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Visual Environment, Attention Allocation, and Learning in Young Children: When Too Much of a Good Thing May Be Bad

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Abstract

A large body of evidence supports the importance of focused attention for encoding and task performance. Yet young children with immature regulation of focused attention are often placed in elementary-school classrooms containing many displays that are not relevant to ongoing instruction. We investigated whether such displays can affect children's ability to maintain focused attention during instruction and to learn the lesson content. We placed kindergarten children in a laboratory classroom for six introductory science lessons, and we experimentally manipulated the visual environment in the classroom. Children were more distracted by the visual environment, spent more time off task, and demonstrated smaller learning gains when the walls were highly decorated than when the decorations were removed.

Keywords

attention, learning, cognitive development, self-control, educational psychology, open data

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Many researchers have suggested that focused attention is crucially important for learning throughout life—from the crib to the classroom and beyond (e.g., Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013; Gaertner, Spinrad, & Eisenberg, 2008; McKinney, Mason, Perkerson, & Clifford, 1975; Oakes, Kannass, & Shaddy, 2002; Ruff & Rothbart, 2001; Yu & Smith, 2012): "If attention were constantly reoriented to every new event, it would be difficult . . . to learn about any single object or event" (Oakes et al., 2002, p. 1644). With respect to student achievement, this idea has been formalized in the time-on-task hypothesis: All else being equal, the more opportunities one has to learn (i.e., the longer one focuses on an activity), the better the learning outcomes (Bloom, 1976; Carroll, 1963).

In this study, we investigated whether the classroom visual environment can affect attention allocation and thereby affect learning in kindergarten children. It is well documented that distractibility decreases markedly with age (DeMarie-Dreblow & Miller, 1988; Higgins & Turnure, 1984; Humphrey, 1982; Ruff & Capozzoli, 2003). For example, the presence of extraneous stimulation during discrimination or memory tasks has been shown to impair performance of preschoolers and first and second graders, but not that of sixth graders (Higgins & Turnure, 1984; Humphrey, 1982). Furthermore, decrements in performance occur whether extraneous stimulation is auditory (e.g., noise in the hallway) or visual (e.g., a large mirror placed next to a child's desk; Higgins & Turnure, 1984).

Developmental decrease in distractibility is commonly attributed to developmental improvements in inhibitory control and working memory. Specifically, maintaining focused attention requires inhibition of orienting to irrelevant objects and events (Colombo & Cheatham, 2006; Kane & Engle, 2002; Ruff & Rothbart, 2001) and active maintenance of task goals (Colombo & Cheatham, 2006; Kane & Engle, 2002). Both of these processes have been shown to undergo protracted development extending into late adolescence and early adulthood (for reviews, see Diamond, 2006; Luna, 2009).

Therefore, maintaining focused attention in classroom environments that contain extraneous visual displays

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may be particularly challenging for young children because visual features in the classroom may tax their still-developing and fragile ability to actively maintain task goals and ignore distractions. In fact, the relationship between student age and typical classroom design is somewhat paradoxical: Younger learners (e.g., kindergarten and elementary school students) are often placed in learning environments that are rich with potential sources of distraction (e.g., colorful educational materials and other visual displays). This problem is compounded by the fact that kindergarten and elementary school students typically receive the majority of instruction in a single classroom (i.e., they do not have a specialized classroom for each subject area as is common in middle and high school). Therefore, students are exposed to large amounts of visual materials that are not relevant for the ongoing instruction. Consider this description of a typical elementary school classroom:

> One spring day, as I observed a student teach a science lesson to a group of 25 first-graders, my gaze wandered around the room. From a small chair in a corner, I counted 19 different, decorated, scalloped borders segmenting portions of the bulletin boards lining the walls. The boards were filled with words: a word wall, class rules, calendar, alphabets, numbers, shapes, and colors, and a plethora of cartoon people and animals . . . . St. Patrick's Day mobiles created from brightly painted rainbows and black-line masters hung from the ceiling just above the children's heads . . . . (Tarr, 2004, p. 1)

