

The Effects of Continuous and Intermittent Distractors on Cognitive Performance and Attention in Preschoolers

Kathleen N. Kannass
Department of Psychology
Loyola University Chicago

John Colombo
Department of Psychology
University of Kansas

We investigated the effects of different amounts of distraction on preschoolers' task performance and attention. Children 3.5 and 4 years of age completed problem-solving tasks in one of three conditions: no distraction, intermittent (periodic) distraction, or continuous distraction. The results revealed differential effects of the distractors at the different ages. The younger group was susceptible to any kind of distraction; task performance and attention were equally impaired during both distraction conditions. The older group was less susceptible to external distraction, with task performance and attention most impaired in the continuous distraction condition. The results are discussed in terms of the relevance of the amount of competition for attentional focus present in distractors and the development of executive functions in early childhood.

The construct of attention is multifaceted, and one important function is endogenous (i.e., internal, voluntary) control of attention (see Colombo, 2001; Ruff & Rothbart, 1996). Endogenous attention is often conceptualized in terms of colloquial constructs like distractibility, attention span, persistence, and perseverance. This project investigates the development of the ability to “hold” or sustain atten-

tion to a task or problem in the midst of competition for attentional focus, that is, distractibility.

The ability to maintain attention or hold focus in the face of distracting events while working on a task is fundamental for early learning. For this reason, the study of distractibility has been a topic of much research in developmental psychology over the past decade. Studies of distractibility in infants and children generally have involved a simple but powerful paradigm in which participants are occupied with a stimulus or task at midline (the “focal” or “central” task or stimulus), and then a stimulus or event (the “distractor”) is presented in the peripheral perceptual field. Distractibility is typically measured in terms of the percentage of trials in which the participant orients to the distractor (higher percentages reflect higher distractibility) or the latency to orient to the distractor (briefer latencies reflect higher distractibility). The purpose of this project is to investigate how distractor characteristics affect young children’s attention to and performance on cognitive tasks.

The available research on this topic indicates that distractibility in infants and children varies with the state of attention to the focal stimulus or event, the age of the individual in question, and the nature of the distractor. These three parameters are considered briefly.

First, the child’s state of attention and level of engagement with the target or focal stimulus is a determinant of whether or not the child will be distracted. For example, infants and toddlers are clearly less distractible during “focused” or sustained attention (i.e., concentrated attention) than they are during more “casual” attention (e.g., Lansink & Richards, 1997; Oakes & Tellinghuisen, 1994; Richards, 1989; Ruff, Capozzoli, & Saltarelli, 1996). States of focused and casual attention are generally inferred through facial expression and motor activity, but the duration of engagement or looking may also be an indicant. In keeping with the theory of attentional inertia (see Anderson, Choi, & Lorch, 1987; Choi & Anderson, 1991; Oakes, Ross-Sheehy, & Kannass, 2004; Richards & Turner, 2001), infants and children are less distractible when they are engaged in long looks to the target than when they are engaged in short looks to the target.

Second, the evidence on change in distractibility between infancy and early childhood is somewhat mixed. Increases in resistance to distraction have been reported between 10 and 42 months in studies using objects or problem-solving tasks as the focal stimulus and multimodal stimuli as distractors (Ruff & Capozzoli, 2003). Similar findings have been seen across the range of 4 to 6 and 8 years of age (Holtz & Lehman, 1995). In contrast, however, studies using dynamic visual targets as both central stimuli and distractors (e.g., movies, television programs) have not observed differences in distractibility between 6 and 24 months (Richards & Turner, 2001) and 3 and 5 years (Anderson et al., 1987). These differences may be attributed to the nature of the focal stimulus or activity, as developmental differences in distractibility may be more evident in the presence of goal-directed, manipulative, or interactive activity at midline.

Finally, the characteristics of the distractor (e.g., auditory and visual components, complexity) have been shown to affect distractibility in infants (e.g., Oakes, Tellinghuisen, & Tjebkes, 2000; Ruff & Capozzoli, 2003; Tellinghuisen et al., 1999). In contrast, there is little systematic investigation of the effects of distractor characteristics on distractibility and performance during the toddler and preschool years. In the few studies that do exist, variation in distractor features and performance measures makes it difficult to draw comparisons among them.

