Neuroimaging findings in Internet Gaming Addiction in Adolescence-A Systematic Review.

Khor E.[1], Mc Nicholas F[1,2,3], Columb D[4]

[1] UCD School of Medicine, University College Dublin, Belfield, Dublin 4.

[2] Lucena Clinic, Rathgar, Dublin 6.

[3] Children's Health Ireland (CHI), Crumlin.

[4] Dublin North City and County Child and Adolescent Mental Health Service, Grangegorman Primary Care Centre, Dublin 7.

Introduction

- Lack of social activities due to Covid-19 restrictions; WHO promoted gaming activities in their '#PlayApartTogether' campaign[1]
- Gaming as coping strategy to relieve psychological stress[2]
- 0.5%-1.6% Irish adolescents with possible internet gaming addictions (IGA)[3]
- No clinically useful neuroimaging biomarker for psychiatric disorders[4]

Aim

To perform a systematic review of neuroimaging studies in adolescents under 18 with IGA

Methods

- **Addiction**: (Addict* OR Patholog* OR Disorder OR Compulsive OR Problem*)

AND

- **Gaming**: (Gaming OR Internet)

AND

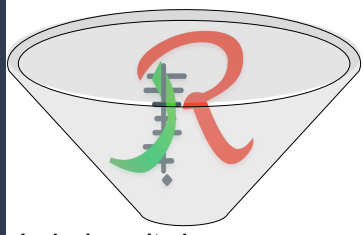
- **Neuroimaging**: (imaging OR neurobio* OR neuroscience OR neuropsycholog*)

PubMed

AMERICAN PSYCHOLOGICAL ASSOCIATION PsycINFO

EBSCO HOST

WEB OF SCIENCE



Inclusion criteria:

1) **Mean age under 18**
2) **English**
3) **Neuroimaging**
4) **Non-addicted control group/s**

JBI

Assess Quality of Studies

Results

Records identified in Pubmed, PsycINFO, Web of Science and CINAHL Plus (n= 2263)

Records after duplicates removed (n=1307)

Records screened (n=1307) → Records excluded based on Title, Abstract (n=1163)

Full-text articles assessed for eligibility (n= 144) → Full-text articles excluded based on:
1) mean age group ≥ 18 (n=118)
2) No comparison group (n=1)
3) Internet addiction (n=1)

Additional article from Pubmed (n=1)

Studies included in data extraction & descriptive analysis
Cross-sectional study (n=23), Follow-up study (n=2)

Figure 1: Prisma Flow Chart

Functional Magnetic Resonance Imaging (fMRI)

Activities & connectivity | **Deficits (Perfusion)** | **Compensation for impaired**

- Auditory cortex to motor cortex
- Putamen to somatosensory region

- Temporal lobe
- Occipital lobe

- Perfusion to temporal lobe
- Global & long-range temporal lobe connectivity

Figure 2: Abnormal sensorimotor regions activities, connectivity with potential compensatory mechanism

Cue

Gaming motivation
(Dysregulated frontoparietal and dorsal striatum regions)

Attention to game
(Increased functional salience connectivity of left frontal eye field)

Working & long-term memory
(Prefrontal and temporoparietal regions connectivity increased)

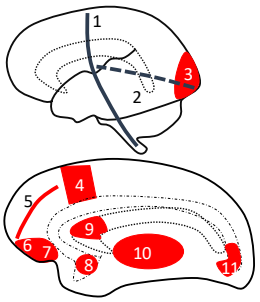
Rewards processing
(cortical-subcortical regions connectivity decreased)

Self-concept & emotional control
(Implicated in cortical and subcortical regions)

Attention to goals
(Implicated in cortical-subcortical & insula-superior temporal gyrus connectivity)

Risky decision-making
(Dysregulated brain rewards and executive systems)

Structural Magnetic Resonance Imaging (MRI)



- White matter connectivity of visual and motor systems
- Visual system via synaptic pruning in the occipital region

- Impaired motor, impulse and emotional control
- Decreased cortical thickness
- Decreased white matter connectivity (frontal, insula and cingulate regions)

Figure 3: (1. corticospinal tract, 2. occipital subcortical tract, 3. lateral occipital lobe, 4. supplementary motor area, 5. frontal lobe white matter, 6. inferior frontal cortex, 7. orbitofrontal cortex, 8. external capsule, 9. genu of corpus callosum, 10. insula, 11. cingulate isthmus

Electroencephalography EEG

No-go N2
No-go P3
Gain FRN

Intra hemispheric θ, α, β in the parietooccipital & temporal regions

- Decreased rewards sensitivity
- Impaired inhibitory control and prediction errors

- Repetitive stimulation of visuospatial working memory and executive system

Higher than control groups | Lower than control groups

Discussion

Habitual gaming → **Prolonged gaming**

Executive Control & Rewards systems

Preoccupation | Tolerance

Rewards Sensitive | Guilt | **Rewards Insensitive**

Withdrawal

Craving

Impulsivity | Compulsivity

Sensorimotor coordination & Working memory → Sensorimotor Deficits

- Impulsivity refers to action without taking consequences into account
- Compulsivity refers to continuous, excessive actions with ignorance of goal-directed tasks
- Failure to control gaming due to impaired cognitive control and rewards processing

Internet gaming addicted adolescents shared:

- Poor emotional control with major depressive disorder (increased θ in temporal region)
- Inattention with attention deficits hyperactivity disorder (decreased frontal-striatal connectivity)
- Cue reactivity with addicted smokers (frontal-limbic network)
- Impaired rewards learning with pathological gambling (decreased ventral attention system-superior temporal gyrus connectivity)

Aberrant Brain Development

- Delayed cortical development
- Random brain topology

Global efficiency | Local efficiency

Limitation

- All studies from Asia
- 24/26 are cross-sectional studies
- Small sample size
- 18/26 recruited males only

Conclusion

- IGA trapped in similar a addiction cycle like other addictive behaviors
- IGA shared similar neural characteristics with other psychiatric disorders (e.g. ADHD, Major Depressive Disorder (MDD)
- IGA showed potential disruption to brain development
- Implications for future research to conduct more cohort studies & clinical applications for diagnosis and informing treatments.

References

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