Institute of Education

IMPLICIT SEQUENCE LEARNING AND VERBAL REHEARSAL SKILLS IN HEARING AND COCHLEAR IMPLANTED CHILDREN

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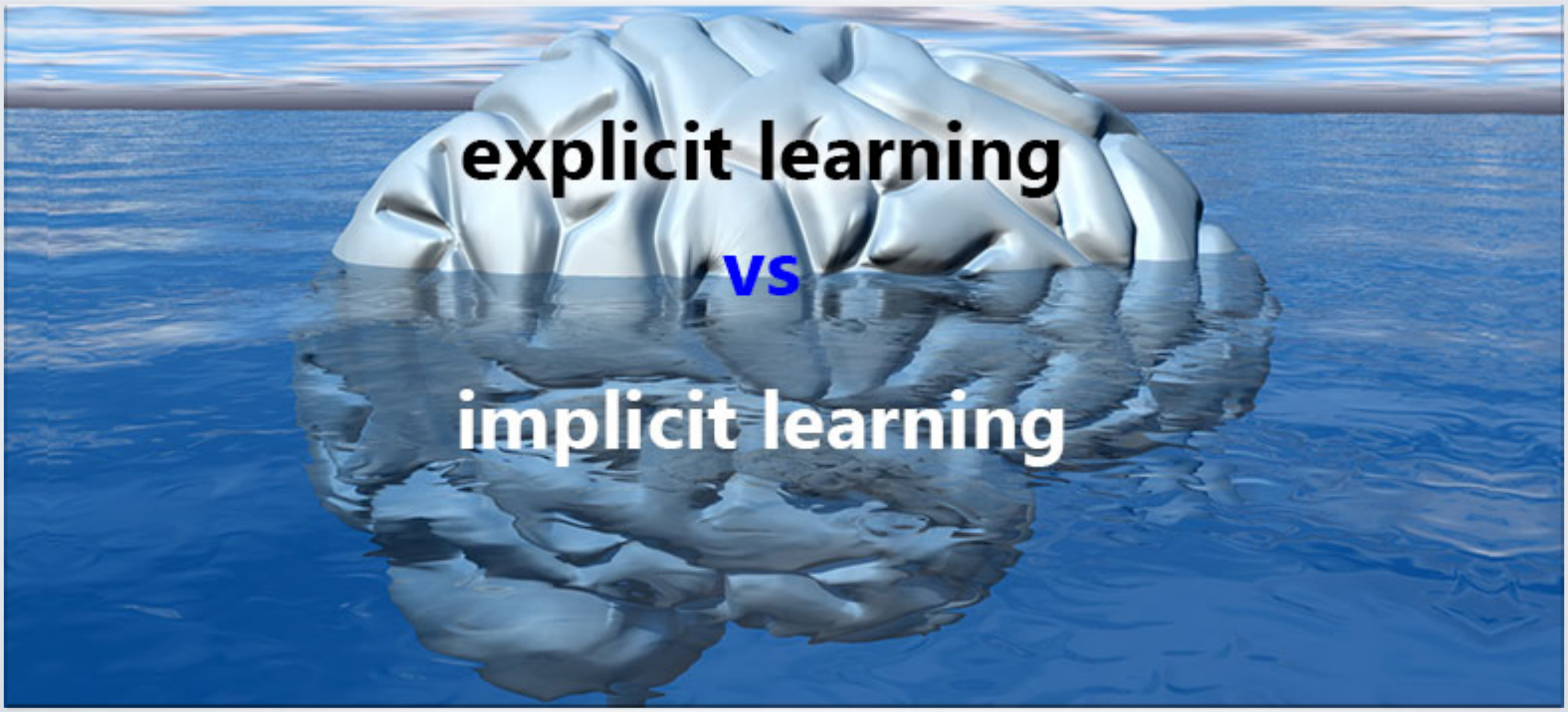
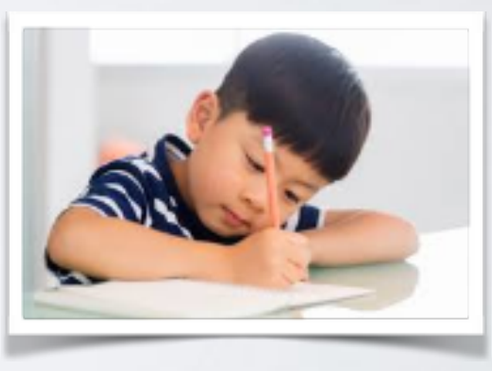
IMPLICIT SEQUENCE LEARNING IS..

The ability to learn implicitly, i.e. without awareness, regularities underlying temporal sequences of stimuli.



IMPLICIT SEQUENCE LEARNING…

A domain-general (?), and automatic learning mechanism used to extract and process regularities in different domains and modalities (Conway et al., 2011).



Language Development in Children

- A non-intentional mechanism, independent of verbal coding (Saffran et al., 1996)

- A fundamental process for cognitive and language development (Conway et al., 2010).

EVIDENCE OF IMPLICIT SEQUENCE LEARNING DEFICITS:

- In children with dyslexia (e.g. Pavlidou & Williams, 2014; van Witteloostuijna et al., 2017)

- Children with language impairment (e.g. Hsu & Bishop, 2014)

- Children with auditory impairment (e.g. Conway et al., 2009)