Some of this research has focused on how distractors affect task performance rather than on orientation or the allocation of attention. In these studies, there is disagreement whether distractors impair or facilitate children's performance. For example, some research suggests that the performance of children between 5 and 8 years deteriorates when a distractor is present (Hale & Flaughner, 1977; Hale & Stevenson, 1974), whereas other research suggests that the performance of children between 3.5 and 10 years improves in the presence of a distractor (Kaniel & Aram, 1993; Ruff, Khaskelberg, & Capozzoli, 2001). Turnure and Higgins have found that distractors impaired the performance of preschoolers and facilitated the performance of 6- to 12-year-old children (Higgins & Turnure, 1984; Turnure, 1970, 1971).

An analysis of the characteristics of the distractor may provide a partial answer to this seemingly conflicting evidence. In the research on preschoolers' attention, distractors may be broadly characterized as being continuous or intermittent in the presentation of competition for attentional focus. Continuous distractors are presented throughout the task (e.g., the continuous presentation of a movie or television program), whereas intermittent distractors are presented only periodically (e.g., random short segments of a movie that periodically appear).

In adults, intermittent noise impairs stimulus detection in comparison to continuous noise (Britton & Delay, 1989), reduces accuracy in comparison to no noise conditions (Carter & Beh, 1989), and has a lower annoyance threshold (as measured by participant adjustment of sound level) than continuous noise (Landstroem, Kjellberg, & Bystrom, 1995). Developmental studies suggest that although intermittent distractors impede performance overall (Hale & Flaughner, 1977; Hale & Stevenson, 1974), the effects of continuous distractors vary with the age of the child; continuous distractors appear to facilitate the performance of sixth graders but impede the performance of preschoolers (Higgins & Turnure, 1984). However, only an experimental manipulation of distractor characteristics will help us understand the potential differential effects of intermittent and continuous distractors on task performance and attention allocation.

The purpose of this study is to investigate the effects of continuous and intermittent distraction on task performance and attention during the preschool years. This study is important for three reasons. First, there has been no systematic investigation of how continuous and intermittent distractors affect performance; this type of manipulation may provide important clarification into the inconsistencies in the

literature. Second, previous distractibility research with children has reported largely on task performance; this study is designed to examine how the type of distraction affects broader indices of cognition (i.e., attention to the task, inattention, duration of looking to the distractor), as well as task performance. Finally, this study investigates attention during the early preschool period, a critical point in the development of attention. Indeed, as previously discussed, there is conflicting evidence of developmental changes in distractibility during this period of time (Anderson et al., 1987; Ruff & Capozzoli, 2003). In addition, although previous research suggests that continuous distraction may impede the performance of preschoolers (Higgins & Turnure, 1984; Turnure, 1971), the effects of intermittent distraction at this point in development are unknown. Moreover, important changes in other endogenous (i.e., internally directed) functions, inhibitory control and executive functioning, occur during the preschool period (Diamond & Taylor, 1996; Gerstadt, Hong, & Diamond, 1994; Jones, Rothbart, & Posner, 2003). Therefore, additional data may help us understand the development of endogenous attentional control and how young children allocate their attention in the midst of distraction.

METHOD

Participants

Seventy-six healthy preschoolers from English-speaking families participated in this project. Because of the distractor stimuli chosen (see following), only children from non-Spanish-speaking homes were included. Because of participant refusal or technical difficulty, 4 preschoolers did not contribute data in the distractibility task, and the final sample consisted of thirty-six 3.5-year-old children (17 girls and 19 boys) and thirty-six 4-year-old children (18 girls and 18 boys). The average age at test was 3.55 years ($SD = .04$) for the 3.5-year-olds and 4.06 years ($SD = .03$) for the 4-year-olds. The children were primarily White. The laboratory's existing database of families in the greater Kansas City, Kansas, area was used to recruit participants. Families received a letter describing the study and a follow-up phone call. Children received token prizes for participating.

Apparatus

All sessions were recorded using a Panasonic camcorder, and a time and date generator was used to generate a record of elapsed time (minutes, seconds, tenths of a second) on the videotapes for coding purposes. The distractors were recorded on videotape and presented on a 68.58 cm (27-inch) video monitor using a Panasonic VCR. Similar to Anderson et al. (1987) and Choi and Anderson (1991), the moni-

tor was located to the child's right and was approximately .91m (3 feet) from and at a 90° angle to the child. A video camera focused on the child was located approximately 1.83 meters (6 feet) from the child. A mirror was located on the wall behind the child and was positioned to capture the reflection of the distractor and, thus, be recorded on videotape for coding purposes.

