Learning from Small Devices: Deficits in Problem Solving Performance but not Factual Recall

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LEARNING FROM SMALL DEVICES: DEFICITS IN PROBLEM SOLVING PERFORMANCE BUT NOT FACTUAL RECALL.

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Given the increasing use of small screen devices to gather and provide important information, a critical question is how learning and problem solving performance is impacted by collecting data on a small device. This study investigates how learning and application of information differs when it is gathered using a small screen device versus a normal size desktop display. Results indicate that while factual recall is equivalent across interfaces, small screen devices appear to reduce how well participants apply these rules towards correct solutions. Further, it appears that solution time is also increased by using a small screen device. These results suggest that while these small technologies are convenient for fact gathering and other simple uses, there is a potential tradeoff when this learned information must be used in complex and appropriate ways.

INTRODUCTION

Advances in the power and availability of mobile technology, coupled with the "on-the-go" lifestyle of many individuals, have made small screen devices nearly ubiquitous in everyday life. Often professionals and non-professionals alike carry at least one small device that is used regularly for many of their daily activities. For example, professionals regularly rely on mobile handheld devices (e.g., personal digital assistants (PDA) and smartphones) to check emails, gather data, and make critical decisions while away from the home office. Non-professional uses include navigation, web surfing, and entertainment, again with the goal of collecting information and using this information in task relevant ways.

This trend is increasing rapidly, especially in the business sector, as J. Gold Associates predicts that smartphone use will increase by 200% over the 3-year period from 2008-2011 (Computerworld, 2008). The increase of smartphone usage across all other demographics is also rapidly increasing as annual sales of smartphones already exceed 40,000,000 units worldwide (Gartner, 2009).

However, while mobile devices enable convenient access to large amounts of information, an important question is whether information gathering from such small screens results in a cognitive trade-off in subsequent performance. In other words, does this enhanced personal flexibility result in accurate and acceptable levels of performance, such as reading speed, comprehension, and ability to apply the information one has gathered?

One potential drawback of these portable devices is the diminutive size of the screen itself. This limits line length, which has been shown to reduce reading speed on computer screens (Dyson & Kipping, 1998). Information must either be scaled down or resized, and even then often does not fit easily on a single screen. As a result, the user must scroll and move between screens to access all information. Prior research has shown that scrolling negatively impacts performance on desktop displays (Brooke & Duncan, 1983; Morrison & Duncan, 1988; Piolat, Roussey & Thunin, 1997; Sanchez & Wiley, 2009), but does the same hold true for these small screen devices?

This study explores the effects of learning from small screen devices and examines whether performance suffers compared to normal sized desktop interface. Participants read several emails on either a small screen device or a desktop environment and were asked to recall factual knowledge, and also use this knowledge in successful decision making.

METHODS

Participants and Design

Thirty-two students (N = 32) at a large public Southwestern US university participated for course credit. This experiment was run within-subjects.

Materials and Procedure

Participants read 2 scenarios adapted from problems similar to those formerly seen on the analytical section of the GRE. Participants read 1 scenario on a virtual small-screen device and the remaining scenario was read on a full (19”) desktop display. The small-screen device utilized a presentation area that was 208 x 276 pixels at 96ppi, analogous in size to most popular smartphones. Twelve point Times New Roman font was used in both conditions. Sample interfaces are presented in Figure 1. These scenarios (trip planning and presentation schedule) each contained 3 rules that restricted the potential solution set, although multiple acceptable solutions were possible. Scenario and order of interface presentation was completely randomized across participants.

Figure 1.

Each scenario was introduced over a series of 5 emails, 3 of which each contained a single rule or restriction. Given the reduced size of the small screen device, participants were required to scroll down to read the entire email in this presentation condition. Participants were first given 5 minutes to read these emails, and were instructed to read all the emails. After the 5 minutes were up, participants were then given a paper and pencil test on their ability to recall the 3 basic rules for each scenario. The interface was unavailable to the participants during rule recall.

After recall, participants were given up to 8 minutes to answer 7 multiple choice questions that presented potential solutions to each scenario. Participants were instructed to answer all the questions as quickly and accurately as possible, and to not skip any questions. Participants were timed while answering these questions, and also had access to the requisite display to help answer the questions.

