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Effects of using a smart phone on pedestrians' attention and walking

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Abstract

Effects of "smart-phoning" (using a smart phone) while walking were investigated in a laboratory experiment. While walking with an iPhone 5s, 24 undergraduate students texted a message, watched a video, played a game, and just held the phone in one hand in addition to performing visual and auditory detection tasks at the same time.
The detection tasks were to respond to designated target signals as quickly as possible by clicking the wireless mouse held in the hand that did not hold the phone. The visual stimuli were presented on 4 video displays placed outside of the walking route. The target was a sudden change in screen color from blue to red. The auditory signals were presented through a loudspeaker once each second for a duration of 500 ms, and the target was to respond to a higher pitch within the tones. Participants performed these multiple tasks while walking clockwise along the perimeter of a 3 m by 3 m square marked on the floor. Results showed that the number of right footsteps that missed the line marking the walking route was greater under cell phone-use conditions than under the control condition, with results for the game condition worst among the cell phone-use conditions. Mean reaction times for both visual and auditory targets were significantly longer under cell phone-use conditions than under the control condition. Again, the game condition was the worst among cell phone-use conditions. Number of missed visual targets was significantly higher with the game condition than the control and video watching conditions. In summary, the results suggest a higher risk of accidents among pedestrians who are using cell phones, especially for those who are playing games with a smart phone.

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Keywords: cell phone, texting, game, inattention, laboratory experiment

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1. Introduction

In Japan, as in many other countries, people use cell phones anywhere and any time. According to statistics issued by the Tokyo Fire Department, their ambulances transported to hospitals 122 pedestrians who were injured while using cell phones during the last 4 years (2010-2013) [1]. This number had increased year by year and is still increasing. Among these 122 people, 51 (42%) collided with other people or objects, 38 (31%) fell to the ground, and 30 (25%) fell from heights such as stairs and railway platforms. Cell phones are used not only for talking but also for other purposes. Forty of the 122 pedestrians (33%) were injured when they were operating cell phones (texting, playing a game, searching for music, taking a photo, etc.), 30 (25%) were watching their cell phone screen, and 25 (20%) were talking. Of the 122 pedestrians, 98 (80%) were injured on/in traffic facilities, including streets. Of the 98 people injured on/in traffic facilities, 30 (31%) were injured in railway stations. Public address systems in stations repeatedly play a message urging people to stop using cell phones while walking, but these messages are ignored.

Driver distraction caused by cell phone use has been the subject of many studies [e.g. 2-6]. However, there are only a few studies on inattention caused by cell phone use by pedestrians [7-10]. Moreover, previous studies have focused mainly on talking on cell phones. The cell phone was developed first as a mobile telephone, but unlike the originally invented cell phones ("feature phones"), recent devices ("smart phones") are practically small portable computers that can be used in various says. People use them as music players, video players, game machines, book and magazine readers, SNS tools, etc. Current rate of distribution of smart phones is estimated to be 39.7% of the Japanese adult population; however, when younger ages are considered separately, 80.6% of those in their 20s, 68.9% of those in their 30s, and 57.0% of those in their 40s own smart phones [11].

In our previous study, we showed deteriorating effects of texting on walking and visual/auditory attention in comparisons of the smart phone with the feature phone [12]. In this study, we compared the size of the effects between different uses of the smart phone while walking: texting a message, watching a video, and playing a game. As dependent variables, we measured reaction time and errors in response to visual and auditory signals as well as the number of steps off the walking route and subjective ratings of workload.

2. Methods

2.1. Participants

Twenty-four undergraduate students (12 males and 12 females, average age 20.5 years) participated in the experiment. All had their own smart phones and were familiar with using them.

2.2. Smart-phoning tasks

With an iPhone 5s in one hand, participants walked clockwise for 1 minute along the perimeter of a 3 m by 3 m square marked by a 2.5 cm-wide yellow adhesive tape on the laboratory floor. While walking, they texted a message, watched a video, played a game, or just held the phone while at the same time performing visual and auditory detection tasks. Four 16-inch video displays were placed on an extension outside of the walking route. A loudspeaker to present auditory signals was placed at one corner of the laboratory (Figure 1). Participants were asked to keep walking at their usual pace, keeping the right foot on the line (Figure 2). A video camera on the center of the ceiling recorded the participants' behavior.

There were four conditions for cell phone use: (1) movie condition, (2) texting condition, (3) game condition, and (4) control condition. Although participants could choose which hand to hold the phone, all chose the right hand for all trials.

