Allocation of Attention in Classroom Environments: Consequences for Learning

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Abstract

The current study investigates how young children allocate their attention in learning environments. Prior research has shown that elementary school students spend between 25% and 50% of instructional time off-task. However, the available research has not clearly identified the common sources of distraction, nor specified the relationship between the distraction source and learning outcomes. In this study we examined how visual features of the environment which are not relevant for on-going instruction (e.g., manipulatives, posters, artwork, maps, etc.) affect young children's ability to maintain focused attention to the content of a lesson. We addressed this question by experimentally manipulating our laboratory classroom environment (e.g., introducing or removing educational materials irrelevant to the current lesson). The effects of the manipulation on children's off-task behavior and learning were measured. Results suggested that children in the Low Visual Distraction condition spent less time off-task and obtained higher learning scores than children in the High Visual Distraction condition.

Keywords: Off-Task Behavior. Learning. Attention. Classroom Environment.

Introduction

Off-task behavior is a serious challenge that educational practitioners face on a daily basis. Indeed prior research has shown that elementary students spend between 25% and 50% of instructional time off-task (Karweit & Slavin, 1981). Off-task behavior is believed to be problematic as it potentially limits students' learning opportunities by reducing instructional time (Carroll 1963; Bloom, 1976). Although previous literature has documented that off-task behavior is common in educational settings, it remains unclear what children are doing while off-task as behavior is often coded as a binary variable (i.e., on-task vs. off-task). Thus, one of the goals of the present study was to identify common sources of distraction in kindergarten classroom environments and to evaluate consequences of off-task behavior for learning.

There is reason to believe that the ability to maintain focused attention during on-going instruction is more difficult for younger children than older children. In particular, research indicates that children's susceptibility to distracters decreases with age while focused attention improves (Ruff & Rothbart, 1996; Ruff & Capozzoli, 2003). Furthermore, children's ability to utilize selective attention strategies continues to develop throughout middle-childhood (DeMarie-Dreblow & Miler, 1988). Thus, with age children are increasingly able to efficiently and flexibly allocate their attentional resources.

Of particular interest for the present study was the role of the classroom visual environment in attention allocation and learning. There are two key reasons to examine this factor. First, the relationship between current practices in the design of classroom visual environments and student age is somewhat paradoxical. As stated above, it is well-documented that distractibility decreases markedly with age (Ruff & Rothbart, 1996). However, younger learners (e.g., kindergarten and elementary school students) are often presented with learning environments containing greater amounts of potential sources of visual distraction (e.g., art work, posters, alphabet charts, etc.; see Figure 1 for an example) than the learning environments of older students. Thus, it is an empirical question as to whether educational materials that are not directly relevant to the ongoing instruction present a distraction for young learners. And if so, does off-task behavior related to the classroom visual environment affect learning outcomes?

The second key reason to focus on the classroom visual environment is its malleability. If the classroom visual environment is found to influence allocation of attention and learning outcomes, then it may be possible to design classrooms that are optimally suited to promote focused attention and learning.

Off-Task Behavior

Prior research examining the frequency with which students engage in off-task behavior have estimated that children spend between 25% and 50% of their time off-task in regular education classrooms (Karweit & Slavin, 1981). Despite the significant amount of time spent off-task, there is limited research identifying which sources of distraction pose a heavy burden on young learners' ability to maintain focused attention during instruction.

(A)

(B)

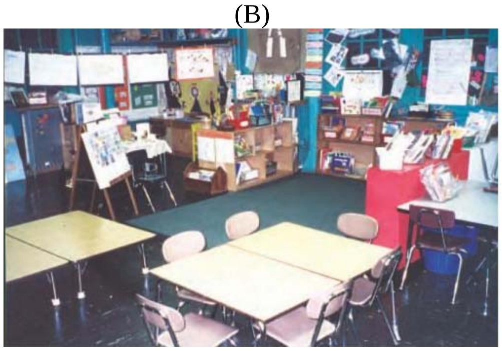

Figure 1. Examples of visual classroom environments. Panel A depicts a kindergarten classroom in Yucaipa, California found through the Google search engine; Panel B depicts a first grade classroom found in "Classroom management in photographs" by Chang (2004).

