The Immediate Impact of Different Types of Television on Young Children's Executive Function

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KEY WORDS
television, preschool, executive function

ABBREVIATIONS
EF—executive function
HTKS—head toes knees shoulders

Dr Lillard conceived of the essential study; Ms Peterson and Dr Lillard developed the methods together; under Dr Lillard's guidance, Ms Peterson conducted the study and coded and entered data; both authors contributed to data analysis; and Dr Lillard wrote the text, and Ms Peterson reviewed it.

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WHAT'S KNOWN ON THIS SUBJECT: Previous study results have suggested a longitudinal association between entertainment television and later attention problems.

WHAT THIS STUDY ADDS: Using a controlled experimental design, this study found that preschool-aged children were significantly impaired in executive function immediately after watching just 9 minutes of a popular fast-paced television show relative to after watching educational television or drawing.

abstract

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OBJECTIVE: The goal of this research was to study whether a fast-paced television show immediately influences preschool-aged children's executive function (eg, self-regulation, working memory).

METHODS: Sixty 4-year-olds were randomly assigned to watch a fast-paced television cartoon or an educational cartoon or draw for 9 minutes. They were then given 4 tasks tapping executive function, including the classic delay-of-gratification and Tower of Hanoi tasks. Parents completed surveys regarding television viewing and child's attention.

RESULTS: Children who watched the fast-paced television cartoon performed significantly worse on the executive function tasks than children in the other 2 groups when controlling for child attention, age, and television exposure.

CONCLUSIONS: Just 9 minutes of viewing a fast-paced television cartoon had immediate negative effects on 4-year-olds' executive function. Parents should be aware that fast-paced television shows could at least temporarily impair young children's executive function. *Pediatrics* 2011;128:e000

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Preschool-aged children watch >90 minutes of television daily,[1] and correlational studies link early television viewing with deficits in executive function (EF),[2–7] a collection of prefrontal[8] skills underlying goal-directed behavior, including attention, working memory, inhibitory control, problem solving, self-regulation, and delay of gratification.[9–12] EF is increasingly recognized as key to positive social[13] and cognitive [14] functioning and is strongly associated with success in school.[15–17]

If television has long-term effects on EF, then one might see small short-term effects; even adults report feeling less alert immediately after watching television.[18] Most research on television has focused on attention, one of many EF processes. Entertainment television is particularly associated with long-term attention problems[19]; thus, its viewing might be most likely to have negative short-term impacts. Within the realm of entertainment television, fast-paced shows seem particularly likely to have a negative impact on attention, one reason for this being that rapidly presented events capture attention in a bottom-up fashion, involving the sensory rather than prefrontal cortices.[20] Thus, fast-paced television would do nothing to train internally controlled (prefrontal) attention over the long-term. In the short-term, the effort to encode rapidly presented events could tax children's executive resources. When adults are presented with televised events in more rapid succession, more resources are allocated to encoding those events,[21] presumably depleting resources that could otherwise be available for other aspects of attention. Thus, we hypothesized that watching a fast-paced cartoon would have an immediate negative impact on children's EF relative to watching a slower-paced, realistic educational cartoon or engaging in a self-paced activity such as drawing.

There is a limited amount of literature on the immediate impact of television show pacing on children's attention or other aspects of EF. One study found that a fast-paced show led to less task persistence than a slow-paced one.[22] However, posttesting was conducted in a large group setting in which the behavior of a few individuals might have affected others. Another study suggested fast pacing is not problematic: watching fast- versus slow-paced episodes of *Sesame Street* had no impact on task persistence or impulsivity in later free play.[23] It should be noted that *Sesame Street* is even faster-paced today than it was 30 years ago[24] when that study was conducted; it is possible that even the fast-paced clip created for the 1977 study was not as fast-paced as today's television shows.