Stimuli

There were two types of stimuli (target tasks and distractors) used in the distractibility task, which was designed to be similar to those used previously with children (e.g., Anderson et al., 1987; Choi & Anderson, 1991). The four target tasks were Legos™, puzzles, matching, and coloring, and children received task instructions prior to each task (see following). In the Legos™ task, each child was presented with model buildings and the appropriate Legos™ for replicating the model buildings, one at a time; the child's goal was to replicate the model building. In the puzzles task, each child received wooden puzzles, one at a time; the child's goal was to complete the puzzles. In the matching task, each child received small cards with pictures on them (e.g., bananas, boats, flowers, shapes, toys), one set at a time, and some of the cards matched, and some did not; the child's goal was to place the matching cards together. In the coloring task, each child received coloring work sheets, one at a time; the child's goal was to color the spaces the appropriate color (i.e., the same color as a dot in the center of each space).

The distractors were segments of a children's television show in Spanish recorded on videotape. Two kinds of distractors were created — an intermittent distractor and a continuous distractor. The intermittent distractor consisted of 5-sec, randomly ordered segments of the show, and in between those segments were intervals of blank (black) tape. Similar to the distractors used by Anderson et al. (1987) and Choi and Anderson (1991) in their studies of distractibility in 3- and 5-year-olds, the intervals of blank tape were 5, 10, 15, 20, or 25 sec in duration, and the order of these intervals was determined randomly. In contrast, the continuous distractor consisted of continuous presentation of the 5-sec, randomly ordered distracting segments. Thus, in both distractor conditions, the children were presented with incomprehensible audio and visual information (i.e., there was no audio or visual story information to follow).

Procedure

Children were seated at a child-sized table, and the child's parent was seated in the same room, behind and to the child's left, out of the child's sight. Twelve children were randomly assigned to each of the three conditions: intermittent distraction, continuous distraction, or no distraction.

Children received each of the four tasks (Legos™, puzzles, matching, coloring) for 3 min each, and task durations were timed using a hand-held stopwatch. The order of the tasks was counterbalanced across children. The experimenter introduced each task by explaining the task-specific directions. For example, in the Legos™ task, she said, “Now it’s time for the Lego™ game. See this cool building? This is my building. Can you use these Legos™ [giving the child the appropriate Lego™ pieces] to make your building look just like mine? Your building should look the same as mine. When you are all done with this one, I’ll give you some more Legos™ and another building.” Children worked independently on the games, and the experimenter kept her interactions to a minimum. For each task, items were replaced on completion (e.g., when children finished a puzzle, they received another one). After the experimenter presented each toy, she used a remote to start the distractor tape in the continuous distraction and intermittent distraction conditions. At the end of each trial, the experimenter said, “You did a great job playing that game,” stopped the distractor, collected the toys, and then began the next trial.

Measures and Coding

The measures consisted of a task performance score and measures of attention and distractibility (e.g., looking to the task, off-task inattention, and looking to the distractor).

Task score. After testing, children’s performance on each of the tasks was recorded on a scoring sheet. Specifically, the sum of correctly placed Legos™, correctly placed puzzle pieces, correct matches, and correctly colored segments was recorded. To assess each child’s total task performance, a composite score of performance across the tasks (consisting of the total sum across tasks) was calculated.

Attention and inattention coding. Coders (who were unaware of the hypotheses of the research) watched the session and recorded the time displayed on the videotape at (a) the start and end of each individual look to a toy (i.e., task) and (b) the start and end of each episode of inattention (i.e., when children directed their attention away from the toys, looking instead around the room, at the experimenter or parent, and so on). An individual look or episode of inattention was defined as being 1 sec or longer in duration. Looks to the toy that were separated by a very short look away (i.e., less than 1 sec in duration) were combined, and vice versa for episodes of inattention separated by a very short look to the toy. Reliability for each behavior was assessed by correlating the duration of each individual look or episode of inattention as recorded by the two coders. At each age, for each task, two coders recorded the behavior for at least 25% of the sample coded for that measure. The average interobserver reliability was .99 for duration of individual

looks (mean difference = .58 sec) and .94 for durations of individual episodes of inattention (mean difference = .21 sec).