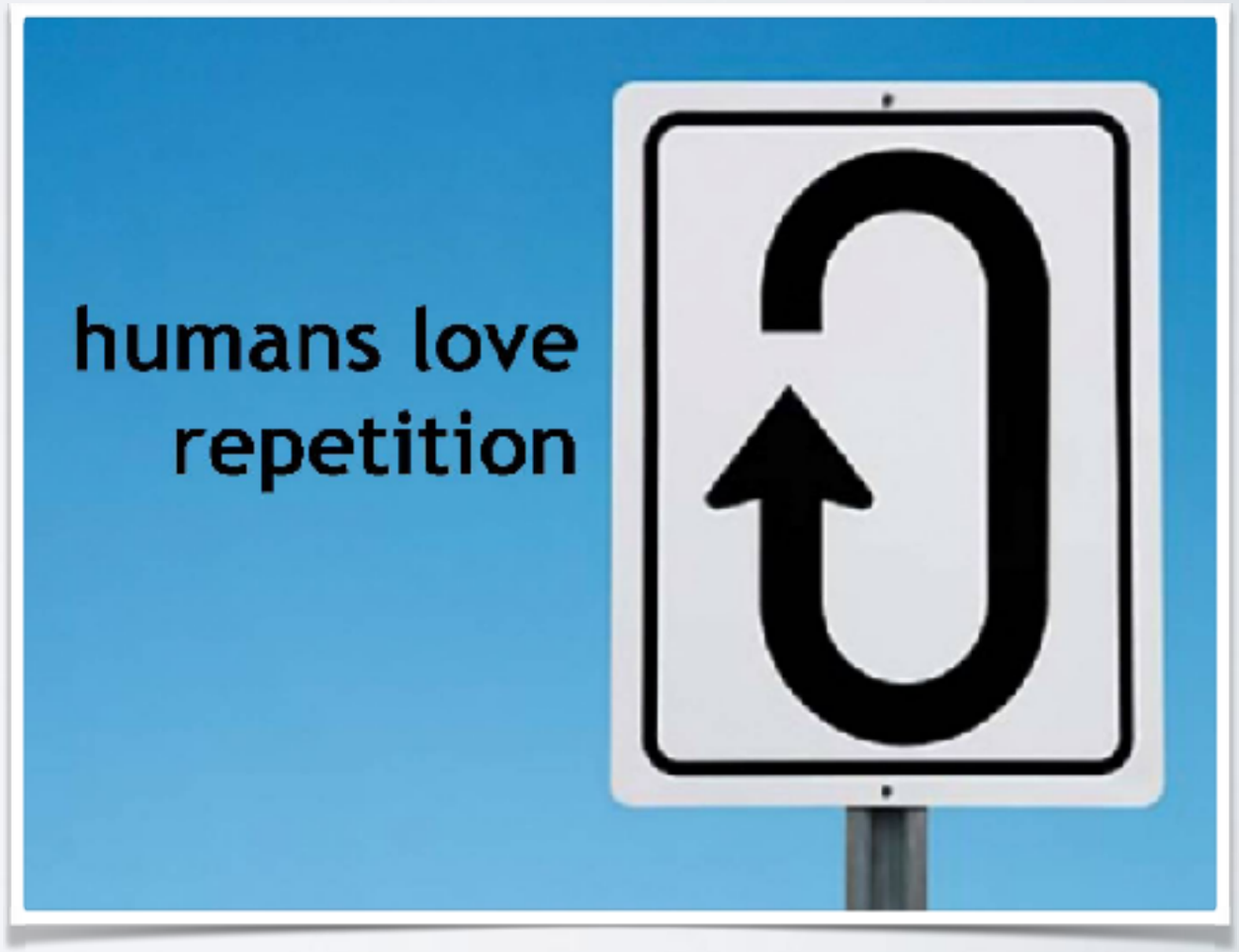
HOWEVER

- Few controlled replication studies exist
- A publication bias seems to exist
- Emerging findings that are not always consistent with the ISL deficit HP (e.g. von Koss Torkildsen et al., 2017)

THE ROLE OF EXPLICIT MEMORY STRATEGIES

- The role of explicit memory strategies in language acquisition (verbal rehearsal) is also recognized (Baddeley et al., 1998)

- BUT, the developmental relationship between the two mechanisms is still debated.



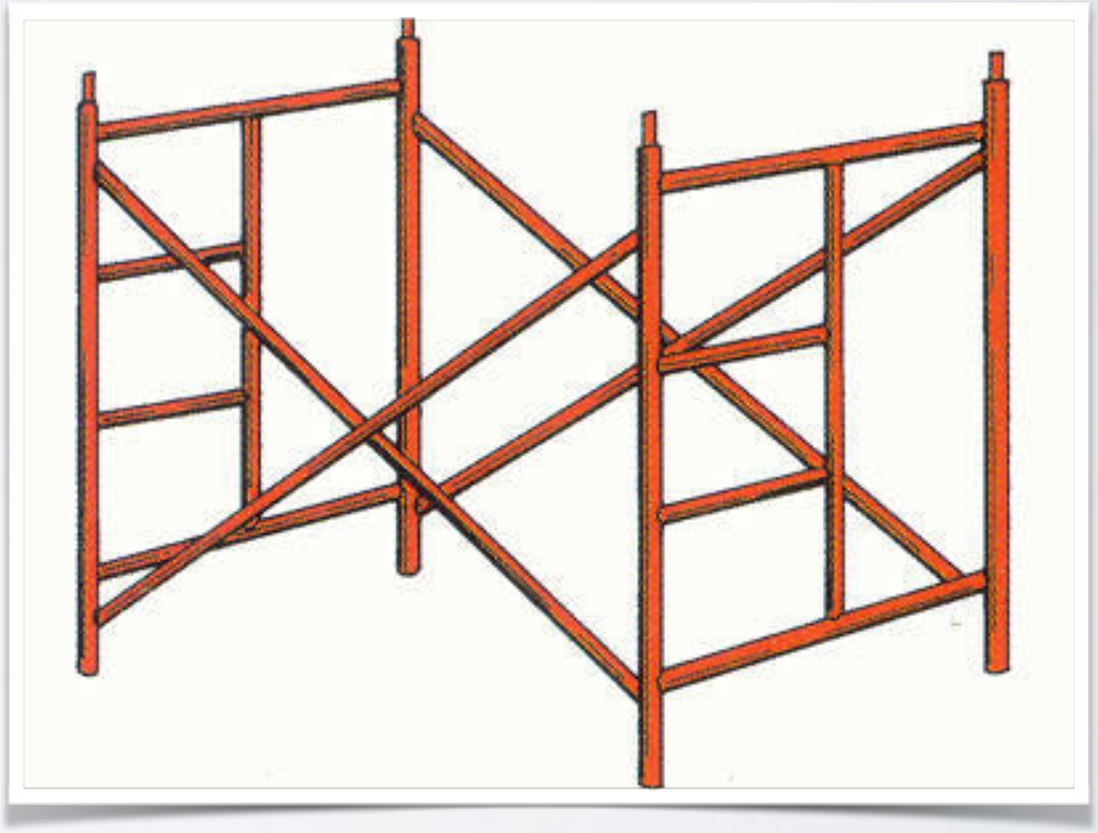
THE RATIONALE

- Its nature is not yet fully understood
- The relationship between SL and explicit memory strategies involved in language acquisition (verbal rehearsal) needs to be explored (e.g. Andrade & Baddeley, 2011)
- And… it is unclear whether implicit SL develops with age.

