

# **Executive functions and achievements in school: Shifting, updating, inhibition, and working memory**

Helen L. St Clair-Thompson & Susan E. Gathercole (2007)  
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# Abstract

The focus of this study was to investigate the relationship among scholastic attainment, shifting, updating, inhibition, and verbal and visuo-spatial working memory in 11- and 12-year old children.

Using exploratory factor analysis, the result pinpointed updating and inhibition as the 2 main executive functions.

- Updating Abilities → Verbal and Visuo-Spatial Working Memory
  - Verbal working memory ⇒ English
  - Visuo-spatial working memory ⇒ English, Mathematics, and Science
- Inhibition ⇒ English, Mathematics, and Science

# Introduction

- Executive Function: responsible for control and regulation of cognitive processes
  - Central Executive Function:
    - Integrate information from the working memory and long-term memory (updating)
    - Multi-coordination
    - Shifting between tasks (shifting)
    - Attend and Inhibit selectively (inhibition)
- Past studies:
  - Verbal and visuo-spatial working memory linked with education attainment
  - Executive functions (shifting, updating, and inhibition) related to scholastic achievement
  - Poor performance on working memory tasks linked with executive skills ⇒ Below standard in national curriculum assessments for English, math, and science

# Hypotheses

3 main goals:

1. Investigate the extent to which executive functions (shifting, updating, and inhibition) are unitary or separable in children
2. Investigate the executive functions' underlying performance on working memory span tasks
3. Assess the extent to which executive functions contribute to children's learning achievements

# Methods: Tasks

## Plus-Minus Task (shifting)

- Add 3, subtract 3, alternate between adding and subtracting 3 (2 minutes)

## Local Global Task (shifting)

- Global figure (ex. triangle) composed on local figures (ex. squares)
- List the number of lines from the global, local, and alternate (2 minutes)

## Letter Memory Task (updating)

- Recall last 4 letters presented on the screen

## Keep Track Task (updating)

- Recall the last word from each target category at the end of each trial

## Stop-signal Task (inhibition)

- Don't categorize monosyllabic words as animal or non-animal if there are 3 asterisks on the bottom of the word (otherwise, categorize)

## Stroop Task (inhibition)

- Name the color of the string of asterisks
- **BLUE** asked to name the color of the font

# Methods: Tasks cont.

## Listening Recall Task (verbal working memory)

- Hear a series of sentences and asked to judge the veracity of each; at the end of the trial, asked to recall the last word from each sentence

## Backwards Digit Recall Task (verbal working memory)

- Recall a sequence of digits in reverse order

## Odd-one-out Task (visuo-spatial working memory)

- Indicate an odd shape (3 images per trial)

## Spatial Span Task (visuo-spatial working memory)

- Indicate whether each shape was “normal” or a “mirror image” of an original shape that remains on one side of the screen

# Methods

- Participants

- 51 children from England (mean age: 11 years and 9 months)
  - 27 boys, 24 girls

- Procedure

- 6 executive tasks and 4 working memory tasks were given to all participants in the same order to avoid different carry-over effect and other external influence
  - Separated into 3 sessions
- School provided the participants' attainment scores on national curriculum tests in English, math, and science

# Results

- Principal Components Analysis (PCA) (factor loadings > .45 not used)

**Table 3.** *Factor loading scores from principal component analysis of executive measures*

	<i>Factor 1</i>	<i>Factor 2</i>
Plus minus task	.32	<b>.48</b>
Local global task	<b>.65</b>	.19
Letter memory	<b>.78</b>	-.01
Keep track task	<b>.77</b>	.12
Stroop task	-.15	<b>.86</b>
Stop signal task	.16	<b>.79</b>

*Note:* Values in bold are in excess of .45.

Due to both shifting tasks exceeding the value of .45 in Factor 1, data for those tasks were not used for further analysis.



# Results

- Principal Components Analysis (PCA) (factor loadings > .45 not used)
  - Excluding both shifting tasks and including the 4 working memory tasks

**Table 4.** *Factor loading scores from principal component analysis of executive tasks and working memory measures*

	<i>Factor 1</i>	<i>Factor 2</i>
Letter memory	<b>−.82</b>	−.07
Keep track task	<b>−.70</b>	.18
Stroop task	.06	<b>.81</b>
Stop signal task	−.11	<b>.85</b>
Listening recall	<b>.71</b>	.08
Backwards digit recall	<b>.71</b>	.07
Odd-one-out task	<b>.83</b>	−.15
Spatial span	<b>.68</b>	−.41

Clear split suggests that updating abilities are closely linked to performance on both verbal and visuo-spatial working memory tasks.

*Note:* Values in bold are in excess of .45.

# Results

- Partial Correlation Coefficients

**Table 5.** *Partial correlation coefficients between executive functions, working memory, and scholastic attainment*

<i>Function partialled out</i>	<i>Executive function</i>		<i>Working memory domain</i>	
	<i>Working memory</i>	<i>Inhibition</i>	<i>Verbal</i>	<i>Visuo- spatial</i>
	<i>Inhibition<sup>a</sup></i>	<i>Working memory<sup>a</sup></i>	<i>Visuo- spatial<sup>a</sup></i>	<i>Verbal<sup>a</sup></i>
English	.62**	.31*	.33*	.42**
Mathematics	.45**	.36*	-.10	.50**
Science	.19	.34*	-.19	.35*

<sup>a</sup>Function partialled out.

\* $p < .05$ ; \*\* $p < .01$ .

Inhibition  $\Rightarrow$  English, Math, and Science (all  $p < .05$ )

Verbal Working Memory  $\Rightarrow$  English ( $p < .05$ )

Visuo-Spatial Working Memory  $\Rightarrow$  English, Math  
(both  $p < .01$ ), and Science ( $p < .05$ )

# Discussion/Conclusion

Goal #1: Investigate the extent to which executive functions (shifting, updating, and inhibition) are unitary or separable in children.

- Updating and inhibiting are unrelated
  - Supports past research that inhibition is dissociable from other executive functions
- Failed to identify shifting as a third executive function
  - Different from a study done with a sample of adults (Miyake et al. 2000)
    - Suggests less mental flexibility in young children

# Discussion/Conclusion

Goal #2: Investigate the executive functions' underlying performance on working memory span tasks.

- Both verbal and visuo-spatial working memory share a common association with updating skills but not with inhibitory processes
  - Worthy to note that all of the working memory tasks were non-verbal while most of the updating tasks were verbal
    - Possible direction for future study:
      - Investigate additional domain-specific components that can explain the relationship between working memory and updating functions.

# Discussion/Conclusion

Goal #3: Assess the extent to which executive functions contribute to children's learning achievements.

- Inhibition related to attainment in English, math, and science
  - Result consistent with previous research findings
- Beneficial to help structure educational settings for young children
  - Various activities used in classrooms require simultaneous process and storage of information as well as executive functions
  - Reduce learning activities that overload working memory to enhance learning for children with a poor working memory function

**Thank you for listening!**