One of the few studies investigating different types of off-task behavior was conducted by Rusnock and Brandler (1979). Rusnock and Brandler observed the frequency with which high and low ability fourth graders engaged in different types of off-task behavior across different learning activities. The authors found no significant group differences between low and high ability students in the total amount of time spent off-task: in both groups children spent approximately 25% of their time off-task. However, there were significant group differences based on the specific off-task behavior the students engaged in and the particular learning activity in which the off-task behavior was more likely to occur. For example, low ability students were more likely to be off-task during recitation, and they were more likely to engage in off-task discussions and other distractions such as doodling than their high ability peers. In contrast, high ability students were more likely to engage in off-task behavior during creative activities. In this study measures of student learning were not obtained. Therefore, it is unclear whether off-task behavior negatively impacted children's learning.

Off-Task Behavior and Learning

The notion that learning is related to the amount of time one spends on a particular task is an axiom of conventional wisdom (Lloyd & Loper, 1986). This view was formalized by Carroll's Time-On-Task hypothesis (1963). According to this hypothesis, longer engagement with learning materials is one factor that promotes learning (among several other factors, such as student's aptitude, perseverance, and quality of instruction). Accordingly, off-task behavior is hypothesized to reduce learning outcomes by decreasing the amount of time on-task.

Carroll's Time-On-Task hypothesis has stimulated a great deal of research trying to establish a relationship between instructional time and learning (See Cobb, 1972; Lahaderne, 1968; McKinney, Mason, Perkerson, & Clifford, 1975; Samuels & Turnure, 1974). However, many of these studies have yielded mixed results.

One study to demonstrate a relationship between off-task behavior and learning was conducted by Karweit and Slavin (1981). In this study the researchers measured time-on-task to see if it was a significant predictor of elementary school children's achievement scores on the Comprehensive Test of Basic Skills (CTBS). Karweit and Slavin found mixed results as a function of age. Time-on-task was found to be a significant predictor of CTBS scores for second and third graders; however, total instructional time was not a significant predictor of CTBS scores. In contrast, for fourth and fifth graders neither total instructional time nor time-on-task was found to be a significant predictor of CTBS scores. Karweit and Slavin also looked at potential differences due to ability level and found that time-on-task was a significant predictor for low ability students but not for high achieving students; this was particularly true for fourth and fifth graders.

In a subsequent study (Lee, Kelly, & Nyre, 1999), students (kindergarten through twelfth grade) were observed for 10 minutes while completing independent seatwork. The duration of time-on-task was calculated as well as work completion rates and quality. Lee et al. found that 80% of students' time was spent on-task. Not surprisingly, students who completed the assignment tended to spend more time-on-task than their peers who did not complete the assignment.

Overall, prior research has established a persistent, albeit sometimes moderate, relationship between time-on-task and learning outcomes, with correlations ranging between 0.13 and 0.71 (for reviews see Caldwell, Huitt, & Graeber, 1982; Frederick & Walberg, 1980; Goodman, 1990). However, as Karweit (1984) noted, it is possible that some other factors covaried with time-on-task but were not measured, thus making it difficult to establish a causal relationship between time-on-task and learning.

Classroom Arrangement and Off-Task Behavior

The preponderance of research examining the interaction between the physical environment and time-on-task has focused on classroom seating arrangements. For instance, Krantz and Risley (1972; see also Ahrentzen & Evans, 1984) found that kindergarteners' ability to maintain focused attention during a read-aloud was impacted by the classroom seating arrangement. Kindergartners who sat in seating arrangements that were more dispersed were found to be more attentive during read-alouds than when the same kindergartners crowded around their teacher. These findings are taken to suggest that the physical arrangement and classroom setting can have a considerable impact on children's on-task behavior; however, the authors did not measure whether the increased amount of time-on-task translated into increased learning gains.

Current understanding of the relationship between classroom design, off-task behavior, and learning remains limited. The present study was designed to investigate whether the classroom visual environment has an effect on attention allocation and learning outcomes in kindergarten children.

Method

Participants

The participants in this study included the kindergarten class at a local lab school. The sample size was 19 children and consisted of 12 females and 7 males (M=5.66 years; SD=0.28). The children were assigned to one of two groups (Group1: n=9, Group2: n=10). Stratified random assignment was used to ensure groups were equivalent on age, gender, and the number of students who were English Language Learners (ELL) (Group 1: M=5.68 years, SD= 0.28, 6 females and 3 males, 2 ELL children; Group 2: M=5.65 years, SD=0.29, 6 females and 4 males, 2 ELL children).

