From *Mortal Kombat* to *Minecraft*: How Video Games Affect Attention and Resting-State Functional Connectivity in Adolescent Males – A Pilot Study

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Background

Video games have been linked to:

- **Improved visuospatial attention,**[1] which may involve the dorsal attention system[2]
- **Reduced sustained attention,**[3] which may involve the default mode network[4]

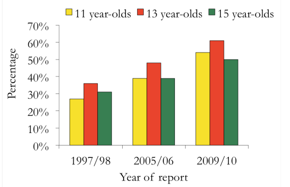
Gaming is increasingly popular in adolescent males (*Figure 1.A*). **However:**

- **Neural correlates** of attention and gaming have not been investigated
- **Pace of video game** has not been measured, despite thought responsible for effects on attention
- **Ecological validity** of improved visuospatial attention has not been assessed

Hypotheses

- Gamers will have more inattention symptoms than non-gamers
- Gamers will outperform non-gamers on a visuospatial attention task. Neural correlates of this will be found in the dorsal attention system
- Non-gamers will outperform gamers on a sustained attention task. Neural correlates of this will be found in the default mode network

A: Increasing rates of gaming in adolescent males



B: Slider pace scale of common video games

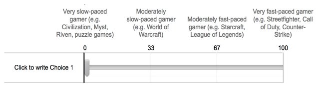


Figure 1. A: Prevalence of adolescent boys playing two or more hours of video games per week in England[5]
B: Scale given to participants to rate pace of games

Methods

Sample:

- 6 gamers playing > 14 hours/week
- 5 non-gamers playing < 7 hours/week
- Male, aged 12-15 years

Design:

- Pilot for longitudinal study
- 1 visit - neuroimaging, questionnaires, tasks

Resting-state functional magnetic resonance imaging was used to compare between-group global connectivity[6] across brain networks[7]

Behavioural Measures:

- Gaming history with **pace** of video game (*Figure 1.B*) and **hours played** per week
- ADHD-Inattention subscale – Swanson, Nolan, Pelham Questionnaire IV (SNAP-IV)
- **Sustained attention** – Continuous Conjunctive Performance Task (CCPT)
- **Visuospatial attention** – Flanker Inhibitory Control Task
- Perception of road-hazards during a **driving simulation** – Hazard Perception
- **Daily gaming habits follow-up** of all participants using a text-message system

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The Context of Video Games

- Winnicott[8] described play as necessary for all to live creatively and to enjoy life
- He believed this need developed with technology, as prior to certain technological advancements, humans were only concerned with basic survival
- With more recent technology and the boom of the Internet, video games have evolved into immersive playable worlds with high resolution graphics and different stories
- These developments allow play, and thus creative living, within virtual realities
- Video games can form a part of creative living in adolescence by providing a way for adolescents to play that is convenient and also socially acceptable to their peers

Figure 2. The evolution of video games.[9] **A:** One of the first computer video games, *Spacewar!* on the PDP-1. **B:** Typical late 80's-90's graphics (*The Untouchables*). **C:** Example of modern graphics (*Trine 2*)

Results

Gamers compared to non-gamers exhibited:

- **Higher inattention** (*SNAP-IV-In*)
- **More errors in sustained attention** (*CCPT*)
- **Better visuospatial attention** (*Flanker*)
- **Similar scores in a real-life perceptual task** (*Hazards*)

Table 1. Behavioural data mean, standard deviation, & task effect size

	Non-Gamers	Gamers	Effect Size (Cohen's *d*)
SNAP-IV ADHD-Inattention†	0.47 (0.33)	0.85 (0.43)	-
Flanker Inhibitory Control Task* (age-adjusted score)	76.22 (3.11)	85.13 (3.47)	1.90
Conjunctive Continuous Performance Test (error)†	6.25 (2.87)	11.67 (11.20)	0.60
Hazard Perception Test (percentage accuracy)†	50 (11.99)	45.42 (9.28)	0.48

*significant at α=.05. †underpowered sample (GPower calculation[10])

Between-group differences were found in key attention-related networks including the dorsal attention network (*Figure 3*). **No differences were found in DMN**.

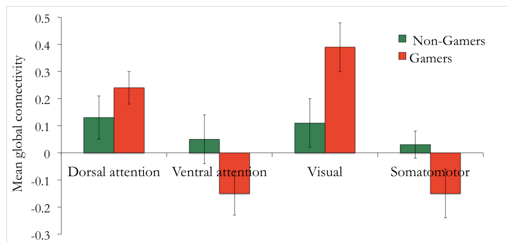

Figure 3. Brain networks that showed significant differences between non-gamers and gamers in global connectivity with the rest of the brain

Combining current pace and weekly hours spent playing showed **stronger positive correlation with visuospatial task performance** (***r_s*(8)= .88, *p*= .001**; *Figure 4*) than hours (*r_s*(8)= .80, *p*= .01) or pace (*r_s*(8)= .38, *p*= .28) alone

Dorsal attention global connectivity showed **strong correlation** with **visuospatial task performance** (***r_s*(8)= .70, *p*= .03**; *Figure 5*)

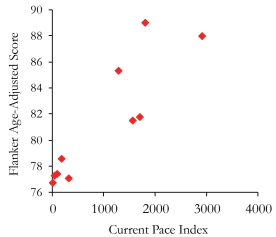

Figure 4. Current fast-paced video game exposure versus visuospatial task performance

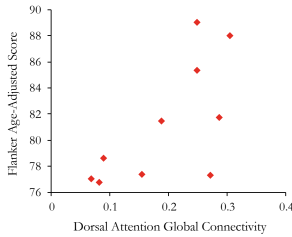

Figure 5. Dorsal attention network global connectivity versus visuospatial task performance

Conclusions

Increased global connectivity in **dorsal attention and visual networks** may be a **functional neural correlate** of **better visuospatial performance** in gamers compared to non-gamers, and fits the existing literature[11]

Reduced global connectivity in the **ventral attention network** could be due to **gamers ignoring distractors** during gaming[11,12]

Current exposure to fast games appears to be related to **visuospatial** task performance, and can be calculated from follow-up data in the longitudinal study

Improved visuospatial task performance in gamers compared to non-gamers may not extend to real-life scenarios such as perceiving road hazards whilst driving

Future & Implications

There are differences between gamers and non-gamers in sustained and visuospatial attention and related neural correlates, but these require investigating in a larger sample with more power

The longitudinal study is feasible and necessary to further investigate these differences

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