Task persistence is only one outcome of high EF. Young children's EF has been assessed by many tasks tapping its various aspects. Performance on these tasks is often found to be intercorrelated,[14,25] and it is also correlated with parent and teacher assessments of children's self-regulated behavior.[26,27] EF was assessed here by using 4 well-known tasks: Tower of Hanoi, backward digit span, delay of gratification, and head toes knees shoulders (HTKS). Although delay of gratification is considered a measure of EF, especially of inhibitory control, it tends to be less well correlated with the other abilities,[28] theoretically because it taps "hot" or emotional decision-making.[29]

In this study, one-half of the subjects were tested by experimenters blind to the subject's study group. It is unusual to use blind experimenters in basic cognitive development research, but we did so out of concern that experimenters might intuitively expect fast-paced television to influence children's performance. Studies of the impact of pretend play, generally presumed to be positive,[30,31] on children's cognitive functioning show experimenter bias influences results in that domain: when experimenters were blinded, positive results went away.[32–34] As a precaution and to examine whether blind experimenters are important in this domain, we tested one-half of the children with a blind experimenter and compared results under the 2 conditions.

METHODS

Sixty 4-year-olds (Table 1) were recruited from a database of families willing to participate in research. Most of the children were white and from middle- to upper-middle-class families. Parents were telephoned and told about the study; willing parents made an appointment to come to the laboratory, where the study was described again, and parents signed a consent form approved by the University of Virginia institutional review board.

Children were randomly assigned (by the experimenter drawing a number

TABLE 1 Study Factors According to Intervention Experience

Characteristic	Fast-Paced Television	Educational Television	Drawing
Mean (SD) age, y	55.10 (3.61)	54.84 (3.72)	53.95 (3.66)
Boys, *n* (of 20)	12	10	10
Attention baseline, mean (SD)[a]	1.83 (2.31)	2.16 (1.57)	2.00 (1.75)
Television time, mean (SD), min/wk	338 (66.73)	278 (66.72)	381 (66.73)
Tower of Hanoi, mean (SD)	0.15 (0.37)	0.35 (0.49)	0.70 (0.47)
HTKS, mean (SD)	19.70 (13.29)	33.20 (28.02)	30.58 (17.71)
Delay of gratification, mean (SD)	146.15 (151.29)	257.20 (132.16)	242.00 (142.10)
Backward digit span, mean (SD)	3.85 (2.58)	4.21 (3.19)	3.90 (4.11)

[a] Assessed by using a scale of 1 to 10 (10 indicates more attention problems).

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from a bag) to 1 of 3 conditions (20 children each): fast-paced television, educational television, or drawing. The fast-paced television group watched a truncated episode of a very popular fantastical cartoon about an animated sponge that lives under the sea. The educational television group watched a truncated episode of a realistic Public Broadcasting Service cartoon about a typical US preschool-aged boy. Free drawing with markers and crayons was the control condition. All children completed the study.

To quantify pacing, the 2 television episodes were viewed for the number of times a complete scene change occurred (eg, from swimming pool to bedroom). For the fast-paced show, the scene completely changed on average every 11 seconds; even within the scene, characters were almost constantly rapidly moving through space. The educational television show had a complete scene change every 34 seconds on average.

The experiment was conducted with each child individually in a small room in a university laboratory. Nine-minute clips of the fast-paced or educational shows were played on an Acer notebook computer (Acer American Corporation, San Jose, CA) to children in the television groups. Children in the drawing condition were given some crayons, markers, and paper and allowed to draw for 9 minutes. Next children were administered the EF tasks in a fixed order using a Latin squares design.

The Tower of Hanoi task[35] used a base with 3 long pegs and a larger and a smaller disk that fit on the pegs, as well as a picture depicting a goal state. The disks were described as monkeys playing on a tree (the left peg), but they were tired and needed to move to their sleeping tree (the right peg). The child was asked to help move the monkeys according to 3 rules[36]: only 1 monkey could be moved at a time, the monkeys always needed to stay on the trees (pegs), and the Daddy monkey (the bigger disk) could never go on top of the Mommy monkey (the smaller disk). The children were given a score of 1 if they moved the disks from the first peg to the third peg following all the rules. Children who broke a rule or failed to complete the task were given a score of 0.

