump and that black circle is to move" or "I would tell them the secret of the code to go to the last master") and *game cue references*, which referred to specific aspects or features of the game (e.g, "There's this little trap that you go underground which you may go at the starting line"). This category also was used to code responses to questions 2 and 3.

Evaluative Comments. This category of comments pertained to the subject's subjective appraisal of the game (e.g, "I like the game" or "It was easy") and was used to code responses to questions 1 and 2.

Definitive Comments. This category pertained to the subject's position on a given question, typically in the form of a "yes" or "no" response, and was used to code responses to questions 1, 2, and 3.

Non-Committal Comments. This category of comments provided no ostensible information about the subject's thoughts or feelings and frequently took the form of "I don't know." This category was used to code responses to questions 1, 2, and 3.

Non-Focused Comments. These comments indicated irrelevant and off-task behavior and were used to code responses to questions 1, 2, and 3.

RESULTS

Game Performance

Characterization of Dependent Variables. In playing *Sonic the Hedgehog 2*, the primary goal is to complete as many successive levels of the game as possible. To meet this goal, a player is given three "Sonics," or lives, at the start of each game. Each Sonic insures one round of play. When a player loses a Sonic on a given level, the game reverts to the beginning of that level. A player accumulates Sonics by successfully locating a free Sonic (as represented by a small Sonic the Hedgehog icon), by accumulating 100 rings during a given round of play, or by receiving a free Sonic at the conclusion of a level (awarded on a random basis). A player loses a Sonic through contact with dynamic hazards (e.g, flying fish that spew rocks) or static hazards (e.g, spike, lava). Based on these rules, the following dependent variables were used to assess children's game performance: 1) highest level attained, 2) total number of levels attained, 3) total number of Sonics lost, 4) total number of Sonics gained, and 5) number of games started. A factor analysis of these dependent variables yielded a single factor accounting for 74% of the variance, supporting the contention that all dependent variables were indicators of game performance. Scores of this single factor, called "game performance," were used for subsequent analyses. The game performance variable is normalized to have mean 0 and standard deviation 1. The factor loadings for each of the five dependent variables are shown in Table 1. The loadings have absolute values greater than 90% for all dependent variables except total number of Sonics gained,

Table 1. Factor Loadings for the Game Performance Variables

Variable	*Factor Loading*
Highest level attained	0.9248
Total levels attained	0.9110
Sonics lost	-0.9040
Sonics gained	0.5677
Games started	-0.9286

which is the most random of the five variables. Only one factor was extracted; therefore, no rotation was possible. Because preliminary analyses of game performance yielded no main effects of gender, the data reported below are collapsed across this variable. The lack of gender differences in the present study may have stemmed from having used a video game designed to appeal to both boys and girls.

Characterization of Subject's Specific and General Game Experience. As part of the experimental instructions, subjects were asked whether they had played *Sonic the Hedgehog 2* before. Only nine subjects (seven second graders and two fifth graders) had not played the game prior to the study. This finding is not necessarily surprising given the popularity of video games among elementary school children, and the Sonic the Hedgehog series, in general (Herz, 1997). Reference to subjects' specific game experience was dropped from subsequent analyses.

Immediately before playing the game, subjects also were asked about their video game experience in general. Specifically, subjects were asked if they played video games "a lot or not a lot." Those children who reported that they played video games "a lot" were characterized as frequent players whereas those who reported "not a lot" were characterized as infrequent players. This measure is admittedly crude. However, among those subjects characterized as frequent video game players, performance was significantly better, as indicated by a point-biserial correlation ($r_{pb} = .28$); $p < .004$, than among those who were characterized as infrequent players.

Analysis of Game Performance. A two-way analysis of variance with grade (second or fifth) and frequency of game play (frequent or infrequent) as between-subject

Table 2. Proportions of Post-Game Responses by Grade and Coding Category

Coding category	*Applicable questions*	*Grade 2 (N=45)*	*Grade 5 (N=57)*	*All subjects (N=102)*
Goal-oriented				
General goal	1	.18	.28	.24
Specific goal	1	.18[a]	.42[b]*	.31
Strategy-oriented				
Attention strategy	2	.02	.09	.06
	3	.67	.70	.69
Game strategy	2	.04[a]	.39[b]**	.24
	3	.07	.18	.13
Game-oriented				
Game mechanics	2	.11	.14	.13
	3	.04	.00	.02
Game cues	2	.16	.11	.13
	3	.22[a]	.46[b]*	.35
Other				
Evaluative	1	.38[a]	.19[b]*	.27
	2	.13[a]	.00[b]*	.06
Definitive	2	.47	.35	.40
	3	.22	.19	.20

Note: Cell means with different superscripts are significantly different at either $p < .05$ (indicated by *) or $p < .005$ (indicated by **).

variables was used to assess developmental and experiential differences in game performance. The main effect of grade was significant, F (1, 103) = 38.65, $p < .0001$, with fifth graders showing better performance ($M = .47$, $SD = .73$) than second graders ($M = -.59$, $SD = .99$). A main effect of frequency of game play also was significant, F (1, 103) = 8.39, $p < .0001$, with frequent players showing better performance ($M = .32$, $SD = .91$) than infrequent players ($M = -.25$, $SD = 1.01$). No significant interaction effects were found.

