UNIVERSITY OF HELSINKI
INSTITUTE OF BEHAVIOURAL SCIENCES

Effects of information and communication technology use in adolescence on attention-related brain activity

Moisala, M.[a, b], Salmela, V.[a, b], Hietajärvi, L.[a], Salo, E.[a, b], Carlson, S.[c, d], Salonen, O.[e], Lonka, K.[a], Hakkarainen, K.[a], Salmela-Aro, K.[a,g] & Alho, K.[a,b,f]

[a] Institute of Behavioural Sciences, University of Helsinki, Finland, [b] Advanced Magnetic Imaging Centre, Aalto NeuroImaging, Aalto University, Finland, [c] Brain Research Unit, Department of Neuroscience and Biomedical Engineering, Aalto University School of Scie
[d] Neuroscience Unit, Department of Physiology, Faculty of Medicine, University of Helsinki, Finland, [e] Helsinki Medical Imaging Center, Helsinki University Central Hospital, Finland, [f] Helsinki Collegium for Advanced Studies, University of Helsinki, Finland, [g] Cicero Learning, University of Jyväskylä

BACKGROUND

Concerns have been raised about how the ever growing pervasiveness of modern information technology in young people's everyday lives affects their developing brains. Claims have been made that the extensive use of digital technologies might lead to a decline in mental ability, e.g., an inability to focus or think deeply (Carr, 2010).

At least two forms of technology-mediated activities have been suggested to impact attentional functioning:

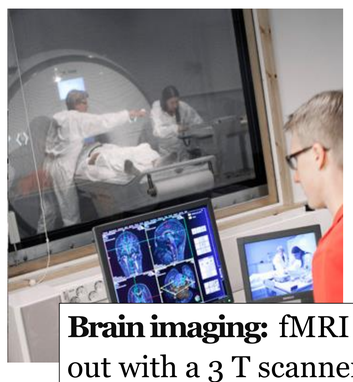
- ***Media multitasking*** has been associated with increased distractibility and greater task switching costs (Ophir et al., 2009)
- ***Gaming*** has been associated with improved performance in a variety of attention tasks especially in the visual domain (Green & Bavelier, 2003).

Using event-related functional magnetic resonance imaging (fMRI) we investigated how media multitasking and gaming affect adolescents' and young adults' (aged 13-24) attentional abilities and brain activity during attentionally demanding tasks.

METHODS

Participants: 149 healthy adolescents and young adults (76 male) in three age cohorts (13-, 16- and 20+ -year-olds), all native Finnish speakers. Sampled from 3000 pupils and selected based on an extensive questionnaire on the daily use of digital technology.

Gaming and ***Media multitasking*** *(MMT)* scores were included in all analyses as continuous between-subjects variables while controlling for Age cohort and Gender.



Brain imaging: fMRI was carried out with a 3 T scanner (TR 2.5 s, slice thickness 3.0 mm). fMRI data were analyzed with SPM and Freesurfer.

Stimuli & Task:

Written and spoken sentences in Finnish, half were semantically logical and half were illogical

Three task types: Stimuli were presented in one modality (***undistracted attention***), or in both modalities simultaneously while participants were asked to attend to just one modality (***distracted attention***) or to both modalities simultaneously (***divided attention***)

The task was to rate the sentence/s as logical or illogical

Media multitasking = consuming multiple media simultaneously (e.g. watching videos while listening to music, texting while playing video games, etc.)
Gaming = playing any type of videogame (e.g. first-person shooter games, adventure games, racing games, sports games, etc.)

RESULTS

MMT score had a main effect on task performance ($F(1,141)=4.10$, $p<0.05$, $\eta^2=0.02$). **A negative correlation between task performance and MMT was observed for the distracted attention condition** (Figure 1.)

No main effect of Gaming on task performance was observed ($F(1,141)=0.01$, $p=0.94$). No significant correlations were observed between gaming and performance in any of the task types (Figure 1.)