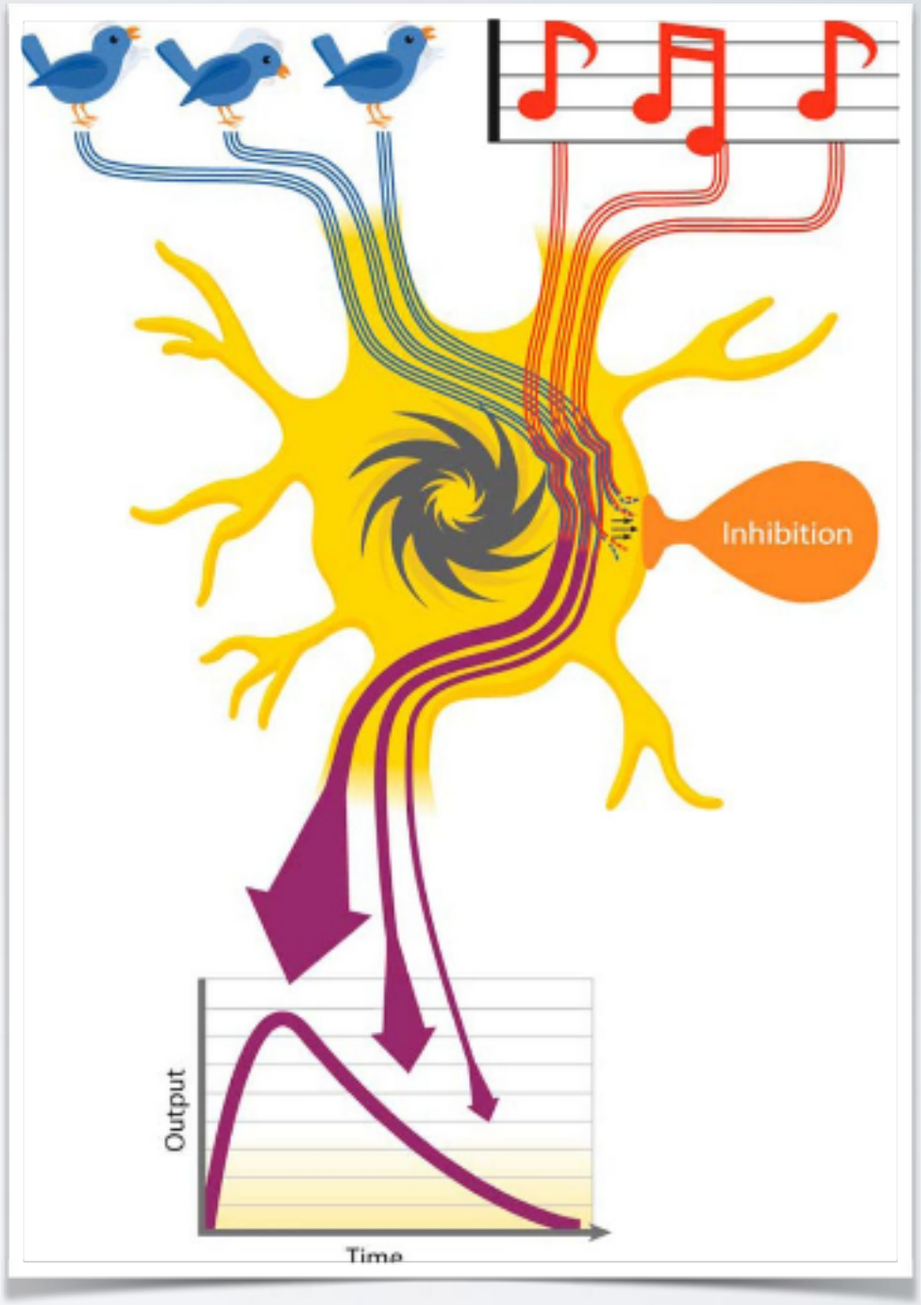
THE AUDITORY-SCAFFOLDING HYPOTHESIS (CONWAY ET AL., 2009)

- Sound is a temporal and sequential signal.
- For the perception of sounds time and serial order are of primary importance (Hirsh, 1967)

- **Thus experience of sounds provides a "scaffolding" for human cognition** and helps individuals to develop general cognitive abilities related to encoding and processing of temporal or sequential patterns (Conway et al., 2009).



SENSORY PROCESSING HAS EFFECTS ON HIGHER ORDER COGNITIVE PROCESSES



TWO LINES OF EVIDENCE..

1. **Modality-specific effects** observed when hearing individuals process sequential or serial order information:

   - **auditory superiority effect** in tasks involving memory of order and timing (e.g. Collier & Logan, 2000)

   - **auditory superiority effect** with implicit sequential learning (Conway & Christiansen, 2005)

TWO LINES OF EVIDENCE..

2. **Non-auditory sequence learning** abilities in children who are congenitally deaf

- Children with CIs (5-10 years old) show greater difficulties in motor sequencing tasks (e.g. finger tapping) compared to their hearing peers, (Conway et al., 2009a).