Design

This study utilized a within-subject design. The visual environment was the within-subject factor (e.g. presence or absence of educational materials irrelevant to the on-going lesson). There were two conditions: High Visual Distraction and Low Visual Distraction. In the High visual distraction (HVD) condition the physical environment of the laboratory classroom was furnished with potential sources of distraction commonly found in kindergarten and elementary school classrooms (e.g. posters, bulletin boards, maps, artwork, manipulatives, etc.; see Figure 2). All of the materials used to decorate the lab classroom were purchased from educational supply stores. In the Low Visual Distraction (LVD) condition all visual materials not relevant to the on-going instruction were removed.

Procedure

Both groups began the study by participating in three familiarization sessions. The familiarization sessions served to acquaint the children with the teacher, the mock classroom, and the procedure. There was a moderate amount of potential sources of distraction present in the mock classroom during the familiarization sessions. After the familiarization session, the children began their respective treatment schedule. The presentation order was alternated (e.g. HVD–LVD–HVD–LVD) to mitigate temporal confounds. The groups were randomly assigned to a presentation order (i.e., HVD first or LVD first). The within-subject design was employed to control for potential differences in lesson interest and assessment difficulty. The dependent variables were the frequency and duration of different types of off-task behavior (described below) and learning scores on assessments (also described below). The lessons were video taped for coding.

Figure 2. Laboratory classroom in the High Visual Distraction condition.

Seating Arrangement During all lessons, children sat in a semi-circle facing the teacher. The children's seating arrangement was randomly assigned. Animal carpet squares were utilized as placeholders and helped the children identify their seat assignment each week.

Lessons The children participated in four mini lessons over the course of a 5 week period (Approximately 1 lesson per week). Each lesson lasted between 5 and 7 minutes and consisted of a short read-aloud which introduced children to the lesson content. To control for novelty, all of the topics were approved by the kindergarten teacher to ensure that the lesson topics had not been covered during the school year. Although children may have had some exposure to these topics at home or elsewhere, the children had not received formal instruction on any of these topics during the current school year. The lesson topics included: plants and seeds, stone tools, matter (solids, liquids, and gases), and weather. All lessons were conducted by the first author of this paper.

Assessments An assessment was administered at the end of each lesson to measure learning. The assessments consisted of a short paper-and-pencil task that included recognition and comprehension questions. For the first two lessons, the children answered 10 questions (8 recognition questions and 2 comprehension questions). For the last two lessons, the children answered 12 questions (6 recognition questions and 6 comprehension questions). The children did not have prior experience with workbooks. Consequently, the first two lessons determined the number of test questions the children would be able to complete. Subsequently, the number of questions was increased from 10 to 12 for the last two lessons.

For all questions, recognition and comprehension, the participants were asked to select the correct answer from four pictorial response options. For the recognition questions, the children were asked to circle the picture they saw in the book that the teacher had read during the lesson. The comprehension questions were intended to be more difficult than the recognition questions as the correct response option was represented by a novel picture that the children had not encountered during the lesson or the children had to select the correct response from four familiar pictures (see Figure 3 for an example).

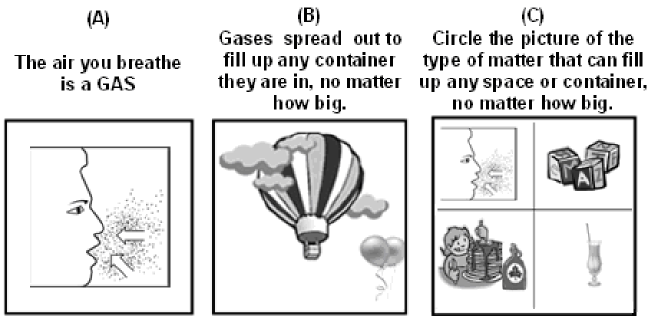

Figure 3. Sample materials from the lesson "Matter": Panels A-B present sample content and panel C presents a sample assessment question. All text was presented verbally by the experimenter.