<u>Movie condition:</u> Participants watched a funny video of animals downloaded from YouTube, which was composed of 10 short video clips. Sound was muted.

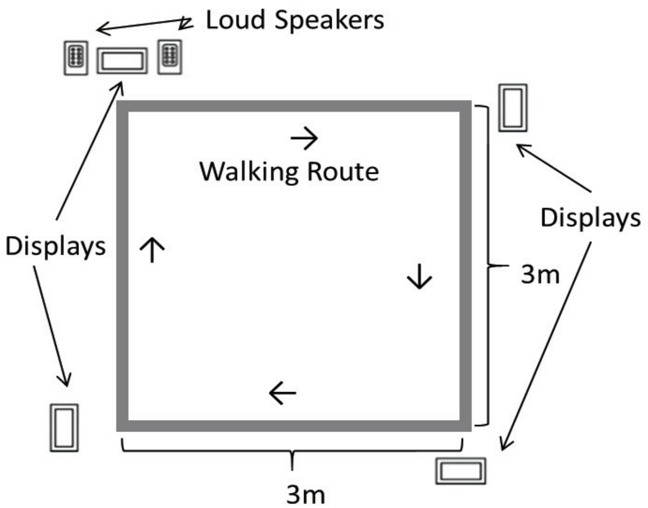


Figure 1. Experimental setting in the laboratory including the walking route

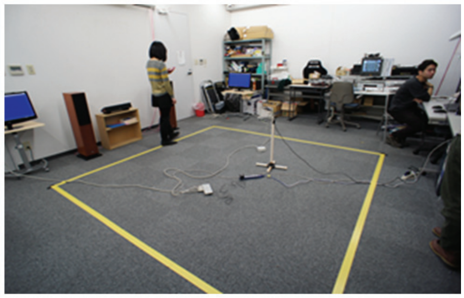


Figure 2. Photo of a trial

Texting condition: Participants typed in the lyrics of a song "Sanpo", which is well known to young Japanese students. They used flick input with the thumb of the hand that held the phone. Printed lyrics were first shown as a reminder, after which the participants typed in the lyrics while seated for 1 minute before the experimental trial. The number of letters (Japanese syllabic phonograms) typed was recorded. Participants were encouraged to type more letters while walking than in the trial seated.

Game condition: Participants played a game "Drop Block", which is similar to Tetris. They played the game for 1 minute while seated, and the score was recorded. In the trial while walking, the participants were encouraged to get a higher score than that formerly recorded. They were instructed to use only the thumb of the hand that held the phone to play the game.

Control condition: Participants walked holding the cell phone.

2.3. Detection Tasks

Auditory and visual signals were presented to the participants while they walked. The task was to respond to the designated target signals as quickly as possible by clicking the wireless mouse held in the hand that did not hold the phone. The left key of the mouse was used for the auditory target and the right key for visual targets. Reaction time and the number of errors in response (missed targets or false alarms) were recorded.

Auditory signals: Computer-generated short-burst (500 ms) tonal signals were presented through a loudspeaker once every second. Ten of 60 signals were at higher tones in pitch, and they were the targets for detection.

Visual signals: The screen color of the displays was usually blue, but unexpectedly turned red for 1 second, occurring 6 times in a 1-minute trial. The change in screen color was the target event to be detected. The 4 displays were synchronized. None of visual targets was presented simultaneously with an auditory target.

2.4. Procedures

After participants provided informed consent to participate in the study, those who were not familiar with an iPhone practiced texting with it. Then the 24 participants performed the experimental trials under the 4 cell phone-use conditions with the order of performance of the 4 trials varied among participants. Since there were 24 possible combinations, each participant could be assigned a different combination.

After each trial, the participants rated the workload of the task with the Japanese version of NASA-TLX [13, 14], using a simplified technique, the Adaptive Weighted Workload (AWWL), without paired comparison between subscales.

3. Results

3.1. Analyses of dependent variables

As for walking, the video record from the ceiling camera was analyzed to obtain distance walked in the 1-minute trial, the total number of steps, and the number of right foot steps that missed the yellow line on the floor. For the auditory and visual detection tasks, time of reaction to the targets and the number of missed targets were compared between conditions. The AWWL score [15] was calculated from ratings on 6 subscales of the Japanese version of NASA-TLX [14], using the weight of 6 for the highest rated subscale, 5 for the second highest, and so forth.