From this record of coding, it was possible to calculate a mean duration for looks to the toy and to count the number of episodes of inattention (i.e., the number of times that preschoolers looked away from the toy). Both the mean length of looking to the toy and the number of episodes of inattention are indicators of how children sustain and maintain their attention. Cronbach's alpha computed on these measures (the mean length of looking to the toy and the number of episodes of inattention) was .70, indicating that these two measures were tapping the same underlying construct of maintenance of attention.

We used these measures to create an attention aggregate in the following manner: First, we reversed the direction of the inattention measure so that the direction was consistent with the looking measure (i.e., a larger number now reflected more attention). Then we calculated a z score for each looking and inattention measure, and then created the aggregate by averaging those two scores for each child.

Looking to the distractor or TV. Coders also recorded the amount of looking to the distractor or TV by recording the start and end of each individual look to a distractor. The mean durations for looks to the TV were calculated. Reliability for at least 25% of the sample was good, $r = .99$ (mean difference = .15 sec).

RESULTS

We examined the effects of distraction on measures of task performance, the attention aggregate, and looking to the distractor. Preliminary analyses revealed no influence of gender (no main effects or interactions), and so gender is not included in the final analyses.

We first examined the effects of the different types of distraction on task performance. The task scores were entered into an Analysis of Variance (ANOVA), with Age (2: 3.5 vs. 4 years) and Condition (3: No Distraction, Intermittent Distraction, and Continuous Distraction) as between-subjects factors. The analysis revealed a main effect of Age, $F(1, 66) = 16.02, p < .01$, a main effect of Condition, $F(2, 66) = 5.64, p < .01$, and an Age \times Condition interaction, $F(2, 66) = 3.15, p < .01$. To decompose the two-way interaction, follow-up ANOVAs were conducted at each age. The analysis on task scores for the 3.5-year-olds revealed an effect of Condition, $F(2, 33) = 3.47, p < .05$, and Least Squares Difference (LSD) post hoc tests revealed that children in the no distraction condition performed significantly better than did children in the intermittent distraction condition ($p < .05$) and the continuous distraction condition ($p < .05$) (see Table 1). There was no difference between performance in the intermittent and continuous distraction conditions ($p = .92$).

TABLE 1
Means and Standard Deviations for the Performance Scores and the
Attention Aggregate Across Distractor Conditions at Each Age

<i>Measure and Age</i>	<i>No Distraction</i>		<i>Intermittent Distraction</i>		<i>Continuous Distraction</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Performance Scores						
3.5 years	57.25	7.31	47.92	8.33	47.50	13.88
4 years	61.42	7.13	64.58	7.00	53.25	10.68
Attention Aggregate						
3.5 years	0.43	0.83	-0.55	0.72	-0.03	0.80
4 years	0.32	0.81	0.28	0.78	-0.45	0.93

That is, at 3.5 years of age, any kind of distraction appears to be disruptive to the children's task performance.

The analysis on task scores for 4-year-olds also revealed a significant Condition effect, $F(2, 33) = 5.76, p < .05$, but the pattern of responding was different (see Table 1). Here, LSD post hoc tests revealed that children in the continuous distraction condition performed worse than did children in the intermittent distraction condition ($p < .01$) or in the no distraction condition ($p < .05$). There was no significant difference in task scores between children in the intermittent and no distraction conditions. Thus, at 4 years of age, performance was impeded in the continuous distraction condition.

To explore whether the effects were the same for each task, we conducted a mixed-model ANOVA with Task (4: Puzzles, Legos™, Matching, Coloring) as the within-subjects factor and Age (2: 3.5 vs. 4 years) and Condition (3: No Distraction, Intermittent Distraction, Continuous Distraction) as the between-subjects factors. We first standardized the scores by computing a z score for each child's task scores, and entered the z scores into the analysis. This analysis was consistent with the overall analysis; there was a main effect of Age, $F(1, 66) = 15.25, p < .01$, a main effect of Condition, $F(2, 66) = 5.23, p < .01$, and an Age \times Condition interaction, $F(2, 66) = 3.24, p < .05$. This significant interaction was decomposed as in the analysis of the overall task scores, revealing the same findings, and it will not be discussed further. In addition, there was a marginal Age \times Task interaction, $F(3, 64) = 2.66, p = .06$. We examined the potential age differences in each task (i.e., four comparisons) and set alpha at .0125 to control for family-wise error. The marginal interaction appears to be due to 4-year-olds' having higher task scores in the puzzle task, $t(70) = 3.32, p < .0125$, and in the Legos™ task, $t(70) = 3.84, p < .0125$, but no age differences in the matching task, $t(70) = 2.34, p = .02$, or the coloring task, $t(70) = .67, p = .50$. In summary, this analysis confirmed that the effects of condition were the same across tasks.