Such visual environments have been described as "visual bombardment" (Bullard, 2010, p. 110) and a "cacophony of imagery" (Tarr, 2004, p. 1).[1] Some educators warn against excessive use of sensory stimulation in primary-grade classrooms (e.g., Tarr, 2004; Thompson & Raisor, 2013). Montessori (1949) encouraged teachers of young children to have sparsely decorated classrooms, a practice that continues in Montessori classrooms today. However, no studies have yet directly examined the possible effects of the classroom visual environment on young children's attention allocation and learning outcomes. Our goal in the present study was to address the following research questions. First, do irrelevant visual displays affect attention allocation in kindergarten students? Second, do irrelevant visual displays affect kindergarteners' learning? On the basis of literature suggesting protracted maturation of the ability to inhibit distracters and maintain task goals (e.g., Diamond, 2006; Luna, 2009), we predicted that visual displays not relevant to the ongoing instruction may decrease focused attention and thereby decrease learning gains in kindergarten students.

The research reported here was conducted in a laboratory adjacent to a university laboratory school. Kindergarten children were brought into the laboratory classroom for six lessons. Instruction consisted of a short period in which the teacher read aloud from a book (hereafter called a *read-aloud*), which is a common instructional activity in kindergarten. Children received three lessons in the decorated-classroom condition and three lessons in the sparse-classroom condition. Immediately after each lesson, paper-and-pencil assessments were administered to measure learning of the lesson content.

All lessons were videotaped for coding episodes in which children became distracted (*off-task behavior*) and episodes in which they were engaged with the teacher or learning materials (i.e., the book; *on-task behavior*). Engagement was determined by the direction of gaze. Eye gaze is a common measure of visual attention (for reviews, see Henderson & Ferreira, 2004; Just & Carpenter, 1976) and has also been used as a measure of auditory attention (e.g., Reisberg, 1978; Saffran, Aslin, & Newport, 1996). Although it is possible that students listen to the teacher while looking elsewhere, doing so by definition constitutes divided attention rather than focused attention. Therefore, in instructional contexts that involve visual materials, direction of eye gaze is a reasonable (albeit imperfect) measure of focused attention and on-task behavior.

Method

Participants

Participants were 24 kindergarten students (12 girls, 12 boys; mean age = 5.37 years). To prevent overcrowding in the laboratory classroom, we used stratified random assignment to create two groups matched on age and gender (Group 1: $n = 12$; 6 girls, 6 boys; mean age = 5.37 years; Group 2: $n = 12$; 6 girls, 6 boys; mean age = 5.39 years). One child was absent during four of the six lessons; consequently, this child's data were excluded from our analyses.

All participants were recruited from the same kindergarten classroom in a laboratory school on the campus of a private university in a Midwestern city in the United States. Participants were predominantly White (74% White, 26% minority) and predominantly from households with high socioeconomic status.

Design

The study took place in a research laboratory modified to look like a classroom. In the decorated-classroom condition, the laboratory classroom was furnished with

Fig. 1. Panoramic view of the laboratory classroom in (a) the decorated-classroom condition and (b) the sparse-classroom condition.

potential sources of visual distraction commonly found in primary classrooms (e.g., science posters, maps, the children's own artwork provided by their teacher; Fig. 1a). All commercial materials were purchased from educational supply stores. In the sparse-classroom condition, all materials irrelevant to ongoing instruction were removed (Fig. 1b). The classroom visual environment was a within-subjects factor. Dependent measures were the amount of time children spent off task and the learning outcomes as determined by the paper-and-pencil assessments. The order of testing in the sparse and decorated classrooms was alternated to mitigate temporal confounds: The first lesson was in the sparse-classroom condition, and the order of conditions was alternated thereafter.

Procedure

Both groups participated in five familiarization sessions. We used the familiarization sessions (a) to acquaint participants with the teacher (i.e., research assistant) and assessment procedures (i.e., paper-and-pencil tests) and (b) to administer pretest assessments. During the familiarization sessions, the laboratory classroom contained a moderate amount of irrelevant visual materials. After the familiarization sessions, children participated in six experimental sessions (i.e., the six science lessons).