Next children were given the HTKS task,[27] in which the experimenter told children, "When I say touch your head, I want you to touch your toes, but when I say touch your toes, I want you to touch your head." After brief training, 10 test items were presented. Children received 2 points for every correct response, 1 point for every response that was initially wrong but corrected (eg, they touched their head then touched their toes), and 0 points for an incorrect response. If children received at least 10 points on the first 10 items, a shoulders-knees rule was added and 10 more items were given. Children who received at least 14 additional points on part 2 went on to part 3, where the rules switched (eg, "Now when I say touch your head I want you to touch your shoulders").

After the HTKS task, children completed a delay-of-gratification[16] task. First, they were shown a bag of miniature marshmallows and a bag of Goldfish crackers and asked which they would like to have as a snack. The experimenter put 10 pieces of the chosen snack on 1 plate and 2 pieces on another, and placed the bell between the 2 plates. Children were told that they could eat the 10 pieces if they waited for the experimenter to return, or they could ring a bell at any time to get the experimenter to come back immediately, in which case they could only have the 2 pieces. The experimenter recorded the time from when she left the room until the child either rang the bell or ate the snack, or after 330 seconds when the experimenter returned.

The children then participated in a creativity task (not discussed here) before completing the backward digit span subtest of working memory capacity from the Woodcock-Johnson tests of cognitive abilities.[37] The experimenter told the child, "I am going to say some numbers and I want you to say them backwards; for example if I say 3,4 then you say 4,3. Now you say the numbers backwards." The experimenter then gave practice items with feedback; once children got 1 correct or after 4 practice items maximum, they moved on to 15 test items until they got 3 consecutive items wrong. Children received 1 point for each correct answer and could receive up to 15 points. A Sony Camcorder (Sony Electronics, San Diego, CA) was used to record children throughout the procedure.

While children were being tested, parents completed a media survey on which they indicated the number of minutes the child watched television and DVDs each week. They also filled out the Strengths and Difficulties Questionnaire,[38,39] a 25-item personality survey with 5 items related to attention. Items were scored 0, 1, or 2 characterizing how true the statement was of the child. The attention-related items were: "restless, overactive; cannot stay still for long," "easily distracted, concentration wanders," "constantly fidgeting or squirming," "sees tasks through to the end; good attention span," and "thinks things out before acting" (the latter 2 were reverse-scored).

RESULTS

Results (mean [SD]) of the study assessments are shown in Table 1. Groups did not differ in attention problems at the outset, as indicated by parent responses on the Strengths and

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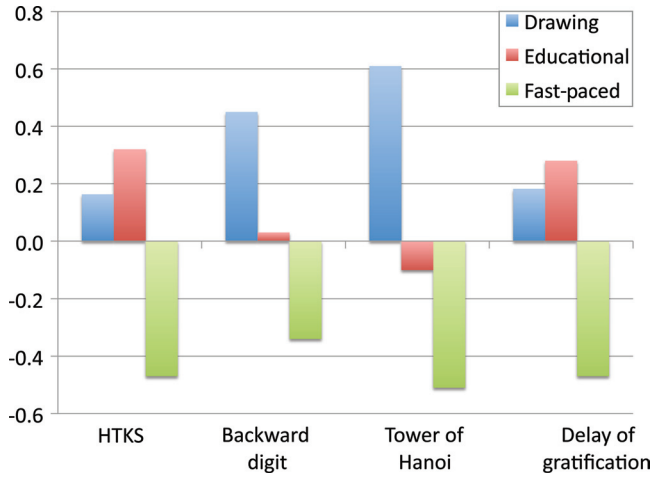

FIGURE 1
z scores for each task.

Difficulties Questionnaire ($P = .88$). There were also no group differences in the amount of television children watched per week ($P = .55$), with the range being 278 (educational television) to 381 (drawing) minutes per week.

Cronbach's α for 3 of the EF tasks (Tower of Hanoi, backward digit span, and HTKS) was 0.69 but dropped to 0.51 when delay of gratification was included. Therefore, *z* scores for the first 3 EF tasks were summed for a composite EF score, and delay of gratification was analyzed separately.