Second, we examined the effects of the different amounts of distraction on the aggregate measure of attention. The aggregate z scores were entered into an ANOVA as before, with Age and Condition as between-subjects factors. The analysis revealed a main effect for Condition, $F(2, 66) = 3.93, p < .05$, and an Age \times Condition interaction, $F(2, 66) = 3.79, p < .05$. Follow-up ANOVAs were conducted at each age to decompose this interaction, with largely the same results seen for the attention aggregate as for the task score results. The analysis on the attention aggregate for the 3.5-year-olds revealed an effect of Condition, $F(2, 33) = 4.63, p < .05$; LSD post hoc tests revealed that children in the no distraction condition were more attentive than were children in the intermittent distraction condition ($p < .01$) (see Table 1). Although children were less attentive in the continuous distraction condition than in the no distraction condition, this difference was not significant ($p = .12$).

The analysis on the attention aggregate for 4-year-olds revealed a different significant pattern of responding across Conditions, $F(2, 33) = 3.19, p = .05$ (see Table 1). Again, LSD post hoc tests revealed that children in the continuous distraction condition were significantly less attentive than were children in the no distraction condition ($p < .05$) and in the intermittent distraction condition ($p < .05$). In other words, at 4 years of age, only continuous distraction impeded attention.

To explore whether the effects were the same for each task, we conducted a mixed model ANOVA with Task (4: Puzzles, Legos™, Matching, Coloring) as the within-subjects factor and Age (2: 3.5 vs. 4 years) and Condition (3: No Distraction, Intermittent Distraction, Continuous Distraction) as the between-subjects factors. This analysis was consistent with the overall analysis; there was a main effect of Condition, $F(2, 66) = 4.89, p < .01$, and an Age \times Condition interaction, $F(2, 66) = 3.17, p < .05$. This significant interaction was decomposed as in the analysis of the overall attention aggregate, revealing the same findings, and it will not be discussed further. In summary, this analysis confirmed that the effects of condition were the same across tasks.

Third, we were interested in how looking to the distractor changed over the course of the session in the intermittent and continuous conditions. In infant distractibility research, infants orient less and less to the distractor over the course of the session (e.g., Oakes et al., 2000, 2004; Tellinghuisen & Oakes, 1997). To conduct this analysis, we derived the average length of looking to the distractor for the first half of the session (Block 1) and the second half of the session (Block 2), and we then entered these averages into a mixed-model ANOVA with Age (2: 3.5 vs. 4 years) and Condition (2: Intermittent Distraction, Continuous Distraction) as between-subjects factors and Block (2: 1 vs. 2) as a within-subjects factor. The analysis revealed a marginal effect of Condition, $F(1, 44) = 3.75, p = .06$, and a significant Block \times Condition interaction, $F(1, 44) = 4.68, p < .05$. For each condition, we compared looking in Block 1 and Block 2 using Tukey post hoc comparisons with a family-wise error rate of .05. In the intermittent distraction condition, the

duration of individual looks significantly decreased from Block 1 ($M = 2.76$, $SD = 1.17$) to Block 2 ($M = 1.76$, $SD = 1.55$), $p < .05$. These children exhibited shorter looks to the distractor in the second half of the session. In contrast, in the continuous distraction condition, there was no change in looking from Block 1 ($M = 4.58$, $SD = 5.40$) to Block 2 ($M = 5.61$, $SD = 8.89$), $p > .05$.

Fourth, we examined the relations between children's task performance and their attention in the distractibility task. We collapsed across age and computed a correlation between performance scores and the attention aggregate for each condition. In other words, because of the small number of children in each condition at each age, we computed separate correlations between performance scores and the attention aggregate for all children in each condition (i.e., all 3.5- and 4-year-olds in the no distraction, intermittent distraction, and continuous distraction conditions). The correlations between the attention aggregate and performance scores were not significant for children in the no distraction condition, $r(24) = .003$, *ns*. However, significant positive correlations were observed for children's attention and task performance in the intermittent distraction condition, $r(24) = .55$, $p < .01$, and in the continuous distraction condition, $r(24) = .49$, $p < .05$. Thus, under conditions in which attention was challenged by the presence of distractors, the ability of children to maintain attention was associated with their task performance.