These variables were compared statistically between conditions using a one-factor repeated-measure analysis of variance (ANOVA) test. The Bonferroni method was used for post-hoc tests. Degree of freedom was corrected by the Greenhouse-Geisser method when sphericity assumption was rejected. Partial eta-squared (η_p^2) was calculated to evaluate the effect size of independent variables.

In the experimental session, the wireless mouse did not work well for 3 participants and reaction to the detection tasks was not recorded. Therefore data for the detection tasks were analyzed for only 21 participants.

3.2. Walking performance

Distance walked represents walking speed because the duration of a trial was the same among all conditions. For the control condition participants walked an average of 3.97 rounds with a standard deviation (*SD*) of 0.51, while for the movie condition participants walked 3.49 rounds (*SD* 0.70), for the texting condition 3.38 rounds (*SD* 0.75), and for the game condition 3.24 rounds (*SD* 0.59). The difference between conditions was statistically significant ($F(2.28, 52.50)=22.51$, $p<.001$, $\eta_p^2=.495$). Post-hoc analyses showed significant differences between the control condition and the movie, texting, and game conditions ($p<.001$) and between the movie condition and the game condition ($p<.05$).

Mean number of steps in a trial was significantly greater in the control condition than in the movie, texting, and game conditions ($p<.01$).

There was a significant difference between conditions in the number of right foot steps that missed the line (Figure 3) ($F(3, 69)=9.37$, $p<.001$, $\eta_p^2=.029$). Post-hoc analyses showed a significant difference between the control condition and texting condition ($p<.05$), between the control condition and the game condition ($p<.01$), and between the movie condition and the game condition ($p<.01$).

3.3. Detection tasks

Mean reaction times to auditory targets are shown in Figure 4. A significant difference between conditions was found ($F(3, 60)=8.55$, $p<.001$, $\eta_p^2=.299$), and post-hoc analyses showed that the participants responded to the targets more slowly under the movie ($p<.05$), texting ($p<.01$), and game ($p<.001$) conditions than under the control condition.

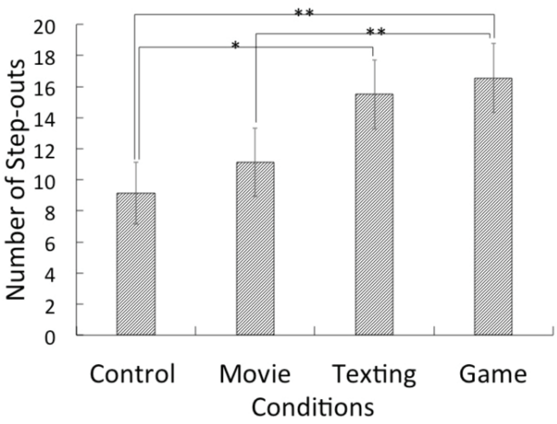
Mean number of missed auditory targets was 0.71 (*SD* 1.12) in the control, 0.71 (*SD* 1.16) in the movie, 0.95 (*SD* 1.17), and 0.64 (*SD* 0.79) in the game conditions. There was no significant difference between conditions ($F(3, 60)=.562$, *ns,* $\eta_p^2=.027$).

Mean reaction times to visual targets are shown in Figure 5. The ANOVA indicated significant differences in reaction time between conditions ($F(1.79, 35.84)$, $p<.001$, $\eta_p^2=.576$). Post-hoc analyses showed that the mean reaction time under the control condition was shorter than under the movie, texting, and game conditions ($p<.001$). Additionally, the mean reaction time under the game condition was significantly longer than that under movie and texting conditions ($p<.05$).

Mean number of missed visual targets was 0.38 (*SD* 1.10) in the control, 0.67 (*SD* 1.09) in the movie, 1.14 (*SD* 1.25) in the texting, and 1.59 (*SD* 1.10) in the game conditions. The difference between conditions was significant ($F(3, 60)=4.46$, $p<.01$, $\eta_p^2=.182$), and the participants missed more targets under the game condition than under the control and movie conditions ($p<.05$).

3.4. Subjective workload

As shown in Figure 6 there were significant differences in the mean AWWL scores between conditions ($F(3, 69)=62.10$, $p<.001$, $\eta_p^2=.730$). Post-hoc analyses demonstrated that the score was significantly lower for the control condition than for the other conditions ($p<.001$). Moreover, the score for the movie condition was lower than that for texting ($p<.01$) and game ($p<.001$) conditions.



**:*p*<.01 *:*p*<.05

Figure 3. Number of steps that missed the yellow line on the walking route under 4 experimental conditions. Error bars show standard errors.