Lessons. Children participated in six lessons over a 2-week period. Lessons consisted of 5- to 7-min read-alouds. Lesson topics were plate tectonics, stone tools, volcanoes, solar system, bugs, and flight (see Fig. 2a for sample lesson content). The children's kindergarten teacher was interviewed before the study to ensure that participants had not received formal instruction on any of these topics during the current school year. The lesson topics were selected to align with the major domains covered in elementary science education and the academic standards for elementary science education specified by the Pennsylvania Department of Education (for details about the lessons and books, see Lesson Content and Creation of Custom-Made Books in the Supplemental Material available online).

During the lessons, the children sat on carpet squares in a semicircle facing the teacher. The seating arrangement was randomly assigned at the beginning of the study and remained constant throughout (i.e., the seating arrangement was similar to the stable seating arrangement participants experienced in their own kindergarten classroom). All lessons were conducted by a female researcher who was blind to the hypotheses and who had prior experience with early childhood education. As is typical for read-alouds with children of this age, the researcher sat on the floor facing the children and read from a book. After reading each two-page spread, she showed the children the illustrations in the book by moving the book slowly across the semicircle. A book was created for each of the six lesson topics. The researcher was instructed to conduct the lessons the way she typically would for children of this age.

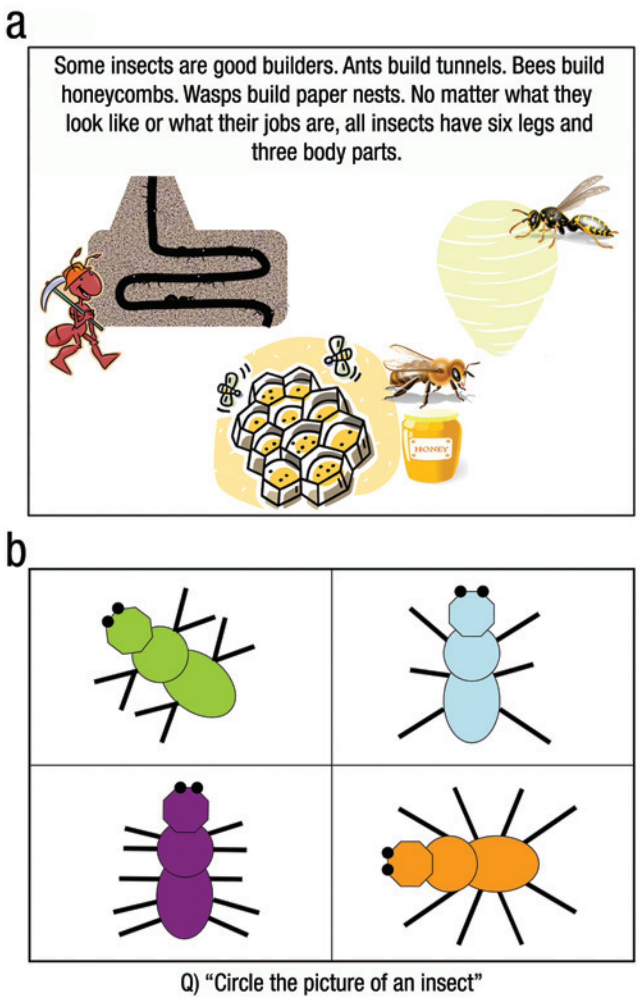

Fig. 2. Sample (a) content and (b) assessment question from the bug lesson. The story content was obtained in part from Rockwell and Jenkins (2001). All text was presented verbally by the teacher.

Assessments. Pretest assessments were administered during the five familiarization sessions. Children were given an assessment workbook, and the teacher read each question aloud and asked the children to select the correct answer from four pictorial response options. Seventy questions were administered during the pretests (13 to 15 questions during each of the five familiarization sessions). The presentation order of the pretest questions was randomized.

Thirty-six pretest questions (six per science lesson) were selected for the posttest assessments. Item selection was based on pretest accuracy: For each lesson, the six items with the lowest rate of accuracy on the pretest were included in the posttest. The mean pretest accuracy for the selected questions was 22.7%, not different from chance, one-sample $t(22) = 1.10$, n.s.

To equalize pretest performance between the sparse-classroom condition and the decorated-classroom condition, we divided the six science lessons into two groups on the basis of pretest accuracy (i.e., higher vs. lower pretest accuracy). We then pseudo-randomly assigned lessons from the two groups into the two experimental conditions, with the restriction that a single condition could not contain all lessons with higher or lower pretest accuracy scores. Using this procedure, the following three lessons were assigned to the sparse-classroom condition: plate tectonics, volcanoes, and bugs. The remaining three lessons—stone tools, solar system, and flight—were assigned to the decorated-classroom condition.

