Computers in Human Behavior 56 (2016) 56–64

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Full length article

Young children's transfer of learning from a touchscreen device

Brittany Huber*, Joanne Tarasuik**, Mariana N. Antoniou, Chelsee Garrett, Steven J. Bowe [1], Jordy Kaufman, The Swinburne Babylab Team[2]

Swinburne University of Technology, PO Box 218, Hawthorn, Victoria 3124, Australia

ARTICLE INFO

Article history:
Received 5 July 2015
Received in revised form
29 September 2015
Accepted 10 November 2015
Available online 27 November 2015

Keywords:
Children
Multimedia
Touchscreen
Human-computer-interaction
Transfer

ABSTRACT

Because young children are devoting increasing time to playing on handheld touchscreen devices, understanding children's ability to learn from this activity is important. Through two experiments we examined the ability of 4- to 6-year-old children to learn how to solve a problem (Tower of Hanoi) on a touchscreen device and subsequently apply this learning in their interactions with physical objects. The results were that participants demonstrated significant improvement at solving the task irrespective of the modality (touchscreen vs. physical version) with which they practiced. Moreover, children's learning on the touchscreen smoothly transferred to a subsequent attempt on the physical version. We conclude that, at least with respect to certain activities, children are quite capable of transferring learning from touchscreen devices. This result highlights the limitations of generalizing across screen-based activities (e.g., “screen time”) in discussing the effects of media on young children's development.

1. Introduction

Plato famously opined, “*Enforced learning will not stay in the mind. So avoid compulsion and let your children's lessons take the form of play*” (Plato, 1955). Indeed, importance of play in education and development has been appreciated from Plato's time through the beginnings of developmental science, and continues today (e.g., Golinkoff, Hirsh-Pasek, & Singer, 2006; Frost, Wortham, & Reifel, 2012; Ginsburg, 2007). Given the perceived importance of play, it is understandable that new and unfamiliar changes to the nature of children's play tend to elicit societal unease. Instances of this can be seen with the decline of outdoor play in the last century (Frost, 2010), and as toys with media branding and electronic features began to saturate the market in the 1970s and 1980s (e.g., Varney, 1999).

While electronic toys and video games were introduced to children's worlds as early as 1972, the release of the iPad in 2010 precipitated a dramatic new shift toward digital gaming by young children. Apple's iPad and similar mobile touchscreen devices have made interactive media accessible to much younger children—largely because the fine motor skills needed to use traditional computers and video games are not necessary (Scaife & Bond, 1991; Vatavu, Cramariuc, & Schipor, 2014). A recent review (Hirsh-Pasek et al., 2015) details that the most popular category in Apple's iTunes App Store is the “educational” category with over 80,000 apps. This finding is consistent with survey results from Common Sense Media, which reported that more than half of parents had downloaded apps specifically for their children (Rideout, 2013).

As with earlier shifts in children's play, the popularity of touchscreen use is raising a new set of worries related to children's cognitive, social, emotional, and physical development (e.g., Carson, Clark, Berry, Holt, & Latimer-Cheung, 2014; Hernandez, 2014; Mascheroni, 2014). Consistent with (and contributing to) these worries is the position statement by the American Academy of Pediatrics (AAP, 2010) on children's media use, which recommends strict limits on screen time for all young children and discourages any screen time for children less than 2 years of age. The AAP's statement appears in many journalistic pieces that cover this topic, often failing to convey that their recommendations are largely based on passive television-viewing research and that there is little peer-reviewed published research on interactive touchscreen media and young children (e.g. Petersen, 2013; Shapiro, 2014; Wright1 Consulting, 2014).

Despite the fact that the AAP's statement has since evolved to

* Corresponding author.
** Corresponding author.
E-mail addresses: bhuber@swin.edu.au (B. Huber), jtarasuik@swin.edu.au (J. Tarasuik), cgarrett@swin.edu.au (C. Garrett), sbowe@deakin.edu.au (S.J. Bowe), jkaufman@swin.edu.au (J. Kaufman).
[1] Now at Deakin University and Swinburne University of Technology.
[2] Swinburne Babylab Team: Mark Finn, Renee Rowsell, Leila Dafner, Jemma Richards, Lucy Sommers and Anthony Bartel. babylab@swin.edu.au

http://dx.doi.org/10.1016/j.chb.2015.11.010
0747-5632/

indicate the suggested limits are particularly relevant to "recreational" (as opposed to "educational") content (American Academy of Pediatrics, 2013; Christakis, 2014), many unanswered questions must still be resolved to evaluate how interactive media promotes or hinders learning in young children, and whether following the AAP's suggestions would have real benefits. For example, how and why should we discriminate between "educational" and "recreational" digital apps when play in the physical world is often assumed to be both educational and entertaining? More specifically, how should we treat interactive touchscreen apps that are essentially digital analogues of physical games and activities? Clearly many such forms of entertainment, such as playing chess, checkers or card games, require important working memory and executive functioning skills that we want to foster in young children. But are children as able to learn from such activities on touchscreens as they are in "real life"? Moreover, when such skills are learned using digital apps, can young children readily show apply, or transfer, these skills in their subsequent interactions with physical objects?