One remaining question was whether the correlations between the attention aggregate and performance scores differed significantly between the no distraction condition and each of the distraction conditions. To investigate this (i.e., the apparent differences in these relations between children in the no distraction and intermittent and continuous conditions), we examined whether there were significant differences in the correlations between (a) the no distraction and intermittent conditions and (b) the no distraction and continuous conditions. We used Fisher's z' Transformation and Comparison between Independent Correlations, a test for the significant difference between two independent correlations (Cohen & Cohen, 1983). The analyses revealed a significant difference between the no distraction and intermittent conditions correlations, $z' = 1.97$, $p < .05$, and a marginal difference between the no distraction and continuous conditions, $z' = 1.71$, $p < .09$. Thus, the correlations between attentional responding and performance in the distraction conditions were different from the correlation between attentional responding and performance in the no distraction condition, suggesting different patterns of responding in the challenging conditions.

Last, we examined relations between children's average length of looking to the distractor and their task performance in the intermittent and continuous distraction conditions. The correlation between the average length of looking to the distractor and performance scores was not significant for children in the intermittent distraction condition, $r(24) = -.29$, *ns*. However, a significant negative correlation was observed for children in the continuous distraction condition, $r(24) = -.74$, $p < .01$. Thus, in the continuous condition, longer looking to distractor was significantly

associated with lower task performance. Again, we compared these correlations, and the analysis revealed a significant difference, $z' = 2.14$, $p < .05$, suggesting that there was a stronger negative relation between looking to the distractor in the continuous condition than in the intermittent condition.

DISCUSSION

This project makes three important contributions to the existing literature on attention and distractibility in early childhood. First, this project shows how different types of distraction affect task performance and attention in early childhood. At 3.5 years of age, both types of distraction were disruptive to performance, as children in the intermittent distraction and continuous distraction conditions had lower performance scores than did the children in the no distraction condition. In contrast, at 4 years of age, attention and performance were adversely affected only in the continuous distraction condition. For the 3.5-year-olds, attention and performance may be disrupted by any competition for attentional focus; 4-year-olds, on the other hand, can apparently tune out the periodic competition for attention represented by the intermittent distractor, but they cannot tune out the constant competition for attentional focus represented by the continuous distractor.

This study is the first to experimentally manipulate continuous and intermittent distractors and examine their effects on attention and performance in the same tasks. As such, these data add to other research on how distractors affect children's performance, but where the effect of only one type of distractor was examined (Hale & Flaugh, 1977; Hale & Stevenson, 1974; Higgins & Turnure, 1984; Turnure, 1970).

Second, our results contrast with adult research on the effects of continuous and intermittent distractors on performance and instead suggest a developmental pattern in which children are first susceptible to any kind of distraction (continuous or intermittent) and then later are susceptible to continuous distraction. For young children, the amount of competition for attentional focus appears to be key. In adults, on the other hand, intermittent noise has been shown to impair performance on a number of tasks and be more disruptive, possibly due to high arousal (Britton & Delay, 1989; Carter & Beh, 1989; Landstroem et al., 1995), whereas continuous distraction has been found to facilitate performance, possibly due to a moderate level of arousal (Britton & Delay, 1989; Poulton, 1979). In summary, then, continuous and intermittent distraction have a different impact on preschool attention versus adult attention.

One important question is what developmental mechanisms might contribute to the observed developmental changes in this project? It is likely that changes in children's susceptibility to distraction in this study are consistent with a gradual increase in endogenously controlled attention (e.g., Colombo, 2001; Ruff &

Capozzoli, 2003; Ruff & Rothbart, 1996). Children are increasingly able to resist distraction and maintain attention across early childhood (Ruff & Capozzoli, 2003; Ruff & Lawson, 1990), and it seems likely that this resistance may also be related to the increase in inhibitory control seen during the early preschool years, with some change occurring primarily between 3.5 and 4.5 years of age (e.g., Diamond & Taylor, 1996; Gerstadt, Hong, & Diamond, 1994; for a review, see Diamond, 2002).