Operational Definitions For the purposes of this research, focused attention was conceptualized as a "state in which attention is directed more or less exclusively to one target or task" (Ruff & Rothbart, 1996, p.110). Focused attention was operationalzied as engagement with the teacher or the learning materials (i.e., the book), and engagement was determined by direction of children's gaze. Eye gaze is commonly used as a measure of visual attention (for reviews see Henderson & Ferreira, 2004; Just & Carpenter, 1976) and there is evidence that visual attention and saccadic eye movements rely on the same neural mechanisms (Corbetta, Akbudak, Conturo, Snyder, Ollinger, Drury, Linenweber, Petersen, Raichle, Van Essen, & Shulman, 1998). Furthermore, eye gaze is sometimes used as a measure of auditory attention (e.g., Spelke, 1976; Reisberg, 1978; Saffran, Newport, & Aslin, 1996; Thiessen, 2007). As we argue below, we also believe that direction of eye gaze is a reasonable measure of focused attention in contexts that involve attending to visually presented instructional materials.

It could be argued that one can successfully listen to the teacher while looking elsewhere. However, if visual materials are used during instruction (e.g., a demo, a movie, or a book) then attending to instruction auditorily but not visually would by definition constitute *divided* attention. In many cases, divided attention leads to decrements in performance not observed under the conditions of focused attention (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Healey & Miyake, 2009; Navon & Miller, 1987). Therefore, in the context of instruction that involves visual materials, direction of eye gaze seems to be a reasonable (albeit imperfect) measure of focused attention and on-task behavior.

Coding All coders were trained by the first author of this paper. The training consisted of extensive practice coding vignettes, video tapes, and live observations. An event sampling strategy was utilized during observations in the experiment proper: Coders were first taught to classify the child's behavior as on- or off-task based on direction of eye gaze (e.g. is the child looking at the teacher and/or the relevant instructional materials?). If the child was classified as being off-task, the source of distraction was identified using a coding scheme developed in pilot research. The possible sources of distraction were categorized as (1) Self-distraction, (2) Peer distraction, (3) Environmental distraction, or (4) Other. Self-distraction was defined as engagement with something on the child's own body such as an article of clothing (e.g. shoe, zipper, button, etc.) or an appendage. Peer distraction was defined as engagement with another child, including touching, talking, or looking at a peer. Environmental distractions included any incident in which the child was looking at anything in the physical environment such as charts, maps, carpet squares, etc. Category "Other" was included for observations that did not clearly align with the three aforementioned categories.

In cases where the child was engaged in several simultaneous off-task behaviors, the indicated category was determined by the direction of eye gaze. For example, if the child was talking to a peer while playing with their button the child was classified as "*off-task – peer distraction*" since the child was looking at their peer.

For each instance of off-task behavior, the coders marked the timing of its onset and cessation. This procedure allowed for determining not only the frequency with which a particular type of off-task behavior occurred, but also the amount of instructional time lost due to each type of off-task behavior. Cohen's (1960) Kappa was calculated for a subset of the lessons between the first author and a hypothesis-blind coder to estimate inter-rater reliability. Kappa was an acceptable 0.74, a level of reliability in line with past classroom research coding off-task behavior, and approaching the 0.75 threshold to which Fleiss (1981) refers to as "excellent".

Results

All results and analyses presented below are based on the coding of the hypothesis-blind coder.

Duration of Time off-Task by Distraction Subtype

Pairwise t-tests were conducted to determine if the duration of time allocated to each distraction subtype differed as a function of condition. Children spent significantly more time attending to the environment in the HVD condition than in the LVD condition. On average children in the LVD condition spent only 5% of the instructional time engaged in environmental distractions, which was significantly lower than in the HVD condition (21%), $t(17) = 4.84$, $p < 0.0001$. In contrast, children in the LVD condition spent significantly more time attending to all other sources of distraction, all $ts(17) > 2.14$, $ps < 0.05$ (see Figure 4).

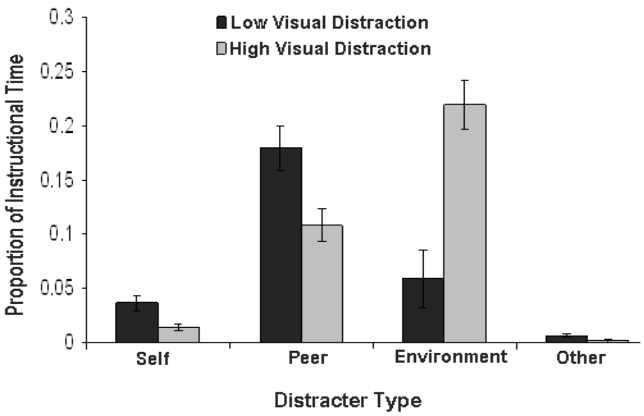

Figure 4. Type of off-task activities by experimental condition. Error bars represent the standard error of the mean.