A posttest assessment was administered at the end of each lesson. Each assessment workbook included six questions pertaining to the completed lesson. The procedure for administering the posttest assessments was identical to that used in the pretests. Specifically, the children were asked to select the correct answer from four pictorial response options (one correct answer and three lures). All response options were novel (i.e., four pictures the children had not seen during the lesson) to ensure that the children were not merely selecting a familiar answer (see Fig. 2b for a sample assessment item).

Coding. Four coders who were blind to the hypotheses were trained by the second author using vignettes, videotapes, and live observations. An event-sampling strategy was used to code children's behavior during the lessons: Coders first classified behavior as on or off task on the basis of the direction of the children's eye gaze. On-task behavior was defined as looking at the teacher or the instructional materials. If the child was classified as exhibiting off-task behavior, the distraction source was identified using a coding scheme developed in pilot observations in a kindergarten classroom. Distractions were categorized as follows: self-distraction (i.e., engagement with one's own body or clothing), peer distraction (i.e., engagement with another child), environmental distraction (i.e., engagement with classroom materials irrelevant for ongoing instruction), or other (i.e., off-task behaviors that did not clearly align with any other category). If the child was engaged in simultaneous off-task behaviors, the primary distraction source was determined by direction of eye gaze.

The coders marked the onset and cessation of each off-task behavior to determine the frequency and duration of off-task behaviors. To estimate interrater reliability, we calculated Cohen's kappa (Cohen, 1960) for a subset (20%) of observations. Kappa was .74, a level of reliability that was in line with past observations of classroom off-task behavior and that approached the .75 threshold considered excellent in the field of classroom observations (Fleiss, 1981).

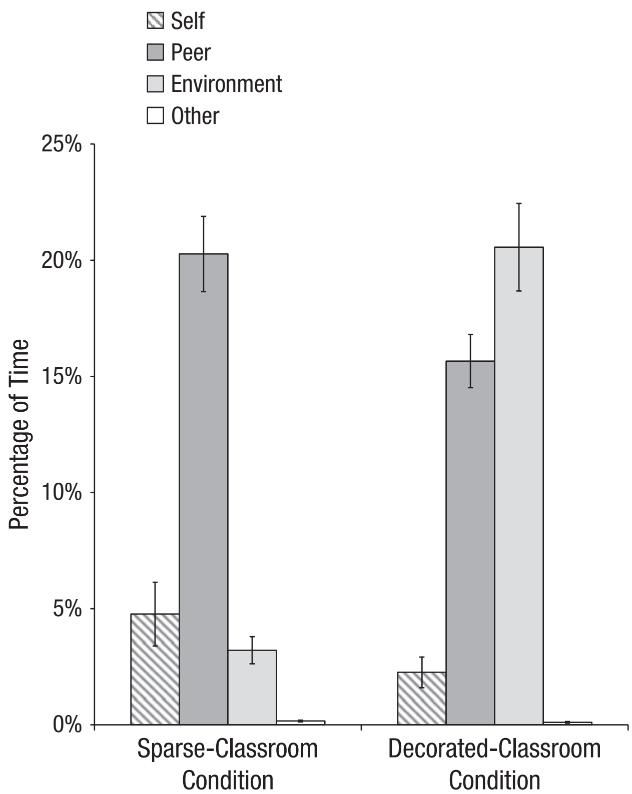

Fig. 3. Percentage of time spent off task as a function of condition and distraction subtype. Error bars represent ±1 *SEM*.

Results

Effect of classroom type on time spent off task

In the two experimental conditions combined, children were on task for 66.5% of instructional time. This percentage of time on task is in line with that reported in previous research (i.e., children were on task for between 57% and 88% of instructional time; Karweit & Slavin, 1981). Therefore, in the present experiment, the teacher successfully engaged the children in the learning activity. At the same time, the rate of off-task behavior varied as a function of condition. The overall percentage of instructional time spent off task was significantly greater when children were in the decorated classroom (M = 38.58%, SD = 10.49) than when they were in the sparse classroom (M = 28.42%, SD = 13.19), paired-sample $t(22) = 4.90$, $p < .0001$; this effect was large, Cohen's $d = 0.85$.

