



The University of Manchester



Effect of air quality in and around schools on cognitive performance in primary school children



The University of Manchester



Philips
Foundation

Background



- Increasing evidence that air pollution impacts brain health, both at young and older age
- GAP/Philips Foundation collaboration to investigate impact of air quality on educational attainment of primary school children in Greater Manchester
- Can air purifiers and other intervention improve educational attainment

What we did I: literature review

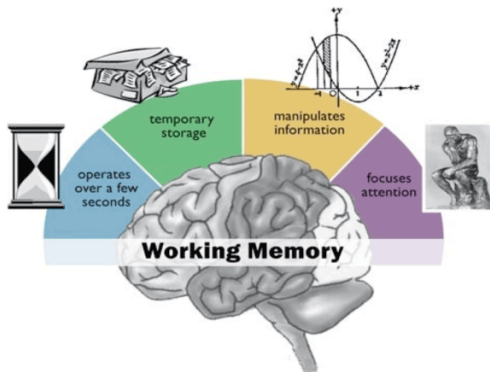
- We started by summarising the existing literature on the links between air pollution in and around schools and executive functioning in primary school aged children
- Executive functioning has been shown to be an important determinant of educational attainment
 - However, quantifying the exact magnitude of the effect is difficult as very context dependent



Executive functioning

Collective term for a range of cognitive processes that manage and control thoughts, emotions and actions aimed at achieving an objective or goal

Working memory
impulse inhibition
cognitive flexibility
planning



CREDIT: [HTTP://COGX.INFO](http://COGX.INFO) (DR. BROWN)

ORGANIZE, PRIORITIZE, ACTIVATE WORK
MONITOR AND SELF-REGULATE ACTIONS
UTILIZE WORKING MEMORY & SHORT TERM RECALL
MANAGE FRUSTRATIONS AND MODULATE EMOTIONS
REGULATE ALERTNESS, SUSTAIN EFFORT AND SPEED
FOCUS, SUSTAIN AND ABILITY TO SHIFT TASK ATTENTION

What we did I: literature review

- Literature searches carried out in February 2020
- Looked for studies which included:
 - At least one continuous and quantitative measure of cognitive or academic achievement
 - At least one continuous and quantitative measure of cognitive or academic achievement
- Studies were excluded if they:
 - Only reported pollution exposure estimates outside of a school setting
 - Only reported measurements of pollutants from non-traffic sources

What did we find?

Nine previous studies had investigated this:

- From a range of continents and countries
 1. Europe: 5 studies (Spain, UK, Austria, the Netherlands, Belgium)
 2. North America: 3 studies (USA)
 3. South America: 1 study (Chile)

What did we find?

Nine previous studies had investigated this:

- Measured different traffic-related air pollutants
 - **PM_{2.5}**, **PM₁₀**, **NO₂**, Elemental carbon [EC], Black carbon [BC], NO_x, O₃, CO, PAHs, and UFP
- Measured pollution in different ways
 1. Direct sampling at school site indoors (2 papers), outdoors (1) or both (3)
 2. Estimated pollutant exposure using geographically modelled pollution levels (7 papers)

What did we find?

Nine previous studies had investigated this:

- Measured outcomes in different ways

1. School attainment:

- Standardised test scores (maths, reading, reading comprehension scores)
- Grade point average

2. Psychological tests:

- Working memory
- Attention

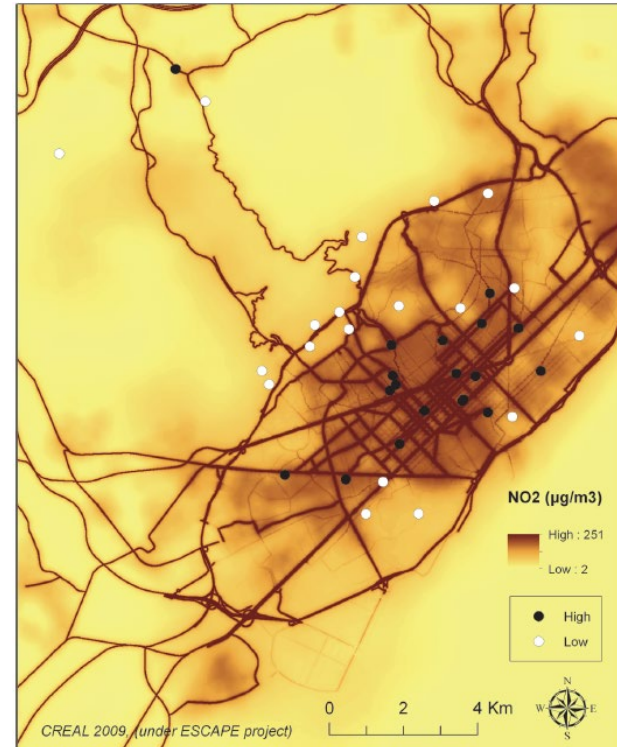
BREATHE Study (Barcelona)