It may appear from the pattern of results in Figure 4 that while classroom visual environment may affect attention allocation in instructional settings, there is merely a trade-off between the types of off-task behavior that different environments promote: classrooms filled with materials irrelevant to the content of the lesson may be more likely to promote attention to these materials, whereas more streamlined classrooms may be more likely to promote off-task peer interaction. However, the type of off-task behavior children are engaged in may have different consequences for the amount of instructional time lost due to off-task behavior.

Total Time off-Task

The total proportion of time spent off-task was measured, and the group means were compared in each condition. The overall proportion of instructional time spent off-task was significantly greater in the HVD condition (M=0.34, SD=0.09) compared to the LVD condition (M=0.28, SD=0.10), paired-sample $t(17)=2.49$, $p=0.02$ (See Figure 5).

Learning Outcomes

Pair-wise comparisons were also conducted to examine group differences on the learning measures. The analyses showed that there was a significant difference on children's total score as a function of condition. Children in the LVD condition obtained higher learning scores (M=0.79, SD=0.11) than children in the HVD condition (M=.70, SD=0.17), and this difference was statistically significant ($t(17)=2.72$, $p= 0.01$); see Figure 5 above.

Follow-up analyses were conducted to examine children's performance on the recognition and comprehension subscales. Children in the LVD condition had higher recognition scores (M=0.85, SD=0.14) than children in the HVD condition (M=0.77, SD=0.21); however, this difference did not reach statistical significance, paired-sample $t(17)=1.60$, $p=0.13$. Similar results were found for the comprehension sub score. Children in the LVD condition achieved higher comprehension scores than children in the HVD condition (M=0.64, SD=0.27 and M=0.52, SD=0.29 respectively); however, this difference also did not reach significance, paired-sample $t(17)=1.37$, $p=0.19$.

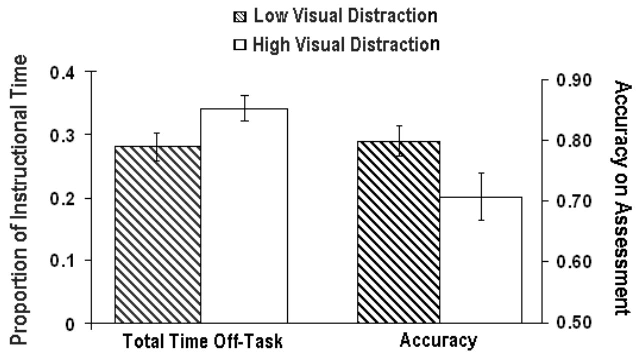

Figure 5. Total proportion of instructional time spent off-task and accuracy on the assessment questions by experimental condition. Error bars represent the standard error of the mean.

Discussion

Overall, the present study yielded several novel and important findings. First, the patterns of attention allocation in kindergarten children changed as a function of the classroom visual environment. In the HVD condition children spent more time attending to the environment, and in the LVD condition children spent more time attending to self, peer, and other distracters. Second, these changes in the patterns of attention allocation led to significant changes in the proportion of instructional time spent off-task. Specifically, children spent significantly more instructional time off-task in the HVD condition than in the LVD condition. Third, a relationship between the visual classroom environment and learning was also found. Overall accuracy on the learning assessments was higher in the LVD condition than in the HVD condition.

A number of previous studies have established a relationship between time-on-task and learning outcomes; however, this study is the first (to our knowledge) to experimentally induce lower or higher levels of off-task behavior and observe corresponding changes in learning outcomes. At the same time, many important questions remain to be answered. Further research is needed to examine whether time-off-task mediates learning outcomes, whether children habituate to static visual environments, and whether the classroom visual environment in naturalistic settings pose a challenge to children's attention allocation and learning (although this is far from a comprehensive list of unanswered questions). Nevertheless, the present study suggests that the classroom visual environment may in principle play a role in how children allocate their attention during instruction.

The results from this study provide a foundation to explore more fully the practical implications of this line of work as our results point toward the possibility that some of children's attention can be redirected to the teacher by mitigating environmental distractions. The development of attention regulation in educational settings is an area of research which warrants further inquiry. This research may lead to design of learning environments that reduce attentional burden and promote allocation of attentional resources toward learning.

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