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Preregistration: a quantitative meta-analysis testing the effects of behavioral and cognitive interventions targeting executive functioning in students aged 2 to 19 years

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A Quantitative Meta-Analysis Testing the Effects of Behavioral and Cognitive Interventions Targeting Executive Functioning in Students Aged 2 to 19 Years.

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Citation

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Review question

Are interventions aimed at improving executive functioning (EF) effective in enhancing either EF abilities or academic abilities in students from preschool up to secondary education?

Exploratory

1. Does the effect an intervention has on (other) EF and/or academic skills (reading, writing, oral language, mathematics, general academic abilities) depend on the focus of the intervention?
2. Is the effect of EF interventions, on both EF and academic abilities, moderated by factors such as study characteristics (e.g., quality, year of publication), training characteristics (e.g., duration, training setting), participant characteristics (e.g., age, sociodemographic factors, diagnoses), or measured outcomes?

Searches

The database searches will be performed in October through December 2024. Grey literature search will be performed continuously over a longer period. No limits were imposed on time period or language in any of the databases in order to maximize the number of relevant studies that can be included and to minimize bias. The only limits that were imposed were: 1) in PubMed we specified the search for studies in humans, and 2) in Scopus we limited the search to the Subject areas Psychology, Social Sciences, Arts and Humanities, Health Professions, and Nursing. Medicine was excluded due to the large number of irrelevant records in preliminary searches.

The databases that will be searched are:

- EBSCO Academic Search Premier
- EBSCO Psychology and Behavioral Sciences Collection
- APA PsycINFO and APA PsycArticles (via EBSCO)
- ERIC (via EBSCO)
- Web of Science Social Sciences Citation Index
- PubMed (including MEDLINE)

- Scopus (Subject areas: Psychology, Social Sciences, Arts and Humanities, Health Professions, Nursing)
- Linguistic and Language Behavior Abstracts (via ProQuest)

Grey literature will be searched in preprint services or databases (such as PsyArXiv, Social Science or Research Network), collections or databases of dissertations (such as ProQuest Dissertations and Theses Global), collections of (policy) reports (such as What Works Clearinghouse), in Google Scholar, and by reaching out to experts in the field. Additionally, the reference lists of included articles will be searched for relevant papers.

The search terms consist of three categories that are combined into the full search string. The first category is dedicated to EF terms (e.g., “working memory” or “attention* shift*”), the second to terms related to interventions (e.g., interven* or RCT), and the final one to the population (e.g., child* or student*). We searched both titles and abstracts for these terms.

After data extraction but before statistical analysis the search will be repeated.

Types of study to be included

1. The study investigates an intervention aimed at improving EF or an intervention targeting EF to improve academic abilities that can be implemented by education professionals or parents in an educational and/or child care setting.
2. The study looks at students aged between 2 and 19 years old.
3. The study reports at least one EF and/or academic ability outcome measure from behavioral tests (incl. neuropsychological tests) and/or behavior observations measurements (such as questionnaires).
4. The study has a (quasi-)experimental design and includes at least one control group (either passive or active) or control condition. In the case of multiple baseline designs there are at least three baseline measurements prior to the start of the intervention (Tate et al., 2013).
5. Study information is available in English.
6. All statistical information and study characteristics relevant to answering the research question are available.

Papers that have been retracted will not be included in this meta-analysis.

Condition or domain being studied

Cognitive (executive functioning) and academic (reading, writing, oral language, mathematics, general academic abilities) in students with and without developmental disorders and/or learning problems.

Executive functioning (EF) is defined as a set of cognitive processes that are involved in managing and regulating other cognitive processes and sensory input in order to achieve goal-directed behavior. Although commonly used theoretical models divide EF into several components such as working memory, inhibition, shifting, attention, and planning (Garon et al., 2008; Dawson & Guare, 2009; Diamond, 2013), a growing body of experimental research using structural equation modeling techniques like factor analysis suggests that EF may in fact be best represented by only a few or even a single factor depending on the age of the participants (e.g., Karr et al., 2018; Löffler et al., 2024). Combined with the well-known task-impurity problem many EF tasks suffer from (e.g., Diamond, 2013), this leads us to reckon with the possibility that coding EF outcomes in different subdomains may not accurately reflect EF abilities. Therefore, we will perform analyses with all EF measures combined and separate analyses for the EF domains from the most commonly used EF models (Miyake et al., 2000; Diamond, 2013).

Participants/population

Children and adolescents with and without developmental disorders (incl. ADHD, ASD, DLD, genetic disorders) and/or learning problems (incl. dyslexia, dyscalculia, etc.) between the ages of 2 and 19 years old.

Intervention(s), exposure(s)

EF interventions are defined as interventions that directly or indirectly target EF with the aim of improving EF abilities. Interventions targeting academic abilities through EF are defined as interventions that use training of one or more EFs as a means to boost academic abilities. These interventions directly or indirectly target EF with the assumption that improving EF will lead to better academic abilities, and are, therefore, included in the present meta-analysis

Interventions will be classified following a predefined coding scheme. We will code whether interventions directly or indirectly target EF, whether they contain a single or multiple components, whether they are computerized or non-computerized, and whether specific features or components such as repeated task practice, teacher/parent training, physical exercise, biofeedback, mindfulness or dietary programs are part of the training. We will also consider near and far transfer effects. Transfer effects are considered EF-near when the intervention targets the EF domain that is also considered as an outcomes. EF-far when the intervention targets one specific EF domain but one or more other EF domains are considered as outcomes, and general-far when outcomes are academic abilities. Studies investigating the effect of medical interventions (incl. medication) will not be included.

