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A Machine Learning Aided Systematic Review of Screen Media Use and Executive Functions among Children and Adolescents

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Background

- Screen media is any media that is produced for or distributed via the screen, including the entire spectrum of what constitutes "the screen".
- Adolescents are heavy consumers of screen media: consume 7.5 hours on a typical day and online almost constantly
- Screen media use involves brain reward mechanism and is designed to enhance the rewarding aspect. Children and adolescents with less developed cognitive control are more likely to be affected.
- Executive functions are a set of higher-order cognitive process strongly associated with inhibition, working memory, and attention and essential for the performance of activities of daily living
- Increased publications, broad scope of topics, inconsistent terminologies in screen media research

Specific Aims

- What have the scientific literatures reported on relationship between screen media use and executive functions among children and adolescents?
- Is it feasible to use supervised machine learning techniques to aid abstract screening in a systematic review?

Methods

Study Design: Systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement

Data Sources:
PubMed.gov Scopus
CINAHL PsycINFO EconLit

Search Terms: Relevant terms on Screen Media Use and Executive Functions and Children/Adolescents

Software: Python and packages "Biopython", "pybliometrics", "pandas", "gensim" and "scikit-learn"

Study Selection:
Participants: children and adolescents aged 4 to 18 years
Exposure: any screen media activities
Outcomes: executive functions or subdomains of executive functions assessed by rating scales, performance tests, or cerebral activation patterns stated to be related to executive functions (e.g., functional MRI)
Study design: experimental studies or observational studies
Language: articles published in English
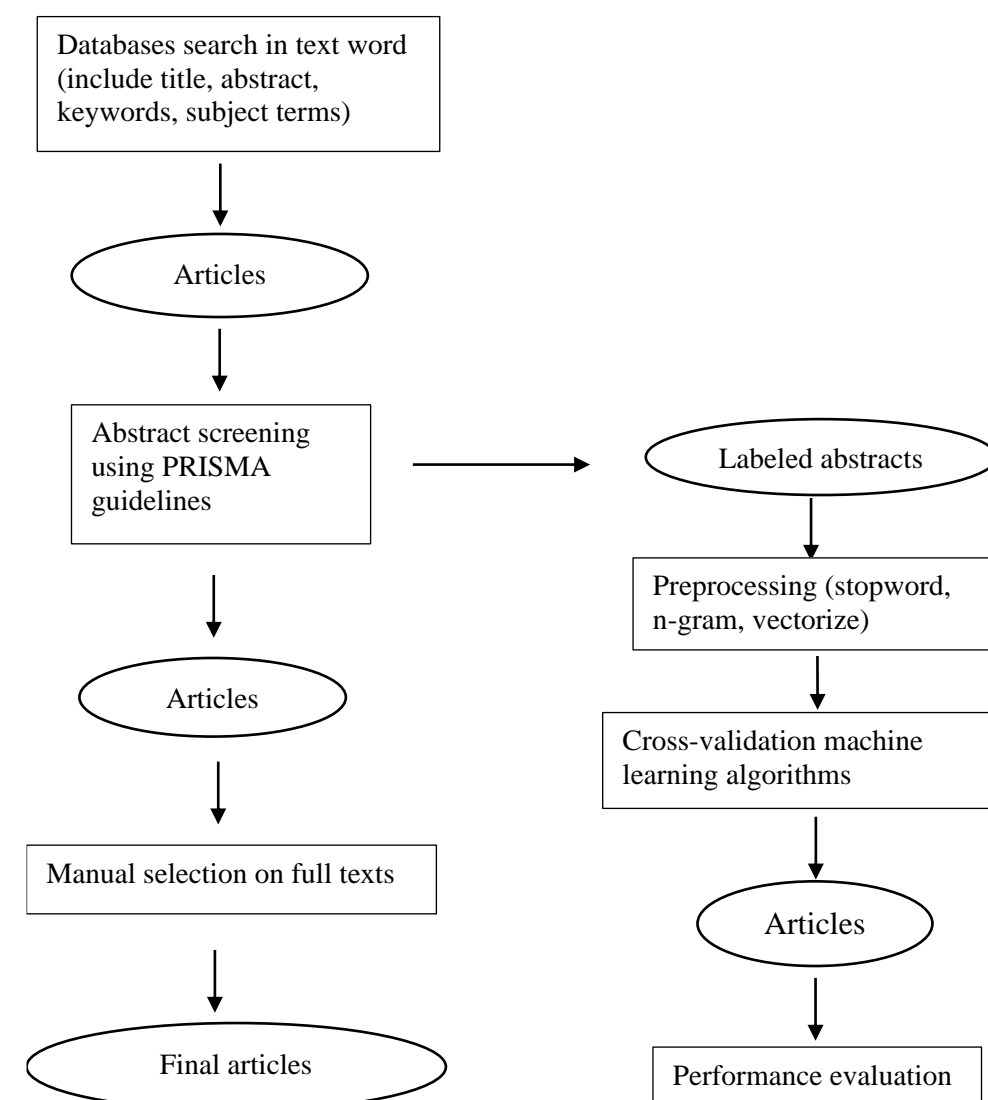
Results