- In visual sequence learning tasks, normally hearing children outperform deaf children (Conway et al., 2009b)

TWO HYPOTHESES ARE FORMULATED:

HP1: Children with CIs have greater difficulties in encoding and learning sequential patterns

HP2: deficits in Implicit SL contribute to problems in learning the grammatical patterns of verbal language

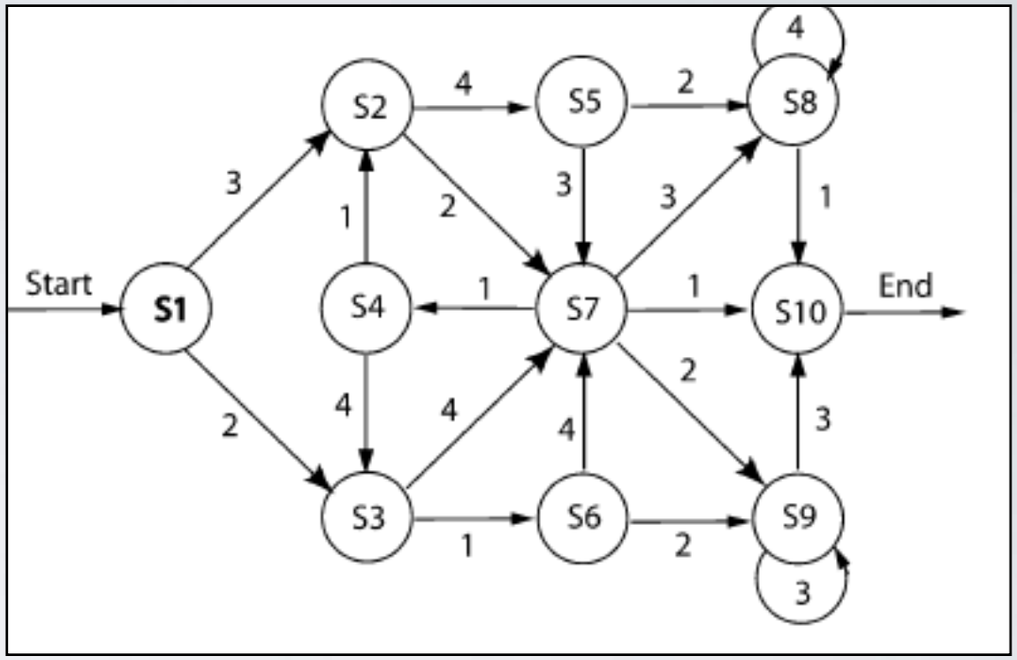
CONWAY ET AL. (2011)

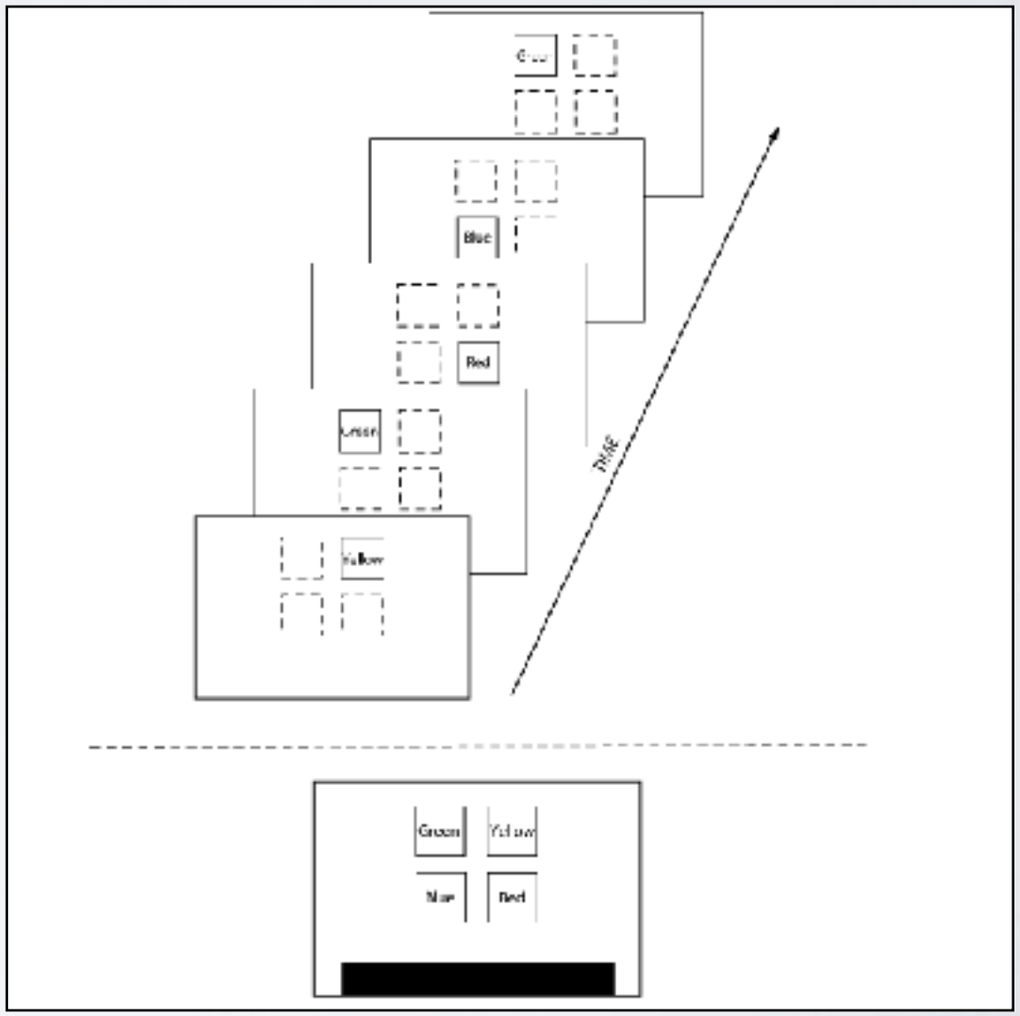
- 23 children with CIs aged 5 to 10 years and 26 NH controls

- **Artificial grammar task**

- Visual sequences were generated through two artificial grammars (A: trained; B: not trained)

- Children were asked to repeat the sequences by touching a screen.