To examine the possibility that the effects reported here were driven by a minority of participants who were particularly sensitive to visual displays, we calculated a difference score for each child by subtracting the percentage of time spent attending to the environment in the decorated classroom from the percentage of time spent attending to the environment in the sparse classroom. Difference scores ranged from 2% to 36%, with a mean of 17% (SD = 9). Few children (n = 3, 13% of the sample) had difference scores below 10% and thus presumably were minimally affected by the visual displays in the decorated classroom. However, most children (n = 20, 87% of the sample) had difference scores that exceeded 10%, which is contrary to the possibility that the observed effects were driven by a minority of participants.

Next, we examined whether the duration of time allocated to each distraction subtype differed as a function of condition. In the sparse-classroom condition, the children spent only 3.21% of instructional time engaged in environmental distractions, whereas in the decorated-classroom condition, they spent 20.56% of instructional time engaged in environmental distractions; this difference was significant, paired-sample $t(22) = 8.78$, $p < .0001$, and the effect was large, Cohen's $d = -2.60$. In contrast, the children spent significantly more time engaging in self-distraction and peer distraction in the sparse classroom than they did in the decorated classroom, both paired-sample ts(22) > 2.75, ps < .012 (Fig. 3). In both conditions, the children spent less than 1% of instructional time engaged in other distractions.

Effect of classroom type on learning

Pretest accuracy was statistically equivalent in the sparse-classroom condition (M = 22%) and the decorated-classroom condition (M = 23%), paired-samples $t(22) < 1$, and accuracy in both conditions was not different from chance, both one-sample ts (22) < 1.3, ps > .21. The children's posttest scores were significantly higher than their pretest scores in both experimental conditions, both paired-samples ts(22) > 4.72, ps ≤ .0001 (Fig. 4). Therefore, in both experimental conditions, the children successfully learned from the instruction. However, their learning scores were higher in the sparse-classroom condition (M = 55%) than in the decorated-classroom condition (M = 42%), paired-samples $t(22) = 2.95$, $p = .007$; this effect was of medium size, Cohen's $d = 0.65$.

Analysis of gain scores corroborated the results of the analysis of the posttest scores. Gain scores were calculated by subtracting each participant's pretest score from his or her posttest score. Pairwise comparisons indicated that the children's learning gains were higher in the sparse-classroom condition (M = 33%, SD = 22) than in the decorated-classroom condition (M = 18%, SD = 19), paired-sample $t(22) = 3.49$, $p = .002$, Cohen's $d = 0.73$.

The relation between time spent off task and learning

First, we examined the relation between time spent off task and learning outcomes. For this analysis, we

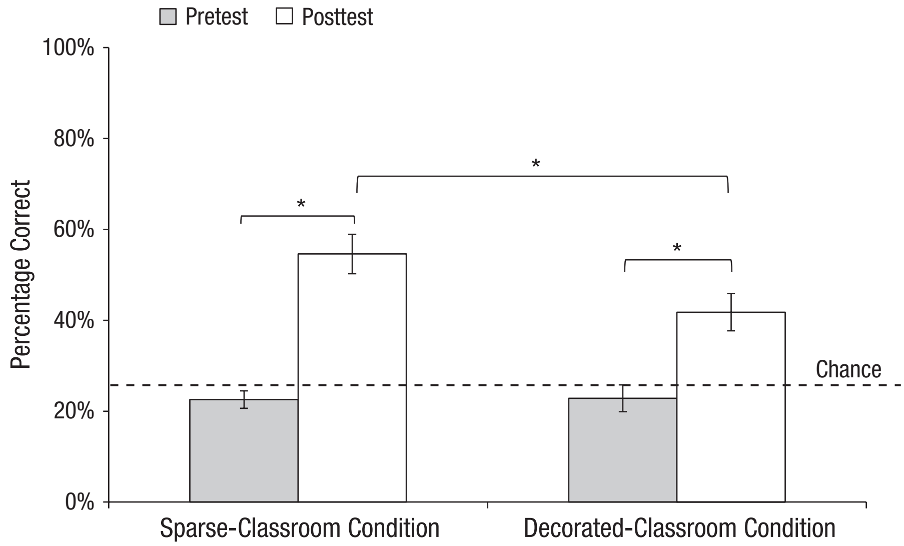

Fig. 4. Percentage of correct answers on the pretest and the posttest as a function of experimental condition. Error bars represent ±1 *SEM*. Asterisks indicate significant differences ($p < .01$).