39 schools in Barcelona (Sunyer et al., 2015):

- Exposed to high and low traffic-related air pollution (NO₂)
- Paired by school socioeconomic index
- 2,715 children, aged 7-10 years

Pollution measurement:

- Measured over 1 week, two times 6 months apart, during class hours (9.00-17.00)
- Indoor air (single classroom) AND outdoor air (courtyard)
- Long-term school air pollution levels obtained by averaging the two 1 week measures
- Pollutants: EC, UFP (10-700nm), and NO₂



BREATHE Study (Barcelona)

Outcome measures:

- INATTENTIVENESS - computerised Attentional Network Test
- WORKING MEMORY - computerised n-back task; 2-back numbers and words d'
- SUPERIOR WORKING MEMORY - computerised n-back task; 3-back numbers and words d'

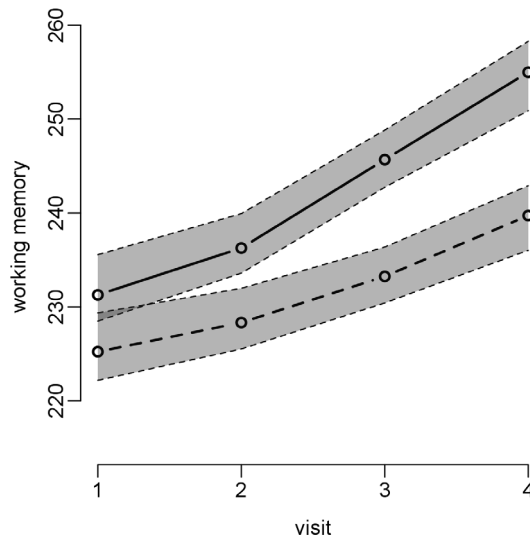
Inattentiveness and working memory assessed on 4 occasions over the course of 1 year.

- 1 year trajectories modelled
- Controlled for age, sex, maternal education, residential neighbourhood SES, air pollution exposure at home

BREATHE Study (Barcelona)

Findings (Sunyer et al., 2015):

- Children attending schools with higher levels of EC, NO₂, and UFP both indoors and outdoors experienced substantially smaller growth in all the cognitive measurements
 - Only exception: NO₂ did **not** have a significant association with attentiveness



Persistence of this finding supported by Forns et al. (2017):

Per one interquartile range increase in exposure, **reductions** in annual working memory development were equivalent to:

- Outdoor NO₂:** - 20% (95%CI, - 30.1, - 10.7)
- Indoor UFP:** - 19.9% (95%CI, - 31.5, - 8.4)

What did we find?

Prevailing finding:

Increased pollution is associated with decreased executive functioning

PM demonstrates a negative relation with working memory, attention and other cognitive outcomes.

NO₂ may have a specific effect on working memory and may not affect other facets of executive function.

What are the implications?