Comparator(s)/control

Due to the different types of interventions that will be included, there is not just one single type of control group or control condition that is deemed appropriate. What is considered an appropriate control group or condition may depend on the supposed mechanism underlying the intervention. Only studies with a control group or control condition, such as studies with a within-subjects design or studies that use multiple baseline measurements (e.g., single or multiple case studies) will be included (Cuijpers et al., 2017). The type of control group or condition will be coded and considered in moderator analyses.

Main outcome(s)

Raw means, standard deviations and/or standard errors of post-test scores or growth scores (pre-post) of EF or academic ability outcomes will be used to calculate effect sizes.

Measures of effect

Hedges' g

Additional outcome(s)

Not applicable

Data extraction (selection and coding)

Title / abstract (TIAB) screening will be performed by two team members and trained graduate student(s). TIAB screening will be performed using the open-source, active learning software ASReview (ASReview LAB developers, 2024; van de Schoot et al., 2021). We will follow the SAFE procedure by Boetje and van de Schoot (2024). As part of the SAFE procedure a random 1% of all records will be screened independently by the researchers that will perform the TIAB screening. This will be used to determine inter-rater reliability, to find priors to train the model, and to estimate the number of relevant records in the total data set. Differences in coding will be resolved through discussion aimed at reaching consensus.

Grey literature will not be included in the TIAB screening in ASReview as grey literature searches can often not be exported. These records will be screened manually without the assistance of software by two team members and trained graduate student(s).

Full-text screening and data extraction will be performed by the three team members and trained graduate students using a predetermined coding scheme. Data extraction will be performed concurrently with full-text screening. All articles will be independently screened and coded by at least two researchers. The variables that will be extracted can roughly be

categorized as:

- study information (e.g., author, year, design)
- participant information (e.g., mean age, sex, any diagnoses, type of controls)
- intervention information (e.g., intervention type, content, duration, intensity, setting)
- outcomes (e.g., number and type of outcomes, M, SD, assessment modality)
- quality assessment variables (e.g., drop-out, treatment fidelity, randomization)

Disagreement will be resolved by checking the article again or by discussion aimed at reaching consensus when it concerns interpretation by the researchers (such as the categorization of intervention type).

More detailed information about the data extraction and coding will be made available.

Risk of bias (quality) assessment

We will not perform a standard risk of bias assessment because we will likely include many different kinds of studies and most risk of bias assessment tools have been developed for one particular type of study design. These might be subsequently difficult to compare. We will, however, extract a large number of variables that can be used to assess the quality of studies to include as possible moderator variables in the analyses. The predetermined variables used to assess study quality are based on frequently used risk of bias assessment tools, such as the ROBINS-I (Sterne et al., 2016), RoBANS 2 (Seo et al., 2023), RoB 2 (Sterne et al., 2019), Quality Assessment Tool for Quantitative Studies (Thomas et al., 2004), Newcastle-Ottawa Quality Assessment Scale Case Control Studies (Wells et al., 2000), TREND (Des Jarlais et al., 2004), and the CONSORT statement and checklists (Boutron et al., 2017; Butcher et al., 2022; Montgomery et al., 2018). Additionally, we will perform sensitivity analyses excluding studies that have been assessed as low quality, studies with imputed data, outliers, and analyses correcting for outcome reporting bias (van Aert & Wicherts, 2024).

Strategy for data synthesis

Hedge's g will be used as an indication of the strength of the intervention effects. We will use a three-level meta-analytic model to calculate the overall effect of interventions and to explore the effect of moderators. Three-level meta-analytical models add a within-study level in addition to the participant level and the between-study level, allowing researchers account for the effect of inter-dependence between effect sizes from the same study (Cheung, 2014; van den Noortgate et al., 2012). Heterogeneity will be quantified with Cochran's Q and estimated with I^2 statistic (Higgins & Thompson, 2002). Moderator analyses will be conducted if sufficient heterogeneity is present. Data will be checked for outliers (z -score exceeding ± 3.29). Data imputation may be used for randomly missing data, although this will be dependent on the nature and amount of the data missing (Kambach et al., 2020). The exact method of data synthesis is dependent on the number of included papers and the data that can be extracted.

Analysis of subgroups or subsets

- Intervention type (direct/indirect, single/multi component, computerized/non-computerized, etc.)
- Transfer (EF-near, EF-far, and general far)
- EF domains
- Academic ability domains
- Students with and without developmental disorders and/or learning problems
- Population (sociodemographic factors)

- Assessment (modality, direct vs. indirect)
- Intervention duration and intensity
- Participant age

The final subgroup (moderator) analyses conducted may be dependent on the number and type of studies that can be included.

Contact details for further information

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Type and method of review

Meta-analysis, Systematic review

Anticipated or actual start date

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Anticipated completion date

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Conflicts of interest

None known

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Country

Netherlands

Stage of review

Review Ongoing

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

Child, Preschool; Cognition; Humans; Mathematics; Reading; Sociodemographic Factors; Students; Writing

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Date of first submission

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Details of any existing review of the same topic by the same authors

Not applicable

Stage of review at time of this submission

Stage	Started	Completed
Preliminary searches	Yes	Yes
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add publication details in due course.

Versions

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