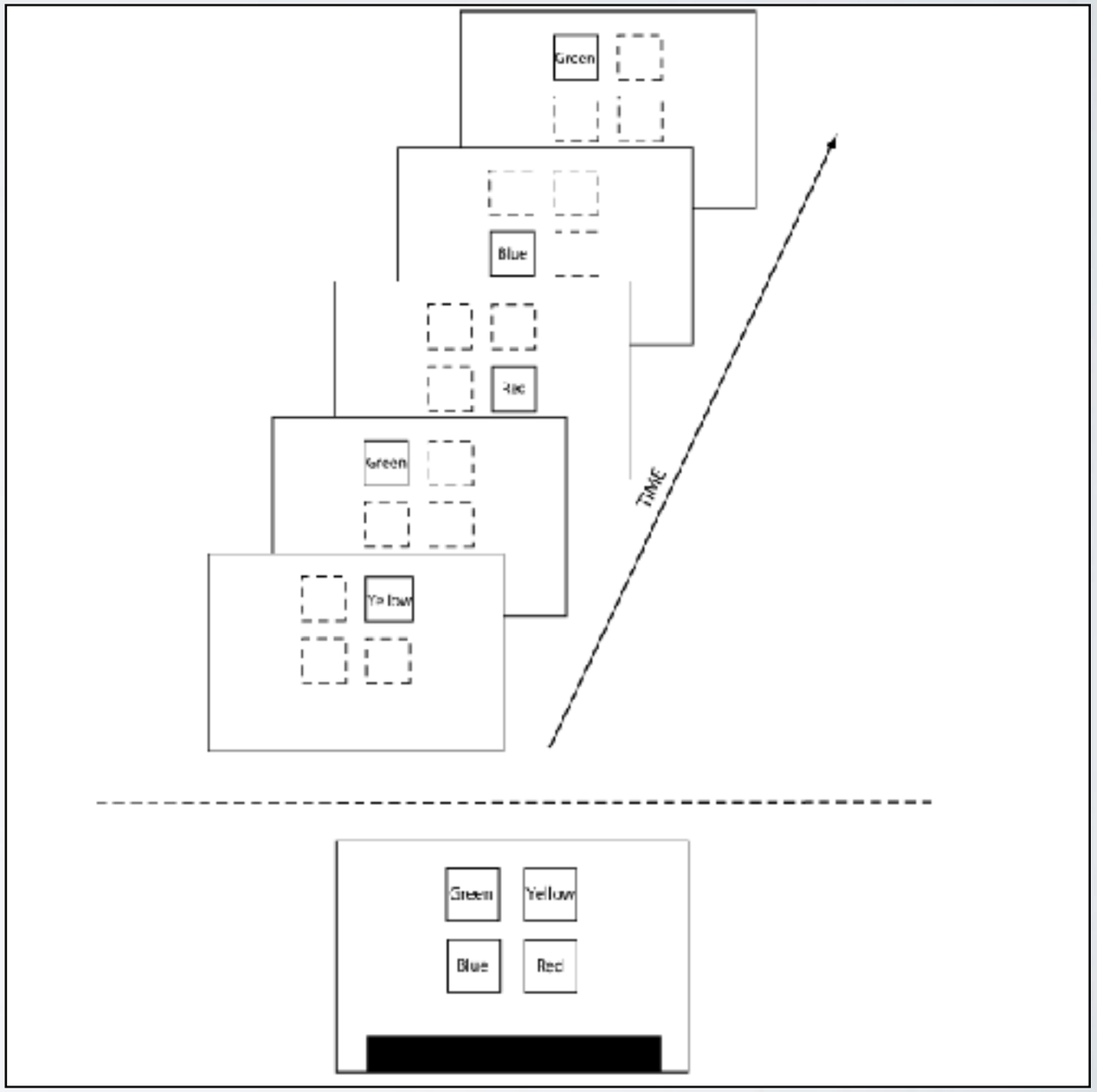


CONWAY ET AL. (2011)

Learning phase:
recalling sequences generated by grammar A (—> immediate memory)

Test phase:
recalling <u>new</u> sequences generated by grammar A or grammar B

Better recall of new sequences generated by grammar A (trained) vs. grammar B (untrained) —> evidence of implicit SL.



CONWAY ET AL. (2011)

Simon task: sequence learning task

Forward and backward digit span

PPVT-3rd edition

+

CELF-4: formulated sentences, recalling sentences, etc.