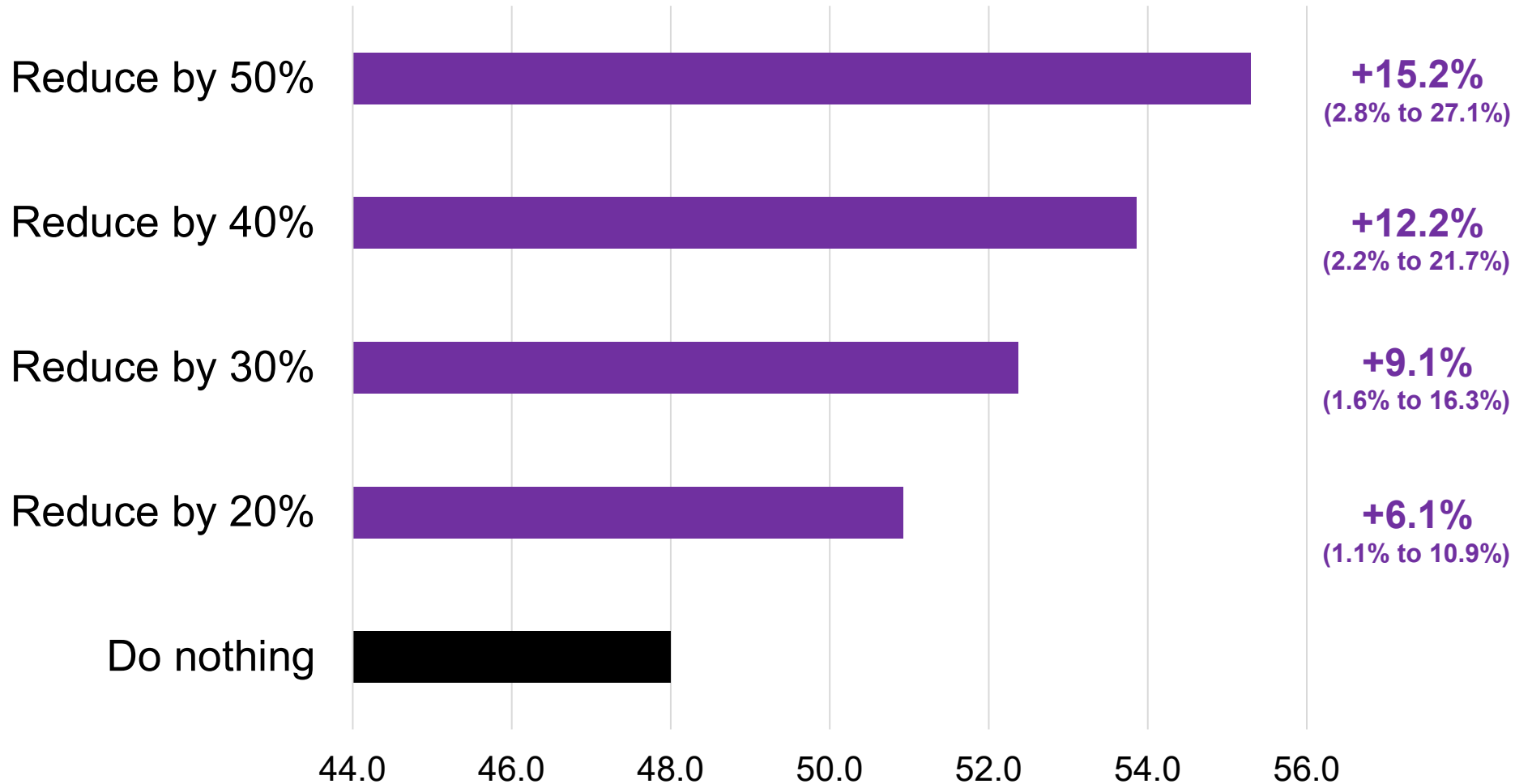
TRAPS appear to hamper the developmental trajectory of working memory

- Levels of working memory are significantly associated with achievement at school (Cortés Pascual *et al.*, 2018)
- Predictive relationship between executive function and working memory in particular in early childhood and performance through the rest of the educational system (Ahmed *et al.*, 2019; Morgan *et al.*, 2019)