After answering these application questions, participants then repeated the procedure with the second scenario/interface. After completing the second scenario, participants were debriefed and dismissed. The entire experiment took no longer than 35 minutes.

RESULTS

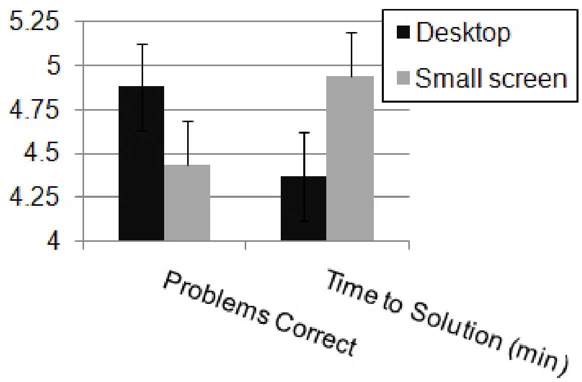
Rule Recall

A simple repeated-measures ANOVA indicated that there was no difference in factual recall of the 3 rules between the small-screen ($M(sd)$ = 2.78 (.55)), and full-screen displays ($M(sd)$ = 2.84 (.45); $F(1, 31) < 1$, $p > .05$). Thus, it appears that recalling facts learned on a small device does not differ from recall of facts learned on a larger, more traditional, desktop display.

Rule Application and Time to Solve

Regarding the ability to apply these rules to produce a correct solution, a repeated-measures ANOVA revealed that learning on a small-screen device significantly reduced participants’ ability to identify correct solutions, relative to the desktop display ($F(1, 31) = 5.61$, $MSe = .55$, $p < .05$, $\eta^2_p = .15$). Participants successfully answered fewer questions correctly when the information was presented on a small screen device (*M*(*sd*) = 4.44 (1.52)), than when a similar scenario was presented on a desktop environment (*M*(*sd*) = 4.88 (1.10)). These results are visible in Figure 2.

Figure 2.



There was also a similar effect found regarding the time taken to solve the problems. On average, answering questions about material learned on a small device took significantly longer (*M*(*sd*) = 296.28 sec. (68.71)) than answering questions on a larger desktop display (*M*(*sd*) = 262.44 sec. (89.79); $F(1, 31) = 5.85$, $MSe = 3133.02$, $p < .05$, $\eta^2_p = .16$).

DISCUSSION

Taken as a whole, these results suggest that while small mobile devices like smartphones and PDAs are convenient and useful for seeking out basic facts or information, there does appear to be a significant tradeoff regarding how well this information can be used in relevant and complex ways. Not only was complex problem solving performance decreased, but the time to solve such problems also increased. Thus, the convenience of using small devices is accompanied by a 2-fold disadvantage. Quite simply, more errors are made, and more time is spent to produce solutions.

Given the rampant use of these technologies in business and other settings, these findings are somewhat disconcerting. For example, it suggests that if simple information needs to be distributed, reading on a small device is not problematic. However, integrating multiple facts or rules across emails, or communications, can be more difficult and time-consuming on a small device. This may represent a real disadvantage for application in domains such as business and medicine, where information must be accessed and used quickly and accurately (Holzinger & Errath, 2007) .

However, what causes this small device deficit? It is highly likely that this reduction in performance is in fact a result of the need for users to scroll through each email on the small screen in order to access all the information. While simple, this intuition is consistent with prior work which has found similar deficits as a result of scrolling in full-size interfaces, for both visual search (Brooke & Duncan, 1983; Morrison & Duncan, 1988) and reading for comprehension tasks (Sanchez & Wiley, 2009). It is likely that the scrolling increases demands on working memory (Sanchez & Wiley, 2009), making it more difficult to integrate information between screens. It may also be the case that the movement created on the screen by scrolling tends to attract user attention to stimuli that are not related to the actual information.

This work has strong implications for the design and use of consumer products, especially considering the rate at which these devices are being acquired and used. Future research should examine ways to attenuate this detrimental effect, and attempt to develop options that enable users to remain mobile and unattached to workstations, while still preserving the ability of these users to make important decisions correctly.

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