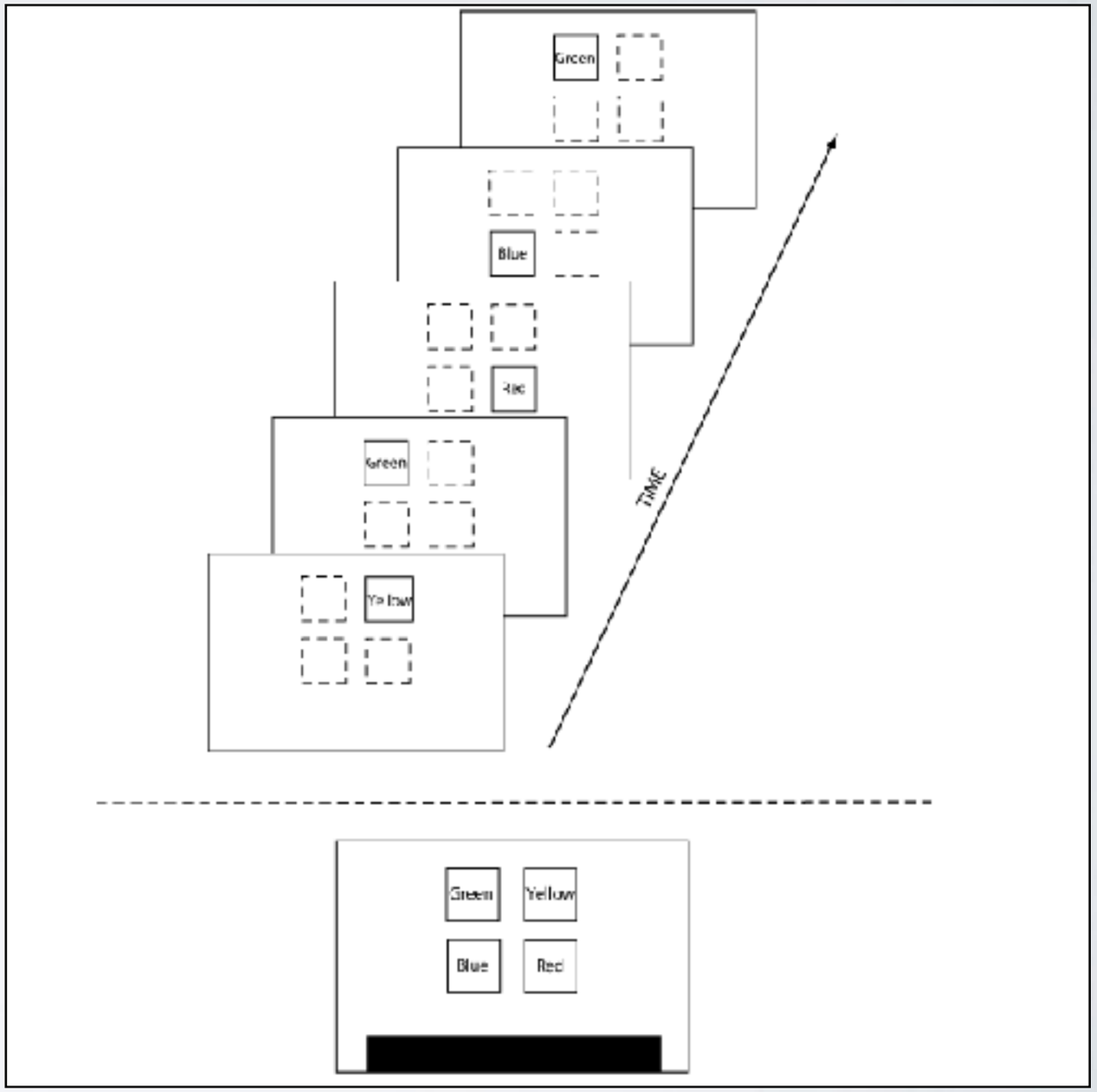
Nonverbal: Visuo-spatial memory task

CONWAY ET AL. (2011): RESULTS

Learning phase:
No differences between the two groups in the ability to immediately recall and reproduce visual sequences

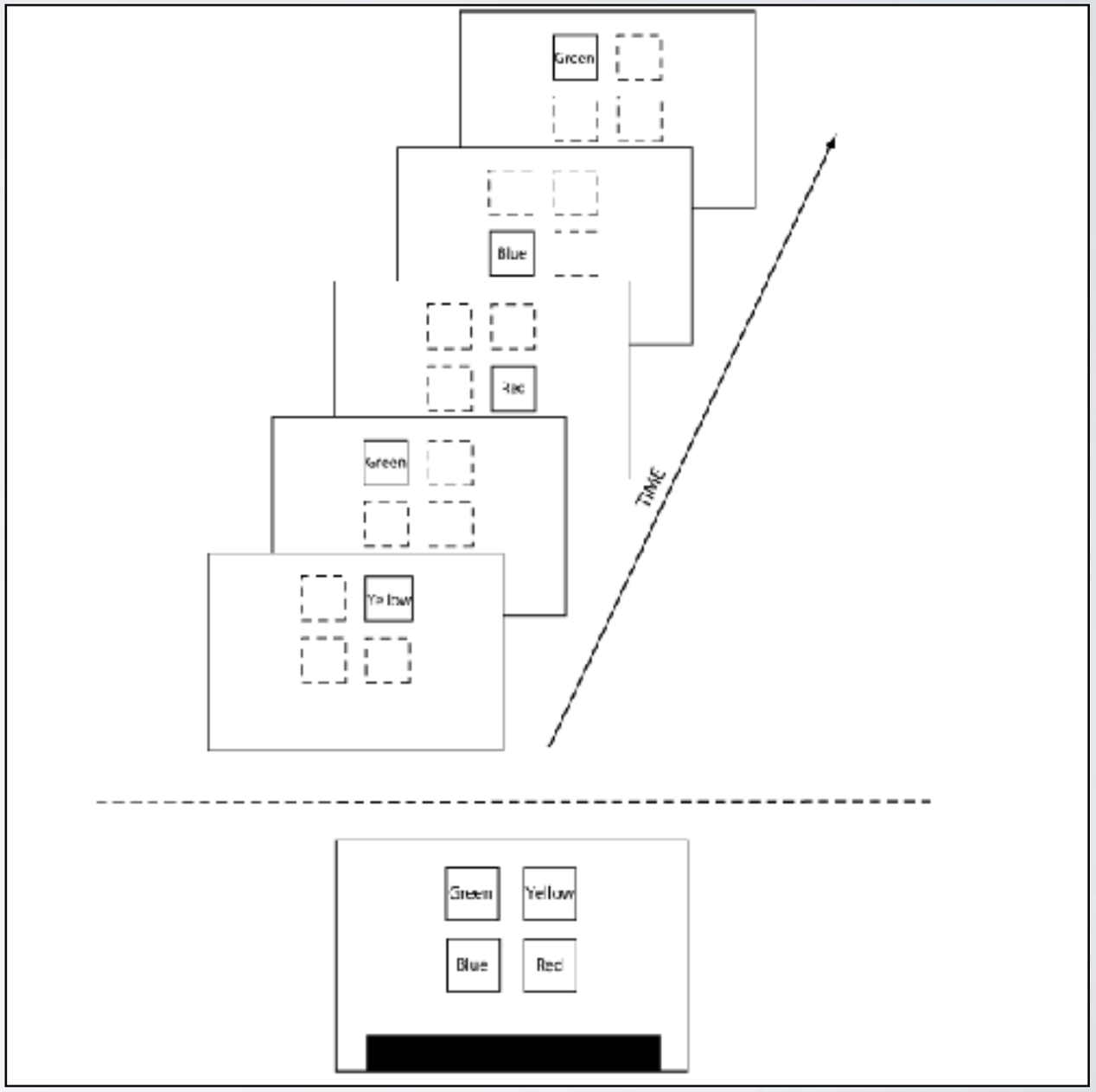
Test phase:
The NH group showed an implicit learning effect (ISL: Grammar A>Grammar B), the CIs group did not show any Implicit learning effects

ISL correlated with language scores (CELF-4)



METHODOLOGICAL ISSUES..

- Colors can be named and rehearsal processes can be used
- Children were trained to name colors before tests
- Selection criteria: no Information about additional disabilities



TWO STUDIES

- Explored the relationship between implicit SL skills and verbal rehearsal skills in hearing children (**Study 1**)

- and children with cochlear implants (CIs) (**Study 2**)

- and, examined changes in implicit SL with age.