averaged each child's time off task and posttest scores across the decorated-classroom and sparse-classroom conditions to derive measures of total time off task and total learning. These scores were negatively correlated: Children who spent more time off task tended to have lower learning scores, $r = -.500$, $p = .015$ (Fig. 5).

Next, we conducted a mediation analysis to examine the relations among classroom environment, time spent off task, and learning outcomes. This analysis indicated that time spent off task significantly mediated the relation between classroom condition (decorated vs. sparse) and learning scores, $p = .011$ (see Details of the Mediation Analysis in the Supplemental Material). This finding suggests that the observed effects stem from the following pathway: Classroom type affected the children's attention allocation (they spent more time off task when the classroom was highly decorated than when it was not decorated), and time off task reduced learning of the lesson content.

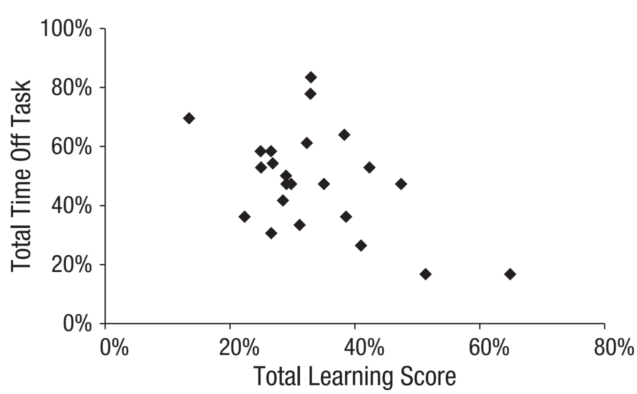

Fig. 5. Scatter plot showing total time off task as a function of total learning score.

Discussion

The present study yielded several novel findings. First, the pattern of focused attention in kindergarten children changed as a function of the classroom visual environment. When placed in a decorated classroom, the children were more likely to be distracted by the visual environment, and when placed in a sparse classroom, they were more likely to be distracted by themselves or by peers. Second, the classroom visual environment affected the overall amount of time the children spent off task: They spent significantly more instructional time off task in the decorated-classroom condition than in the sparse-classroom condition. More than 85% of the children in the sample showed this effect. Third, although the children learned from the instruction in both conditions, learning scores were higher in the sparse-classroom condition than in the decorated-classroom condition. Fourth, there was a negative relationship between the total amount of time the children spent off task and learning: The more time a given child spent off task, the less that child learned. Finally, time off task mediated the relationship between classroom type and learning: The decorated classroom led to greater time off task than the sparse classroom, and greater time off task in turn led to reduced learning.

Although previous research has established a relationship between focused attention and task performance (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Kannass & Colombo, 2007), our study is the first (to our knowledge) to experimentally induce lower or higher levels of off-task behavior in the same group of children and to reveal corresponding changes in learning outcomes in a naturalistic setting. Therefore, these findings provide support to the time-on-task theory of learning in academic settings (Carroll, 1963). Although a large number of correlational studies have provided evidence for this theory (e.g., Frederick & Walberg, 1980; Roberge, Rojas, & Baker, 2012), the present findings provide the first supporting experimental evidence.

Results from the present study suggest that the visual environment plays a role in how young children allocate their attention during instruction. Susceptibility to environmental distractors is probably affected by individual characteristics of the learner. For example, children with less-developed inhibitory control may be particularly susceptible to environmental distractors. Further research is necessary to explore the relations among individual differences, time on task, and learning. We are not advocating sterilizing the learning environments of young children by removing all decorations, artwork, or educational displays. The reported results serve as a proof of concept that the classroom visual environment can induce changes in attention allocation and learning outcomes in kindergarten children. However, further research is needed to examine the optimal level of visual stimulation in primary-grade classrooms to develop evidence-based guidelines for classroom design.