PRISMA 2009 Flow Diagram of screen media use and executive functions among children and adolescents published in English between January 1st, 1949 through December 31st, 2020
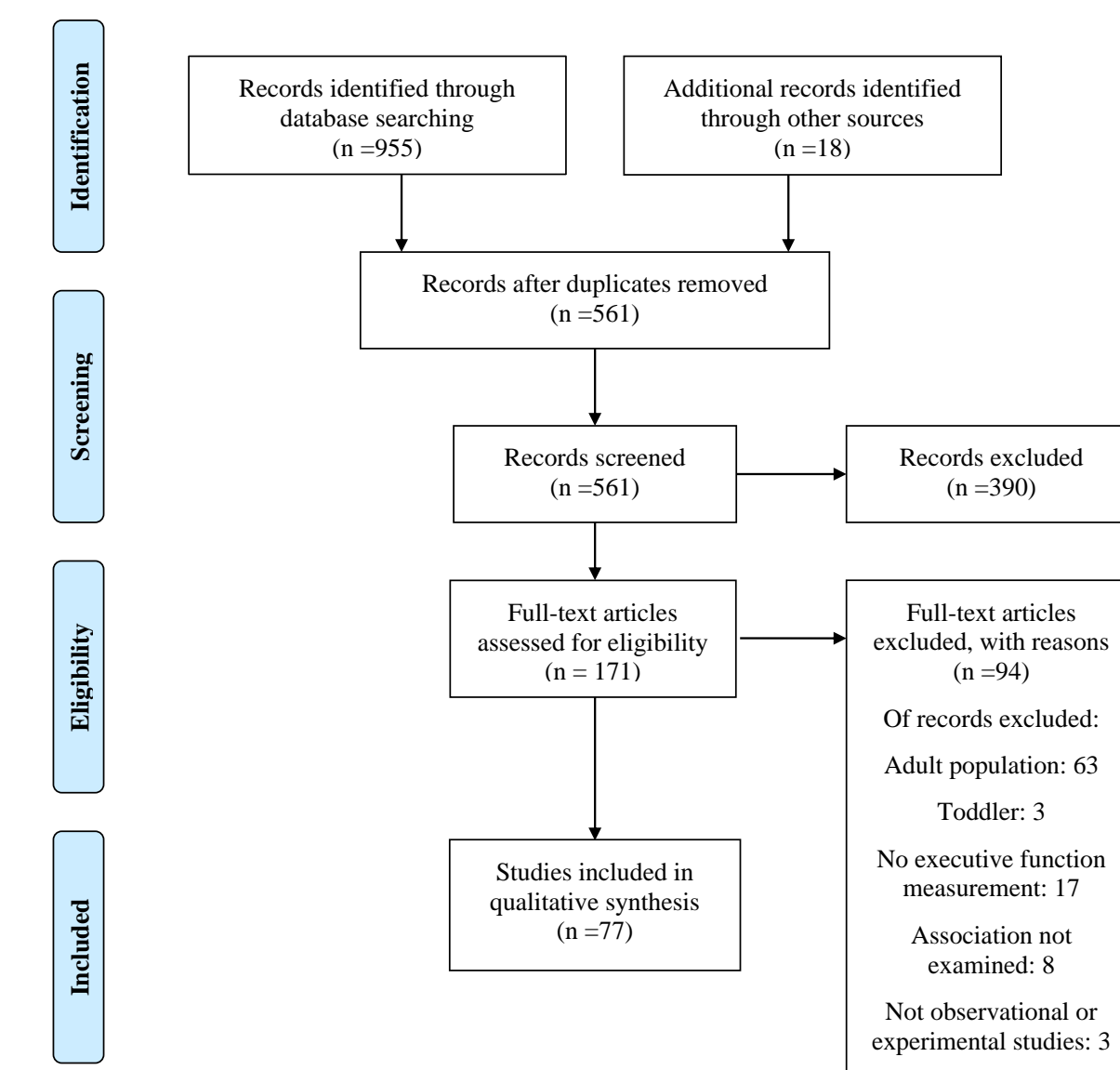

Type of screen media examined in the studies included in this systematic review

- Video game playing (6 exergames) 35%
- Television/video watching 16%
- Internet use 9%
- mobile phone or smartphone use 6%
- Social media applications 4%
- Computer use 1%
- Screen time or multiple screen media activities 29%

Table: Results from Machine Learning Assisted Abstract Screening using Undersampling technique

