Computer games for user engagement in Attention Deficit Hyperactivity Disorder (ADHD) monitoring and therapy

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1. Introduction to Attention Deficit Hyperactivity Disorder (ADHD) - attention, impulse control and (hyper)activity

2. Potential for games

3. Review of literature on games for ADHD

4. Game designs for impulse control based on CPTs, Go/No-go & Stop signal tasks:
   - Existing games: SnappyApp / Attention Grabber
   - New games: Awkward Owls & Wormy Fruit
ADHD is a common neurodevelopmental condition
ADHD affects around 3-5% of the general population
Approximately two-thirds of children with ADHD will continue to experience symptoms in adulthood (2.5% adult population; Simon et al., 2009)
Many adults with ADHD have never been formally diagnosed
Frequent co-morbidities, substance misuse, offending (Xenitidis, Maltezos & Pitts, 2011); wide social & economic impact
Diagnosis can have a significant positive impact for the individual and help to direct appropriate treatment and support
Core characteristics of ADHD

**Inattention**
Difficultly concentrating/completing tasks, forgetful, disorganised, easily distracted, unable to listen

**Hyperactivity**
Fidgety, unable to sit still, talks excessively, always on the go, inner restlessness

**Impulsivity**
Acting quickly without thinking, interrupting other people, difficulty waiting turn

Note: traits are present in the general population
Understanding
Support research into the core traits

Monitoring
Engage people in regular remote or personal measurement of traits to complement diagnosis or treatments

Therapy
Enjoyable means to train and improve cognitive and educational abilities
Clinical status quo

Clinical judgement
Main means of diagnosis

Existing treatments
Drug & CBT

Potential for games
Not in common usage but are of considerable research interest
3 main foci found in the literature:

**Task Focus:**
Measure human performance

**Educational Focus:**
Measure abilities or ‘intelligences’

**Medical/clinical Focus:**
Monitor or provide therapy

Game designs:
Inform or improve health awareness, performance, clinical or educational outcomes
Task focus

- Abilities of game players (action video games, puzzle games) [4, 10-13]

Education/Training/Health Awareness focus

- Cyber-therapy classroom [14]
- Intelligences [15]
- Health awareness [16, 17]
- Cognitive (working memory) training [18]

Medical/clinical focus

- CBT (cognitive behavioural therapy) [19]
- Cognitive tests: CPT (continuous performance tests) [7, 20, 21]; Stop-signal or Go/No-go [22, 23]
- Working memory [24-27]
- Eye-gaze [28-30]
- Neurofeedback/Brain Computer Interfaces: EEG (electroencephalogram) theta/beta [31, 32]; SCP (slow cortical potentials) [33, 34]
- Other biofeedback [9]
Task focus

• Abilities of game players (action video games, puzzle games)
• Includes an element of difficulty that is increased
• Most studies involve tests of visual processing and memory

Examples

• **Flanker compatibility** - spotting specified shapes whilst ignoring peripheral distractor shapes - measure processing speed as the task difficulty increases

• **Enumeration** - counting squares presented momentarily - measuring accuracy as the number of squares is increased

• **Localisation** - accuracy of spotting stimuli objects over space (circles on spokes at different eccentricities)

• **Blink test** - detection of a specified letter stimulus after a task-relevant target stimulus

• **Others:** random task-switching, response inhibition (AKA Go/No-go), various memory tests: *Posner letter identity, proactive inference, N-back & visual short-term memory.*
Task focus results

• Studies have tended to show enhanced cognitive function in habitual gamers (Boot, 2008; McDermott, 2014)

• Also exposing non-gamers to intensive video-gaming sessions can improve their performance (Oei and Patterson, 2013 & 2014)

Implications for ADHD

• Potential for therapeutic benefits for people with neurodevelopmental disorders? - not investigated explicitly

• Likely to be issues around feasibility and acceptability to parents and clinicians
Educational focus

Educational

• Cyber-therapy classroom (Parsons, 2007) – improved attention in VR environment
• Intelligences (Baniqued, 2013)
• Health awareness (Goldman, 2014; Craven, 2014)
• Cognitive (working memory) training – brain research focus (Astle, 2015).
• Also - memory with a clinical ADHD focus (Klingberg, 2002 & 2005; Chacko, 2014)

Near or far transfer effects of video games training?
Gaze control - Attention Eye / Tarkeezy

- Using Tobii eye-tracker
- 3 games aimed at improving children’s attention
- Requires user to maintain or shift attention to fulfil goal
- Back-end for therapist

Examples 1 – Gaze based therapy

https://prezi.com/-y5zjxkqr92w/attentive-eye/

RECOGNeyes (Collins & Liddle)
Attention training with ‘Brain Computer Interface’

• Requires user to ‘concentrate’ to move and collect objects or avoid obstacles/danger