In contemplating the possible practical implications of the reported findings, it is important to consider several issues. First, how robust are the reported effects? This article builds on our prior work, which yielded similar findings (Godwin & Fisher, 2011). In both studies, we observed an increase in total time off task in the decorated classroom compared with the sparse classroom and higher learning scores in the sparse classroom compared with the decorated classroom. These similar results were obtained despite methodological differences between the two studies. For instance, in the present study, lessons were assigned to conditions on the basis of pretest accuracy rates. In contrast, in our prior study, the same lessons were completed in both classroom environments by different groups of children (e.g., half of the children completed the stone-tools lesson in the decorated-classroom condition and the remaining children completed the stone-tools lesson in the sparse-classroom condition). Therefore, the current findings are sufficiently robust to have been observed across two separate studies that varied whether a lesson was completed by all children in the same type of classroom (the present study) or was completed in both classroom types (sparse and decorated) but by different groups of children.

Second, in the present study, we alternated the decorated- and sparse-classroom conditions to mitigate temporal confounds. However, this design may have led the children to be surprised at the frequent changes in the classroom visual environment, thus amplifying the possible detrimental effect of the decorated-classroom condition on attention allocation and learning. A related concern is that in real classrooms, students are exposed to the same visual environment every day and may therefore habituate to the visual environment. In a recent study, we videotaped groups of kindergarten children who received instruction in a decorated classroom every day for 2 weeks (Godwin & Fisher, 2012). Before receiving instruction in the decorated classroom, the children participated in a weeklong series of lessons in a sparse classroom, which served as a baseline. In the sparse classroom, the children spent 29% of instructional time off task. Off-task behavior in the decorated classroom was significantly greater in both Week 1 (48% of time spent off task) and Week 2 (46% of time spent off task). It is possible that greater habituation might occur with longer exposure. Nevertheless, these findings indicate that young children often find visual displays distracting, even after multiple consecutive exposures.

Finally, it is unclear whether our findings can be generalized to children in grades beyond kindergarten. There is some indirect evidence that they can. Barrett, Zhang, Moffat, and Kobbacy (2013) examined the relationship between several environmental factors and student achievement in primary school students in the United Kingdom; most students in the study were between the ages of 3 and 11 years. The researchers found that a number of school- and classroom-level factors were related to children's achievement scores, even when controlling for the contribution of socioeconomic status. For example, achievement scores were positively associated with the amount of natural light and air quality in classrooms. The authors initially hypothesized that greater amounts of color in a classroom should correspond to better achievement, which would be consistent with the pervasive belief that primary classrooms need to provide sensory stimulation. In contrast, Barrett et al. found that classroom color ratings were negatively related to achievement scores. The present findings provide a theoretical framework for interpreting this surprising outcome. Specifically, colorful visual displays may promote off-task behavior in young children, resulting in reduced learning opportunities and achievement. It remains to be assessed experimentally whether our current findings generalize to older children. Nevertheless, our findings and those reported by Barrett et al. suggest that the classroom visual environment can be optimized to promote on-task behavior and to improve learning outcomes in elementary school students.

Author Contributions

A. V. Fisher was responsible for the conceptualization of the study and contributed to study design and data analyses. K. E. Godwin contributed to the conceptualization and design of the study and to data analyses, and she created the study materials and trained the coders. H. Seltman conducted the mediation analysis. All authors contributed to the writing of the manuscript.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

Open Practices

All data have been made publicly available via Dryad and can be accessed at http://dx.doi.org/10.5061/dryad.d2441. There was no preregistration of the data analyses in a public open-access repository. However, a data-analysis plan was submitted in a grant proposal (Institute of Education Sciences, U.S. Department of Education, Grant R305A110444) before data collection and analyses. The complete Open Practices Disclosure for this article can be found at http://pss.sagepub.com/content/by/supplemental-data. This article has received the badge for Open Data. More information about the Open Practices badges can be found at https://osf.io/tvyxz/wiki/view/ and http://pss.sagepub.com/content/25/1/3.full.

Note

1. Examples of highly decorated primary-school classrooms can be obtained by a simple Internet search (e.g., using "kindergarten classroom" or "primary classroom" as search terms).

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