These are important questions to answer for a number of reasons. From a practical perspective, parents and educators should know if they can safely replace or augment physical games with these digital analogues. We note that this question is not just a hypothetical, as parents, educators, and journalists have raised it with us repeatedly over the past several years—typically in the form of the question: "Does [activity x] count as 'screen time'?" Additionally, answering this question will help clarify which aspects of interactive digital play interfere with or foster learning. Specifically, does the screen itself or the lack of rich haptic feedback somehow make learning less likely for young users?

As such, the key aims of the present investigation were: 1) to determine if children improve at a problem-solving task after practicing with an isometric task on touchscreen; 2) to explore the extent to which practice modality (e.g. touchscreen or physical version) affects performance; and 3) to determine if the benefits of touchscreen practice require prior experience solving the physical version of the task.

To achieve these aims, it was important to select a problem-solving task with an isometric touchscreen version that allowed for meaningful comparisons of children's performance across modalities. Consequently, we carried out two experiments using the Tower of Hanoi puzzle. There were five main reasons for this choice.

First, unlike a game of checkers or chess, there is a single optimal solution path that does not depend on the performance of a competitor—thus vastly reducing the inter-game variability in performance. Second, regardless of whether one tackles the puzzle using the standard physical disks or using a touchscreen app, the solution to the puzzle and the scoring methods for proficiency are identical, which allowed us to make straightforward comparisons across modalities. Third, prior work with the puzzle indicated that it can be used to assess problem solving in children as young as 4 years of age (e.g., Bull, Espy, & Senn, 2004; Lillard & Peterson, 2011) and we wanted to include preschool children in our sample—as this is a group that until recently has little experience using computing devices (Scaife & Bond, 1991; Vatavu et al., 2014). Fourth, the Tower of Hanoi (ToH) puzzle is also used to assess the same set of cognitive and executive functioning abilities (e.g. planning) that are used in games like checkers or chess (Klahr & Robinson, 1981; Welsh, Friedman, & Spieker, 2006)—thus allowing us to draw conclusions about the extent to which children can learn from digital analogues of these types of games. Finally, pre- and post-intervention administrations of the ToH task have previously been used to successfully investigate other factors that can affect learning (e.g., sleep; Ashworth, Hill, Karmiloff-Smith, & Dimitriou, 2014).

In Experiment 1 we addressed the question of whether ToH practice on a touchscreen device improved performance when children returned to the physical version of the same task (aim 1). We also compared performance of those who received touchscreen practice to those that practiced on the original physical version of the task (aim 2). In Experiment 2, we addressed the question of whether touchscreen practice has benefits even if the child has had no recent experience with the physical version of the problem (aim 3). The general methodology of both experiments is illustrated in Table 1.

2. Experiment 1

In a baseline trial, 4- to 6-year-old children attempted to complete the Tower of Hanoi puzzle in its standard, physical three-dimensional (3D) form. Children then received two practice trials on either the same 3D physical version or on a two-dimensional (2D) touchscreen version of the same puzzle. Following these practice trials, the children received a final test trial on the original 3D physical version. We compared how the two types of practice affected performance on this final trial. We reasoned that an ability to transfer problem-solving skills gained in the touchscreen practice trials would manifest in a significant improvement from baseline.

2.1. Method

2.1.1. Participants

Participants were 50 children (27 female, 23 male) aged 4–6 years ($M = 5.1$ years, $SD = 0.8$) recruited from the university's greater metropolitan area. Each was assigned to one of two conditions, Transfer ($n = 21$, M age = 5.2 years, $SD = 0.8$) or No-transfer ($n = 29$, M age = 5.1 years, $SD = 0.7$). There was no statistically significant difference in mean age of the condition groups, $t(48) = -0.365$, $p = .717$. An additional 10 children were recruited but were not included in this data set for the following reasons: failure of recording equipment ($n = 7$; all were in the Transfer condition as the failure related to screen recordings of the iPad), refusal by the child to attempt the task ($n = 2$), and procedural error ($n = 1$). All parents provided informed consent for their child's participation, approved by the host institution's research ethics committee.

2.1.2. Materials

The ToH puzzle has been used extensively with children and adults to assess problem solving, planning ability, and executive functioning. Novel to most children, the task requires self-control and working memory of three rules to inhibit making an invalid move. We used the three-disk version of the ToH, which consisted of three wooden pegs and three wooden disks, each a difference color and size (small, medium, and large) that can travel across any of three pegs. To solve the puzzle, the three disks must be moved from their starting peg to the third peg while abiding by three rules: 1) only one disk can be moved at a time, 2) a larger disk cannot be placed on a smaller disk, and 3) the disks must always be placed on one of the three pegs (i.e., they cannot be put on the ground or table).

Touchscreen ToH trials were completed on a commercially available, 2D iPad app ("Extra Tower of Hanoi" by Morard Dany) played on an iPad 2. The traditional 3D model of the ToH is described above. The child's ToH set was situated on a table directly in front of the child. An additional set sat across the table in front of the experimenter. This set was used to depict the goal state, and was visible to the child throughout the task. This goal state set always had the same modality as the child's set (i.e., when the