• Control of the ratio between slow (theta, 4-7Hz) and fast (beta, 13-20Hz) oscillatory brain waves (theta/beta ratio)

• Controlled studies with promising results

Examples 2 – Electroencephalogram (EEG) theta/beta ratio

1. Cogo Land game with Brainpal BCI

2. Play Attention
Example 3 – Slow Cortical Potentials (SCP)

**SnappyApp** – Conventional visual Continuous Performance Test – Android & web-app versions of AX-CPT (touch X only after seeing A) (Young et al., HCII 2014)

**SnappyApp Fruit / Attention Grabber** - gamified web-app versions of X-CPT (touch Bananas) and AX-CPT (touch Bananas only after seeing Cherries)
SnappyApp AX-CPT study
- Healthy UK University staff and students (N=11)
- CPT (completed 3 times) – recorded Omission Errors, Commission Errors, Reaction Time (RT) and Reaction Time variation
- UPPS-P self-reporting Impulsive Behaviour Scale
- Participant feedback questionnaire
(Young et al., HCII 2014)

Results
- Sensitivity to some ADHD-related traits in healthy individuals as correlated with UPPS e.g. Positive Urgency
- Measures stable over the course of each test
- Good test-retest reliability
- Positive user experience

Similar results with fruit version at a school
- Correlation of omission errors with SWAN (Strengths and Weaknesses in ADHD) score in school study (N=25)
(Owen Williams, 3rd Year Medical Student project, 2014)
Awkward Owls

• Go/No-go Test – web-app implemented
• Random sequence of owls (75% yellow), interval between owls 1.8-2.8 secs
• Touch Yellow owls (Hoot!) but ignore Brown (Boo!)
• Score based on reaction time to touch Yellow with penalties for omissions & Brown touches

Wormy fruit (concept)

• Stop signal task
Awkward Owls study with children aged 4-11

University of Nottingham Summer Scientist Week 2015

**Awkward Owls**
Keshara Perera, Michael Craven, Maddie Groom

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### Why are we doing this study?
Currently it is very difficult for doctors to assess the symptoms of children with attention deficit hyperactivity disorder (ADHD). Children with this condition have to attend clinic frequently for their symptoms to be measured.

We have developed a smartphone app to measure some of the core behaviours associated with attention deficit/hyperactivity disorder (ADHD), including excessive movement, poor attention and impulsive reactions.

We hope to use this app in children with ADHD so that their symptoms can be easily measured away from the clinic. The first step is to test the app in lots of children who do not have ADHD.

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### What does the app do?
The app presents owl cartoon characters in the centre of the smartphone screen. Children have to collect the yellow owls by pressing the screen. But they must ignore the brown owls!

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### How do we use the app data?
The app tells us how many times each child presses correctly for the brown owl and how many times they press incorrectly for the yellow owl. This gives a measure of response control.

Performance over the course of the game gives us a measure of attention and movement.

When this study has finished we will test the app in children with ADHD.

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### Has this poster increased your knowledge and understanding of this topic?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Not very much</th>
<th>Don’t know</th>
<th>A little</th>
<th>A lot</th>
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Awkward Owls - protocol

Two days at Summer Scientist week (N=120)

Session:
1. Practice with 20 owls (15 secs)
2. Enter ID + perform Full test with 100 owls (75 secs) with data collection
3. User experience questionnaire

Collected game data + raw RT & device motion

4. Strengths & weakness of ADHD (SWAN) questionnaire administered to all SSW participants

User experience questionnaire

- How much did you like the game? A. Liked a lot B. Liked a bit, C. neither liked nor disliked, D. Disliked a bit, E. Disliked a lot
- Why? _________________________ If you didn’t like it, can you imagine anyone in your family or friends that would like it? ____________
- Did you think the game was: A. Really easy, B. Quite easy, C. Neither easy nor hard, D. Quite hard, E. Really hard. Why? _________________________
- Did you think the game was: A. Much too long, B. A bit too long C. About right. D. A bit too short E. Much too short.
- How many times a day would you play the game if you had it on your phone: A. More than once a day, B. Every day, C. Once a week D. Once a month or less. E. Never
- What do you suggest to improve the game?
- Owl preference!  🦉 🦉
Conclusions

Summary

- Review: three main foci: Task, Educational, Medical/Clinical
- New games - based on Go/No-go and Stop-signal tasks, suited to monitoring in ADHD, with potential for training of inhibitory control. One new game implemented.

Future work

- Analyse Owls data – game play, reaction times, motion sensor data
- Level design – how to increment difficulty to maintain engagement
- Further games ontology development? – identify/specify cognitive or executive functions in game descriptions or designs
- Explore question of authenticity of cartoon characters (for engagement) versus robustness in cognitive testing protocols
- Investigate the value of additional game elements or mechanics?
- Perform systematic review to assess evidence more fully
Thank you

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Any questions?