Methods	Features	Sensitivity/Recall Mean (SD)	Area Under ROC Curve Mean (SD)
Multinomial Naïve Bayes	Word Count	0.86 (0.04)	0.76 (0.04)
	TF-IDF	**0.96 (0.02)**	0.73 (0.03)
	TF-IDF N-gram	0.90 (0.04)	0.75 (0.04)
Logistic Regression	Word Count	0.69 (0.06)	0.70 (0.03)
	TF-IDF	0.78 (0.05)	0.77 (0.04)
	TF-IDF N-gram	0.81 (0.05)	0.76 (0.03)
Support Vector Machine	Word Count	0.73 (0.05)	0.74 (0.02)
	TF-IDF	0.77 (0.07)	0.76 (0.04)
	TF-IDF N-gram	0.83 (0.05)	0.77 (0.02)
Random Forest	Word Count	0.74 (0.06)	0.71 (0.04)
	TF-IDF	0.78 (0.06)	0.73 (0.03)
	TF-IDF N-gram	0.78 (0.07)	0.74 (0.03)
eXtreme Gradient Boosting	Word Count	0.70 (0.07)	0.68 (0.04)
	TF-IDF	0.72 (0.07)	0.69 (0.05)
	TF-IDF N-gram	0.74 (0.09)	0.68 (0.05)

*N-gram range was set to unigram to trigram.

Summary of Results

- **Multiple screen media activities:** Most of studies (n=16, 72.7%) showed negative associations with executive functions.
- **Video games:** Mixed findings with both positive and negative associations.
- **Television:** Mixed findings depending on the content. Fantastic content (imaginative and remote from reality) was negatively associated with executive functions, regardless of educational or entertaining content.
- **Internet/Computer/Phone:** Problematic internet use was associated with diminished behavioral inhibition. One study on computer use reported weak negative association. Phone use was associated with poorer inhibitory function.

Quality of Studies

- Longitudinal and cross-sectional studies examining associations with time spent on screen media use did not include objectively measured variables.
  - The time was estimated based on either self-reporting or parents/guardians reporting.
- Twenty-one studies (27.3%) did not include potential confounders in the analyses or failed to report such information.

Discussions

- Executive functions and their subdomains were measured in different ways.
- Inhibitory control was mostly assessed by performance tests whereas self-control was mostly assessed by rating scales.
- Despite both being concrete measures of "executive function," executive function rating scales measure different underlying constructs than do performance-based tests.
- All 10 studies on brain functional or structural changes reported significant functional or structural changes associated with screen media activities
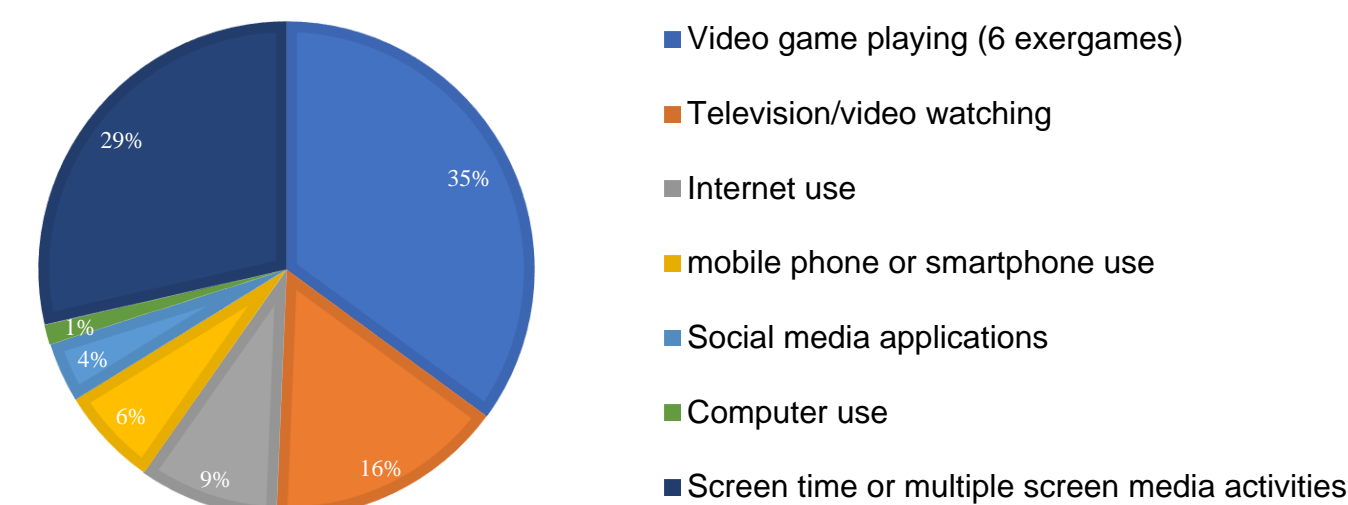
Conclusions

- Overall screen media activity was inversely associated with executive functions among children and adolescents.
- The association may be mediated by other unobserved confounding factors (e.g.,socio-demographic factors, clinical characteristics, sleep quality)
- The mixed findings on video games revealed the content in video games could play a major role in this association
- Except for exergames, other studies rarely explored the conditions in which children and adolescents were using screen media.
- Problematic use was associated with poor behavioral inhibition.

Reference

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