THE HYPOTHESES

- SL may not be driven by a single cognitive process, but rely on two distinct mechanisms:

1. implicit, active since an early age

2. explicit, dependent on individual attentional resources (i.e. rehearsal)

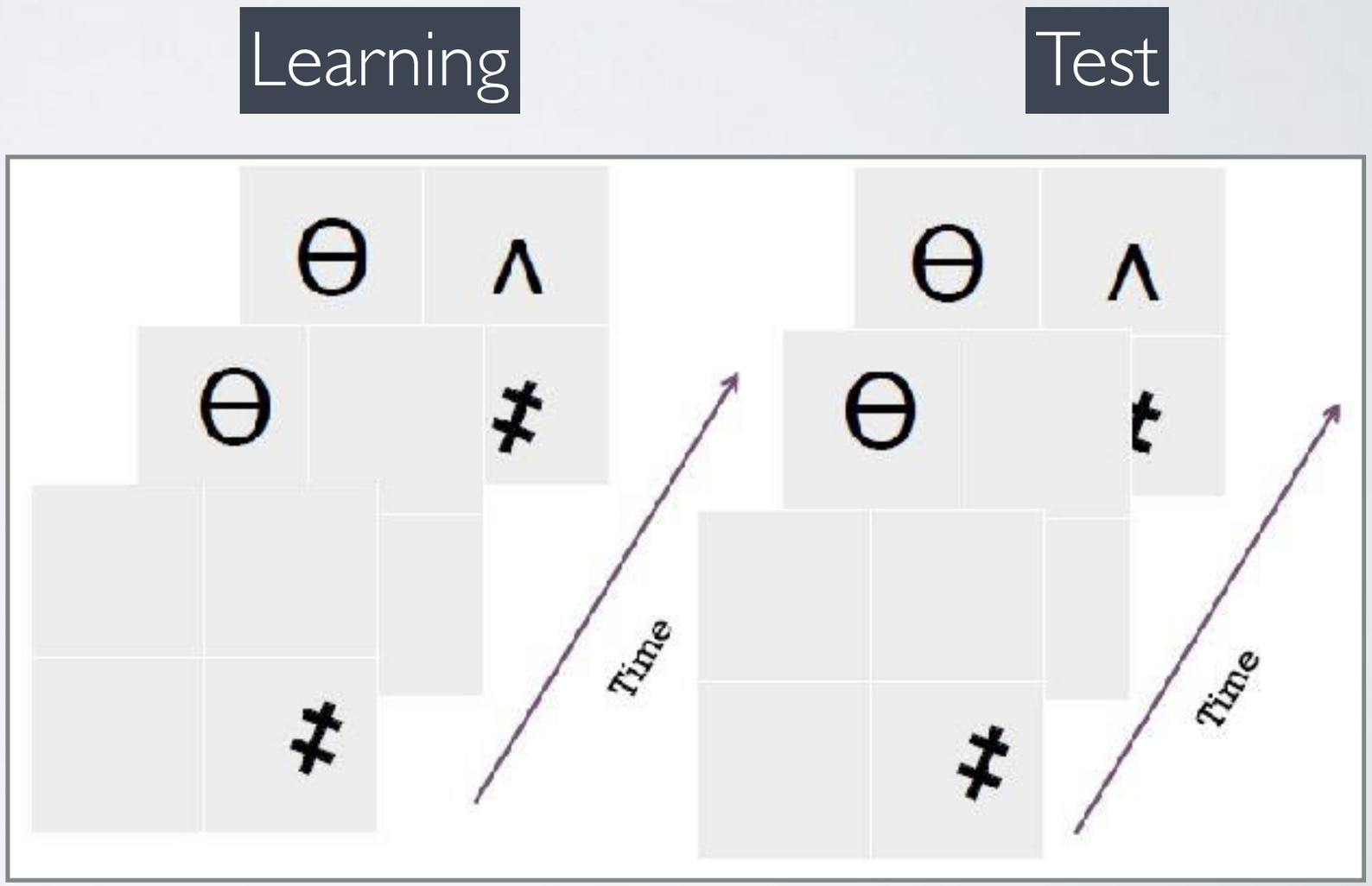
- When explicit mechanisms are more efficient, ISL is masked (or replaced —> RR mechanism)

OUR STUDIES

An adapted version the Implicit SL task (Arfé & Mulatti)