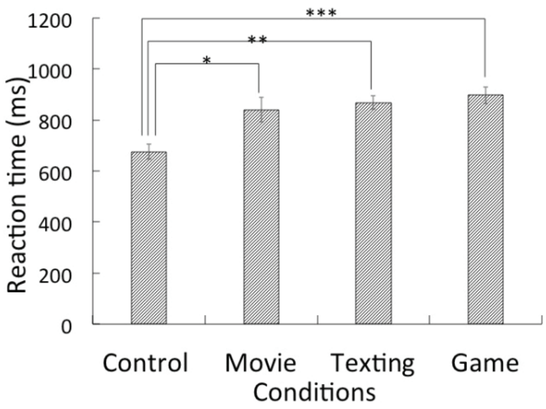


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Figure 4. Reaction time to auditory signals under 4 experimental conditions. Error bars show standard errors.

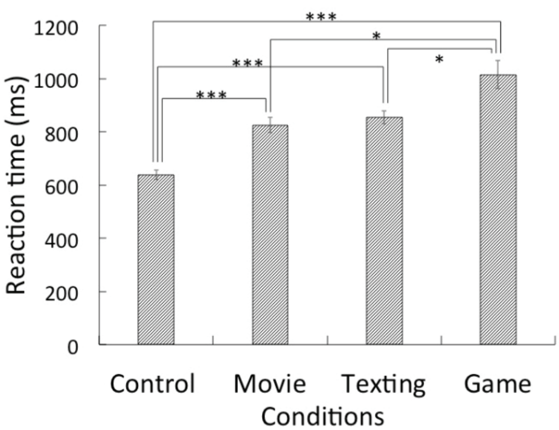

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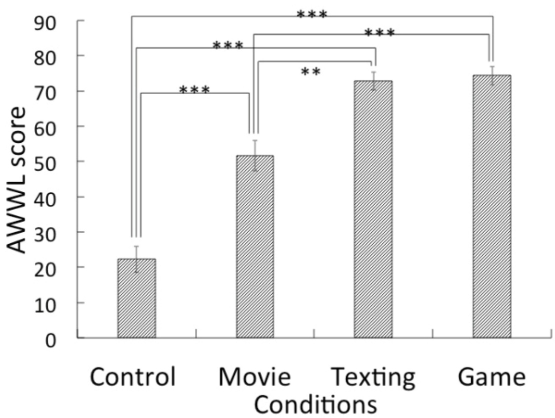
Figure 5. Reaction time to visual signals under 4 experimental conditions. Error bars show standard errors.



***:*p*<.001 **:*p*<.01

Figure 6. Adaptive Weighted Workload (AWWL) score of NASA-TLX under 4 experimental conditions. Error bars show standard errors.

4. Discussion

In Itabashi, Tokyo, October 2013, a man in his 40s was hit by a commuter train and died at a level crossing where the warnings (flashing red lights and tonal alarm) were on and the barrier was closed. It was observed that he was operating a cell phone while walking into the crossing [13]. On a subway platform in Nagoya, Aichi, October 2014, a junior high school student fell onto the track just before a train came in and was killed by the train. A witness to the accident reported that the victim, watching his cell phone screen, walked straight to the edge of the platform after a public address system announced that a train would be arriving [14].

Results of our experiment demonstrated the contributing factor to these accidents: inattention by smart-phoning pedestrians. In this study, we found that cell phone use impaired auditory and visual attention in a laboratory setting. Cell phone use while walking affected the user's attention not only to stimuli of the same modality, but also to stimuli in various sensory modalities.

Cell phone use also negatively affected walking itself.

These results showed that mean reaction times to both visual and auditory targets were significantly longer under cell phone-use conditions than the control condition, with the game condition worst among cell phone-use conditions. The number of missed visual targets was significantly higher in the game condition than the control and movie conditions. The number of missed steps on the walking route was greater under cell phone-use conditions than under the control condition with the game condition worst among cell phone-use conditions. In summary, these results suggest a higher risk of accidents for pedestrians who are using cell phones, especially for those who are playing games with their smart phone.

Cell phones are now almost indispensable in our daily life, but the results of our experiment suggest that cell phone use makes pedestrians inattentive to hazards and increases the risk of traffic accidents and possible casualties in railway stations. Talking on a hand-held cell phone while driving an automobile is banned by traffic law in Japan. We may need some kind of prohibition or restriction on walking while using a cell phone in railway stations and busy streets.

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