Our results also revealed changes in how children attended to the distractors over the course of the session. In particular, the data suggest that children habituated more readily to a periodic distractor (intermittent distraction condition) than to a continuous (continuous distraction condition) one. This decrease in looking to the intermittent distractor over time is consistent with other research using intermittent distractors (e.g., Hale & Flaughner, 1977; Oakes et al., 2000, 2004; Tellinghuisen & Oakes, 1997), and it might account for the persistent effects of continuous distraction seen here well into the preschool period.

Third, the analysis of the correlations between attention and performance across the various conditions revealed a theoretically important point: The associations between attention and performance were strong in situations in which attention was “challenged” by distractors (i.e., the intermittent and continuous distraction conditions), but nonexistent under conditions in which there was no competition for attentional focus. This is an important point for future work looking to link these processes, as well as for future studies of individual differences. These results are consistent with previous research showing significant negative relations between off-task, inattentive responding and learning or task performance in distraction conditions and insignificant relations in control or quiet conditions (Higginson & Turnure, 1984; Turnure, 1971).

Furthermore, longer looking to the distractor was significantly associated with poorer performance only in the continuous distraction condition. This finding, in combination with the results on looking to the distractor over time, bolsters the interpretation that constant competition for attentional focus might be most disruptive for cognitive function and performance. These findings have direct implications for research on how ambient television might affect cognitive development (see Anderson & Pempek, 2005). For example, our results are wholly consistent with recent work by Kirkian, Anderson, Schmidt, and Pempek (2005), who found that 12-, 24-, and 36-month-old toddlers who played with toys in the context of continuous background television had shorter play episodes and exhibited less concentration than did toddlers who played with toys without background television. Other research has shown that preschool children who watched cartoons first and then engaged in various tasks (e.g., using finger paints, using Play-Doh™, looking at books) spent less time on-task than did children in a control group or children who had first viewed an educational program (Geist & Gibson, 2000).

Collectively, this work suggests that constant competition for attentional focus (such as background television) may have cognitive implications during a point in development when toddlers and preschoolers are known to increase their visual attention to television (Anderson & Levin, 1976). Future research is needed to better understand the impact of distraction on cognitive development and the influence of factors such as distractor content and the nature of focal stimulus events.

In summary, our findings provide valuable insight into the influence of distractor characteristics on attention allocation and task performance and the developmental course of attention. Furthermore, this line of work has important implications for the construction of early learning environments that will facilitate “on-task” attention and learning.

ACKNOWLEDGMENTS

This research was made possible by Grant HD35903 awarded to John Colombo, and Kathleen N. Kannass was supported by NICHD interdisciplinary training Grant T32 HD07525.

Portions of this research were presented at the biennial meetings of the International Conference on Infant Studies (April, 2004 in Chicago, IL) and the Society for Research in Child Development (April, 2005 in Atlanta, Georgia).

We would like to thank Stephanie Gettler and the undergraduates in the University of Kansas Infant Cognition Center for their help in the data collection and coding phases of this project and also thank the delightful participants and their parents.

REFERENCES

- Anderson, D. R., Choi, H., & Lorch, E. P. (1987). Attentional inertia reduces distractibility during young children's television viewing. *Child Development, 58*, 798–806.
- Anderson, D.R., & Levin, S. R. (1976). Young children's attention to “Sesame Street.” *Child Development, 47*, 806–811.
- Anderson, D. R., & Pempek, T. A. (2005). Television and very young children. *American Behavioral Scientist, 48*, 505–522.
- Britton, L. A., & Delay, E. R. (1989). Effects of noise on a simple visual attention task. *Perceptual and Motor Skills, 68*, 875–878.
- Carter, N. L., & Beh, H. C. (1989). The effect of intermittent noise on cardiovascular functioning during vigilance task performance. *Psychophysiology, 26*, 548–559.
- Choi, H. P., & Anderson, D. R. (1991). A temporal analysis of free toy play and distractibility in young children. *Journal of Experimental Child Psychology, 52*, 41–69.
- Colombo, J. (2001). The development of visual attention in infancy. *Annual Review of Psychology, 53*, 337–367.

- Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. T. Stuss, Donald T., & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 466–503). New York: Oxford University Press.
- Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the ability to remember to what I said and to “do as I say, not as I do.” *Developmental Psychobiology*, *29*, 315–334.
- Doolittle, E. J., & R, H. (1998). Distractibility during infants’ examining and repetitive rhythmic activity. *Developmental Psychobiology*, *32*, 275–283.
- Geist, E.A., & Gibson, M. (2000). The effect of network and public television programs on four and five year-olds’ ability to attend to educational tasks. *Journal of Instructional Psychology*, *27*, 250–261.
- Gerstadt, C. L., Hong, Y. J., Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 1/2-7 years old on a Stroop-like day-night test. *Cognition*, *53*, 129–153.
- Hale, G. A., & Flaugher, J. (1977). Distraction effects in tasks of varying difficulty: Methodological issues in measuring development of distractibility. *Journal of Experimental Child Psychology*, *24*, 212–218.
- Hale, G. A., & Stevenson, E. E. (1974). The effects of auditory and visual distractors on children’s performance in a short-term memory task. *Journal of Experimental Child Psychology*, *18*, 280–292.
- Higgins, A. T., & Turnure, J. F. (1984). Distractibility and concentration of attention in children’s development. *Child Development*, *55*, 1799–1810.
- Holtz, B. A., & Lehman, E. B. (1995). Development of children’s knowledge and use of strategies for self-control in a resistance-to-distraction task. *Merrill-Palmer Quarterly*, *41*, 361–380.
- Jones, L. B., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental Science*, *6*, 498–504.
- Kaniel, S., & Aram, D. (1993). Developmental impacts of meta-attention instructions. *International Journal of Cognitive Education and Mediated Learning*, *3*, 110–121.
- Kirkian, H. L., Anderson, D. R., Schmidt, M. E., & Pempek, T. A. (2005). TV and toddlers. Paper presented at the Society for Research in Child Development, Atlanta, GA.
- Landstroem, U., Kjellberg, A., & Bystrom, M. (1995). Acceptable levels of tonal and broad-band repetitive and continuous sounds during the performance of nonauditory tasks. *Perceptual and Motor Skills*, *81*, 803–816.
- Lansink, J. M., & Richards, J. E. (1997). Heart rate and behavioral measures of attention in 6-, 9-, and 12-month-old infants during object exploration. *Child Development*, *68*, 610–620.
- Oakes, L. M., Ross-Sheehy, S., & Kannass, K. N. (2004). Attentional engagement in infancy: The interactive influence of attentional inertia and attentional state. *Infancy*, *5*, 239–252.
- Oakes, L. M., & Tellinghuisen, D. J. (1994). Examining in infancy: Does it reflect active processing? *Developmental Psychology*, *30*, 748–756.
- Oakes, L. M., Tellinghuisen, D. J., & Tjebkes, T. L. (2000). Competition for infants’ attention: The interactive influence of attentional state and stimulus characteristics. *Infancy*, *1*, 347–361.
- Richards, J. E. (1989). Development and stability of HR-defined, visual sustained attention in 14-, 20-, and 26-week-old infants. *Psychophysiology*, *26*, 422–430.
- Richards, J. E., & Turner, E. D. (2000). Extended visual fixation and distractibility in children from six to twenty-four months of age. *Child Development*, *72*, 963–972.
- Ruff, H. A., & Capozzoli, M. C. (2003). Development of attention and distractibility in the first four years of life. *Developmental Psychology*, *39*, 877–890.
- Ruff, H. A., Capozzoli, M. C., & Saltarelli, L. M. (1996). Focused attention and distractibility in 10-month-old infants. *Infant Behavior and Development*, *19*, 281–293.
- Ruff, H. A., Khaskelberg, A., & Capozzoli, M. (2001, April). Preschoolers control attention to meet task demands. Presented at the Society for Research in Child Development, Minneapolis, MN.
- Ruff, H. A., & Lawson, K. R. (1990). Development of sustained, focused attention in young children during free play. *Developmental Psychology*, *26*, 85–93.

- Ruff, H. A., & Rothbart, M. K. (1996). *Attention in early development*. New York, Oxford University Press.
- Tellinghuisen, D. J., & Oakes, L. M. (1997). Distractibility in infancy: The effects of distractor characteristics and type of attention. *Journal of Experimental Child Psychology*, 64, 232–254.
- Turnure, J. E. (1970). Children's reactions to distractors in a learning situation. *Developmental Psychology*, 2, 115–122.
- Turnure, J. E. (1971). Control of orienting behavior in children under 5 years of age. *Developmental Psychology*, 4, 16–24.