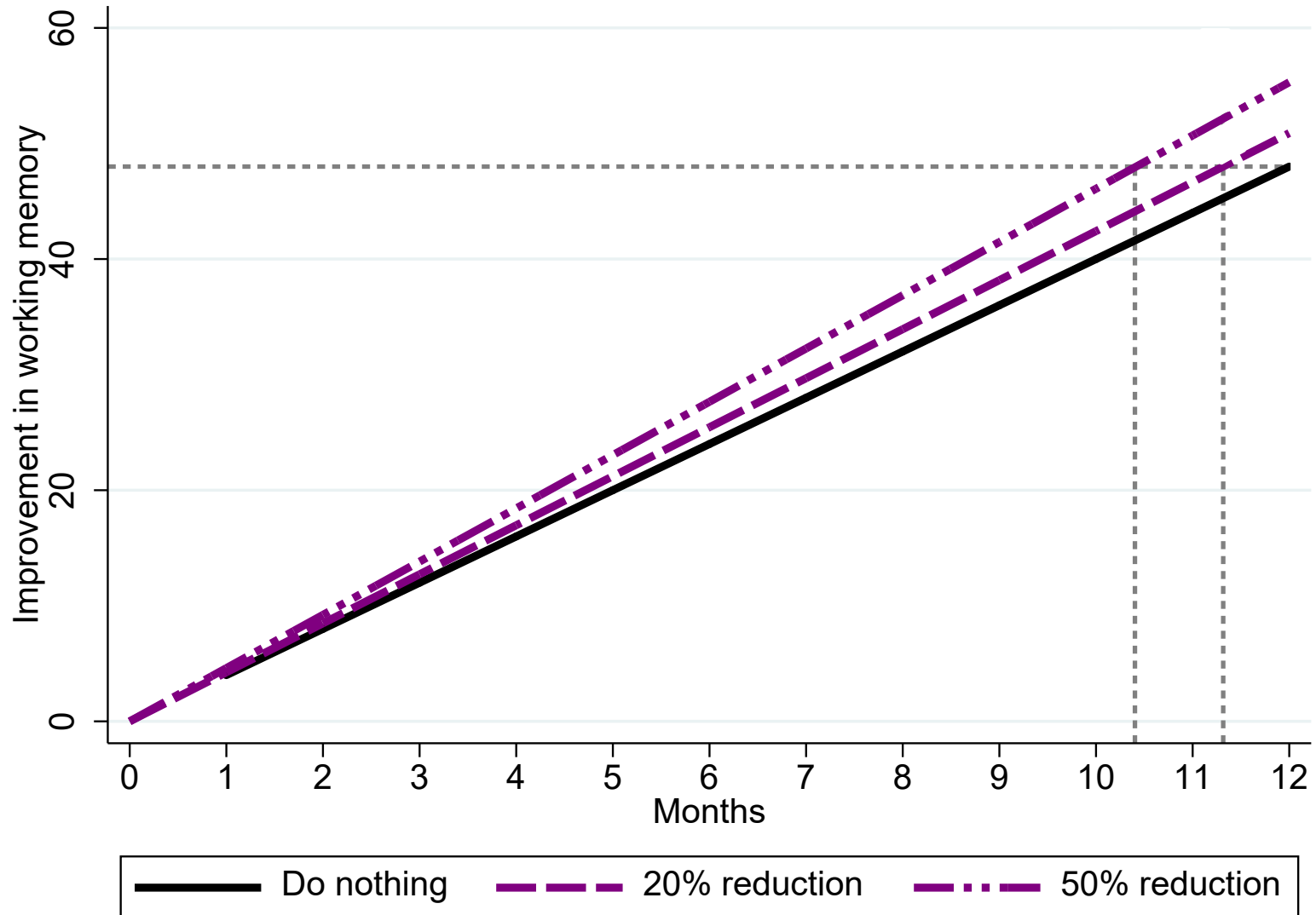
What we did II: modelling

- We then used *estimates* from the existing literature to *predict* what could happen to working memory (a key component of executive functioning) following changes in pollution
- We focus on two pollutants:
 - Outdoor air pollution, measured by NO_2
 - Indoor air pollution, measured in $\text{PM}_{2.5}$

Effect of outdoor NO₂ on working memory



Outdoor Pollution (NO₂)



Summary of results

- Decreases in air pollution could lead to considerable increases in working memory:
 - A 20% reduction in outdoor NO₂ could improve the growth in working memory by about 6%, around 3 weeks worth of growth per-year
 - A 50% reduction in outdoor NO₂ could improve the growth in working memory by about 15%, around 7 to 9 weeks worth of growth per-year
- Similar results when we consider indoor air pollution (PM_{2.5})

Key takeaways

- Reductions in air pollution in and around primary schools could improve the working memory of children
- This is important as it is predictive of educational attainment