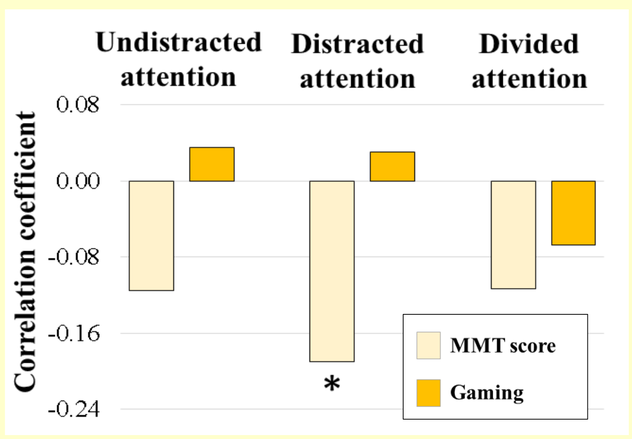
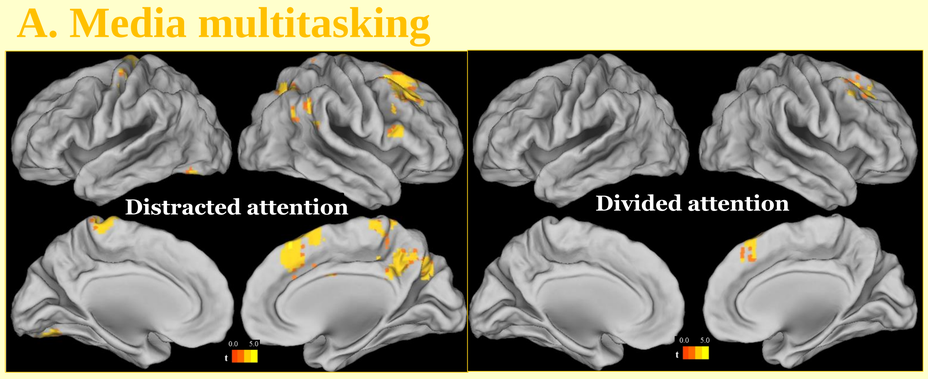


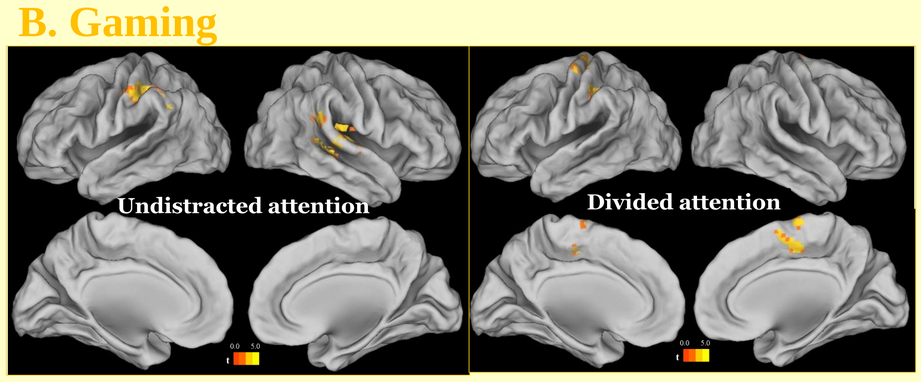
Figure 1. *Partial correlation coefficients (controlled for Age cohort and Gender) between task performance and the MMT and Gaming scores for the tree different task types. * p<0.05*

A. Media multitasking



MMT score showed a positive association with activity in right lateral and medial prefrontal regions during both distracted and divided attention (Figure 2A).

B. Gaming



Gaming score was negatively associated with activity in the left somatosensory cortex during undistracted and divided attention, and in the right superior temporal lobe during undistracted attention (Figure 2B).

Figure 2. *Cortical regions showing a positive association between MMT score and brain activity during distracted and divided attention* ***(A)****, and cortical regions showing a negative association between Gaming and brain activity during undistracted and divided attention* ***(B)****. Voxel-wise height threshold t=2.35, cluster size>100, p<0.05 (FWE-corrected at the cluster-level).*

DISCUSSION

- **The results suggest that daily media multitasking is associated with behavioral distractibility and increased recruitment of brain areas known to be important for attentional and inhibitory control, and that media multitasking in everyday life does not translate to performance benefits in multitasking in the laboratory setting.**
- **Gaming did not have an effect on attentional performance or brain activity in regions involved in higher order cognitive functions in our study. This suggests that the previously seen gaming-related cognitive enhancements reported in earlier studies (e.g., Green & Bavelier, 2003) might be limited to less ecologically valid experimental tasks or to a selected group of hardcore gamers.**

REFERENCES:
•Carr, N. (2010), *The shallows: How the Internet is Changing the Way We Think, Read and Remember*, London, UK: Atlantic Books Ltd.
•Green, C. S., & Bavelier, D. (2003), Action video game modifies visual selective attention, *Nature*, 423, 534-537.
•Ophir, E., Nass, C., & Wagner, A. D. (2009), Cognitive control in media multitaskers, *Proceedings of the National Academy of Sciences*, 106(37), 15583-15587.

ACKNOWLEDGEMENTS:
This research was funded by Academy of Finland Mind Program project "Mind the Gap - between digital natives and educational Practices" (#265528), an Academy of Finland grant to the research project "Overloaded brain" (#260054), and the Antti and Jenny Wihuri foundation.