Post-Game Responses. A series of independent t-tests comparing the mean number of post-game responses for each category by grade indicated significant developmental differences for references to specific goals for game play, game strategies, specific game cues, and evaluations of the game. Given the relative infrequency, across grade levels, of non-committal (11,1, and 4 responses for questions 1, 2, and 3, respectively) and non-focused comments (1, 2, and 1 responses for questions 1, 2, and 3, respectively), these categories were dropped from further consideration. The proportions of post-game responses by grade and coding category are shown in Table 2. Because of equipment failure, the post-game responses from one second grader and one fifth grader were lost. Accordingly, the analysis of the post-game responses is based on one fewer subject per grade.

Second graders were more likely than fifth graders to make evaluative responses to questions 1 and 2. Fifth graders, however, were more likely to mention a higher proportion of specific game goals, game strategies, and on question 3, references to game cues.

An examination of the differences in the types of comments made by frequent versus infrequent players yielded only a significant difference for reference to attention strategies in response to question 3 (M frequent = .83 v. M infrequent = .57; t (100) = -2.912; $p < .004$). This distinction is not surprising given the attention demands involved in playing video games, of which the frequent player is ostensibly aware.

Relationship Between Post-Game Responses and Game Performance. A series of point biserial correlations were computed to determine the nature of the relationship between subjects' conceptualization of the game goals and game aspects warranting attention with their game performance.

Subjects' references to particular game goals did appear to be related to their game performance. Those who cited specific goals for game playing in response to the first post-game question showed better game performance, ($r_{pb} = .21$); $p < .03$. In contrast, reference to evaluations of the game in response to question 1 was negatively correlated with game performance, ($r_{pb} = -.24$); $p < .02$. Reference to game strategies was reflective of game performance, ($r_{pb} = .20$); $p < .05$, in response to question 2 only. Surprisingly, reference to game cues in response to question 2, presumably an indication of what subjects monitored during game play, did not relate to performance, ($r_{pb} = .01$); $p < .95$. However, in response to question 3, the same type of reference was related to game performance, ($r_{pb} = .25$); $p < .01$.

DISCUSSION

This study was designed to assess children's attention in the context of a more ecologically valid task than has been used in many of the developmental studies of children's attention while learning. One goal for using the video game as an attention task was to provide a familiar, and motivating learning situation for both age groups in the study. An equally

important goal was to engage children's attention in much the same manner as would be reflected in a learning situation of their choosing. Accordingly, children were expected to show a vested interest in paying attention while playing the game and to demonstrate a greater awareness of their behavior and feelings toward the game. The interest value of the video game as a task was evidenced by the participation of over 100 students in a single school.

The analysis of children's game performance showed traditional patterns of results, as developmental differences in video game performance were found. Not surprisingly, children who reported frequent video game play showed better game performance than those who reported infrequent play. However, the most interesting results concerned the distinct types of comments children made in response to the post-game questions. Specifically, younger children's comments reflected a greater emphasis on personal feelings about the game, whereas those of the older children reflected a greater emphasis on specific goals or personal standards for mastering the game. This type of emphasis was not unexpected. Fifth graders have been shown to demonstrate more competitive and comparative concerns for their performance (Frey & Ruble, 1990) than younger children. That the task used in the current study is used in competitive play situations also may have facilitated more standard-driven concerns among the older children. A standard-driven concern was positively correlated with game performance while an affective one was negatively correlated, and children voicing the former performed significantly better.

The better game performance of the fifth graders combined with their greater reference to game strategies that new players should use when first learning the game (question 2) and to cues new players should monitor (question 3) provides evidence for their ability to use their understanding of the task to mediate performance. In general, the pattern of comments demonstrated among the younger and older children may attest to the different aspects of the learning situation that children monitor while learning, and how these impact performance. Specifically, younger children may be more cognizant of their personal assessment of a task while learning. This behavior may help sustain their attention to the task in general at the expense of their monitoring specific task features that would improve performance. Also, younger children may approach learning situations with less stringent or different criteria for successful performance than older children (see Winne, 1997), potentially accounting for their stronger emphasis on how much they like the learning situation, as demonstrated here. Finally, it is possible that younger children's tendency to overestimate their performance has positive implications for learning on a long term basis (Bjorklund & Green, 1992) while undermining their ability to monitor learning task aspects that improve performance on a short term basis.

Future work should examine the specific effects of children's goals for learning on their performance and corresponding patterns of attention while learning. This study showed that performance improved with age and with the adoption of a personal standard goal. Subsequent studies may seek to manipulate the type of goals used and to assess their effects on attention and performance. A question of interest is whether the type of goal adopted affects patterns of attention and performance among younger and older children in a comparable manner. Addressing this question may provide insight into whether motivation for learning accounts for developmental differences in children's attention and performance.

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