A first analysis of covariance assessment examining whether experimenter blindness influenced results in any condition, controlling for children's age, revealed that blindness had no influence on condition scores ($P = .83$ for composite EF and .62 for delay of gratification). Thus, we are confident that experimenter bias did not influence results for those subjects whose assessments were not run blind.

Combining across these groups and using age as a covariate, there was a significant main effect of intervention on the composite EF score ($P = .01$, $p\eta^2 = .15$). Posthoc analyses revealed that the fast-paced television group did significantly worse on the EF composite than the drawing group ($P = .004$). The difference between the fast-paced and the educational television groups approached significance ($P = .05$) (Fig 1), and there was no difference between educational television and drawing. A regression analysis was performed entering the amount of television watched per week, attention problems, and child's age at the first step, and intervention condition at the second step, setting the drawing and educational television conditions as baseline. The first 3 variables made no significant contribution to the EF composite score but condition did ($P = .03$).

Delay of gratification was analyzed separately and showed similar results, with a significant main effect of intervention condition on the number of seconds waited ($P = .03$, $p\eta^2 = .12$), and posthoc analyses revealed that the fast-paced television group waited significantly less long than either the drawing group ($P = .03$) or the educational television group ($P = .02$), which did not differ from each other. Another regression analysis was performed entering the amount of television watched per week, attention problems, and child's age at the first step and intervention condition at the second step, setting the drawing and educational television conditions as baseline. Again, the first 3 variables made no significant contribution but condition did ($P = .006$).

DISCUSSION

This study provides empirical evidence that watching a 9-minute episode of a fast-paced television cartoon immediately impaired young children's EF relative to watching an educational television show or drawing. Children in the fast-paced television group scored significantly worse than the others despite being equal in attention at the outset, as indicated by parent report. This result is consistent with others showing long-term negative associations between entertainment television and attention.[19] Given the popularity of some fast-paced television cartoons among young children, it is important that parents are alert to the possibility of lower levels of EF in young children at least immediately after watching such shows.

In addition to the pacing, we speculate that the onslaught of fantastical events that was also present in the fast-paced show might have further exacerbated EF. Whereas familiar events are encoded by established neural circuitry,[40] there is no such circuitry for new and unexpected events, which fantastical events often are. Encoding new events is likely to be particularly depleting of cognitive resources, as orienting responses are repeatedly engaged in response to novel events.[41] Because cognitive depletion taxes self-regulation,[42,43] we hypothesize that the fantastical aspect of the fast-paced show could also be partly responsible for the EF effects seen here. This hypothesis will be tested in further research.

This study has several limitations. First, we cannot tell exactly what fea-

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tures of the fast-paced television cartoon created the effects. We have speculated that the combination of fantastical events and fast pacing are responsible, but further research systematically varying those features is needed. A recent study has begun this effort by replicating the effect with different fast-paced and fantastical episodes and shows.[44] Second, only 4-year-olds were tested; older children might not be negatively influenced by fast-paced television. Third, we do not know how long the negative effects persist or what the long-term effects of habitual viewing include. Finally, we only used 9 minutes of viewing; many children's cartoon episodes last 11 minutes, and typically 2 episodes are shown in a one-half hour programming slot. Watching a full fast-paced cartoon program could be more detrimental.

Some strengths of the study were the use of a blind posttester for half of the children, with results suggesting blindness is not crucial in this domain; random assignment to conditions; and groups of children who were similar at the outset in terms of weekly television exposure and parental ratings of attention. The use of a range of EF tests was also an asset, as was the testing of a children's television cartoon that is currently the most-watched television program among 2- to 11-year-olds.[45]

CONCLUSIONS

Children watch a great deal of television, and it has been associated with long-term attention problems. However, there is little research on the immediate impact of television on EF. The present study found that 9 minutes of viewing a popular fast-paced fantastical television show immediately impaired 4-year-olds' EF, a result about which parents of young children should be aware.

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