Association with oral and written language

Correlation with DS



OUR STUDIES

SL task

Digit span

Visuo-spatial memory task

PPVT-3rd edition

TROG

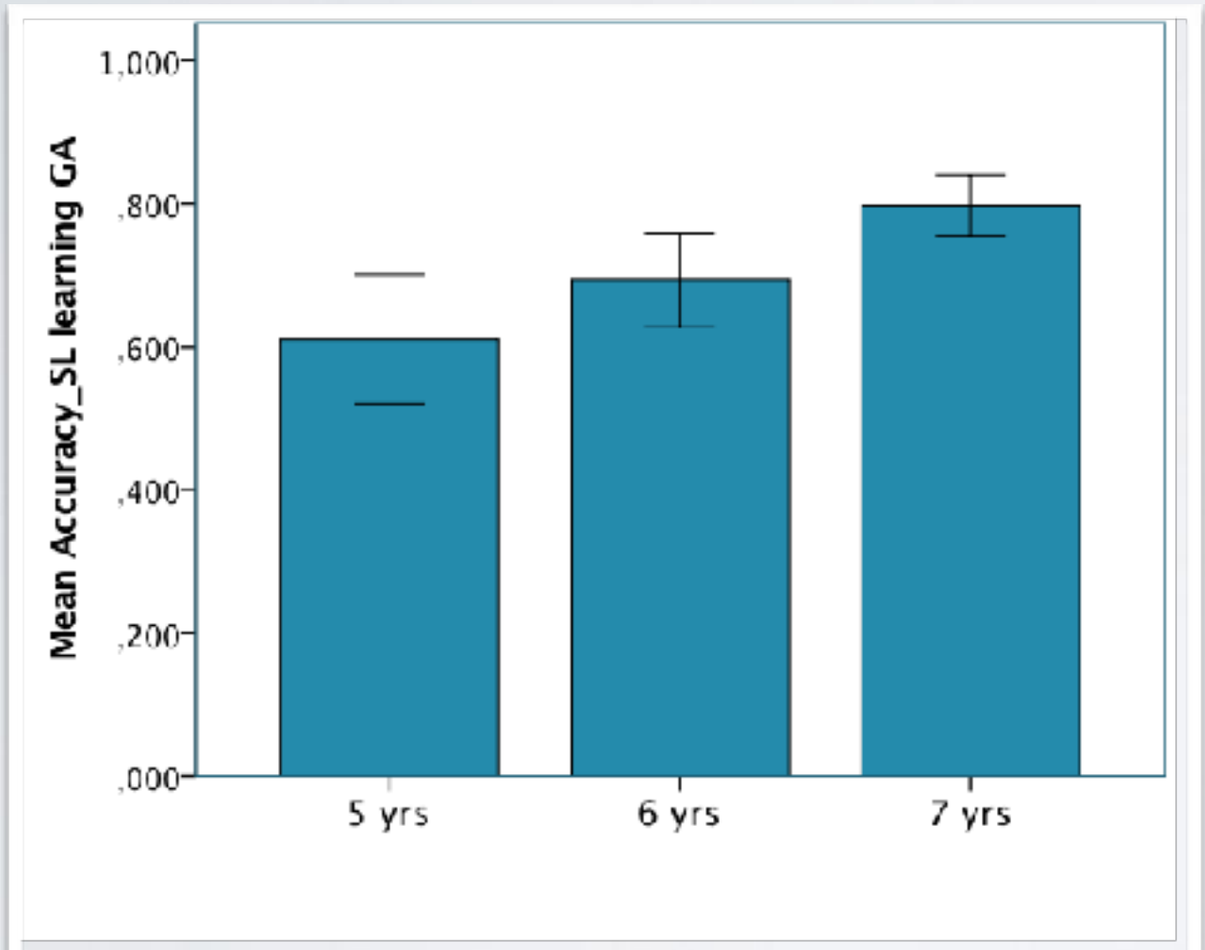
Non-verbal: RAVEN

STUDY 1: GRAMMAR EFFECT

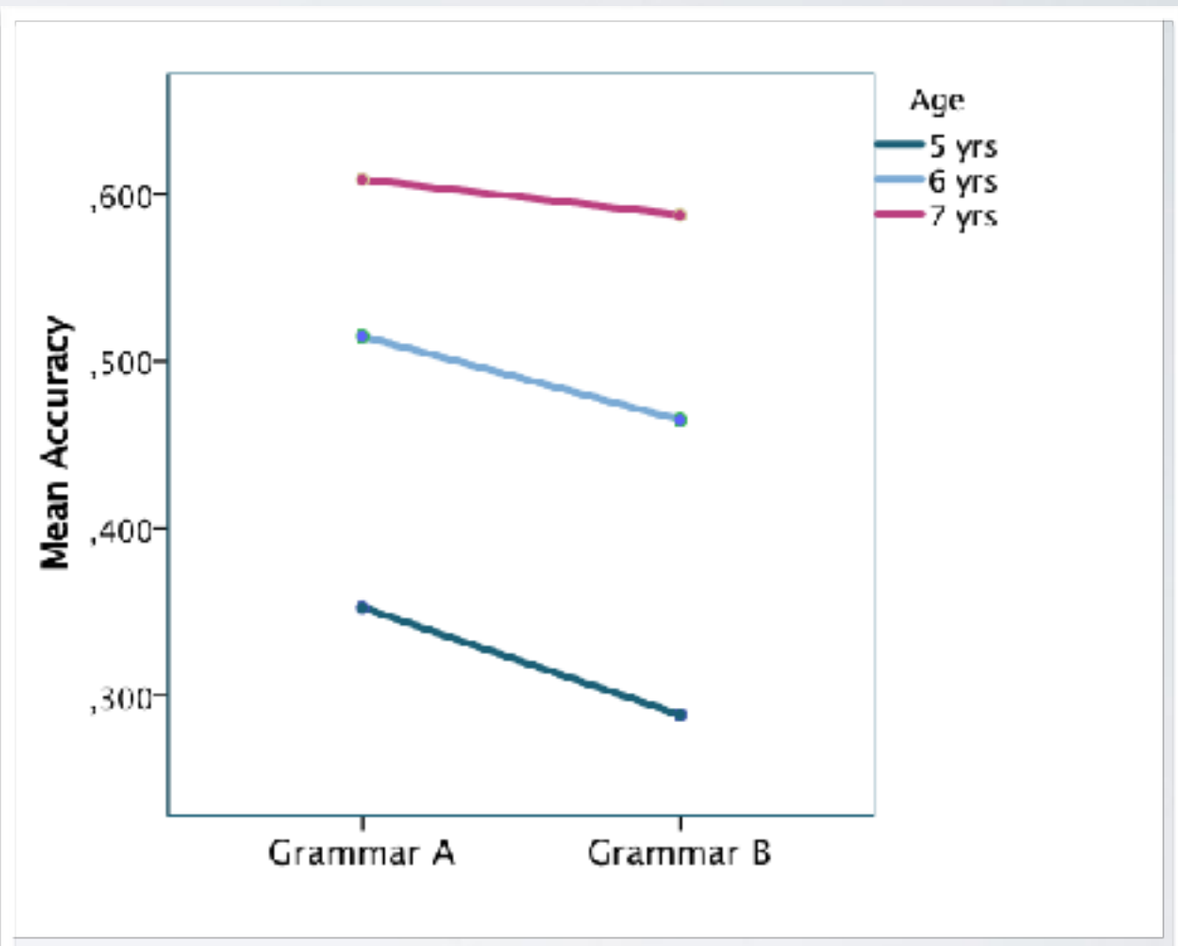
- Participants: 139 NH children

  - 35 (5 year-old; 16 girls)
  - 45 (6 year-old; 24 girls)
  - 59 (7 year-old; 29 girls)

IMPLICIT SL EFFECT



7year-olds outperform the other age groups



Only 7year-olds do not show SL effects

CORRELATIONAL ANALYSES

- **Partial correlations controlling for age**: Immediate recall shows significant positive correlations with visuospatial memory ($r=.340$, $p<.01$) and negative correlations with the SL effect ($r=-334$, $p<.01$)

- **Only for the 7-years-old the performance in GA e GB correlated positively with Digit Span**

- Implicit SL skills did not account for unique variance in language outcomes

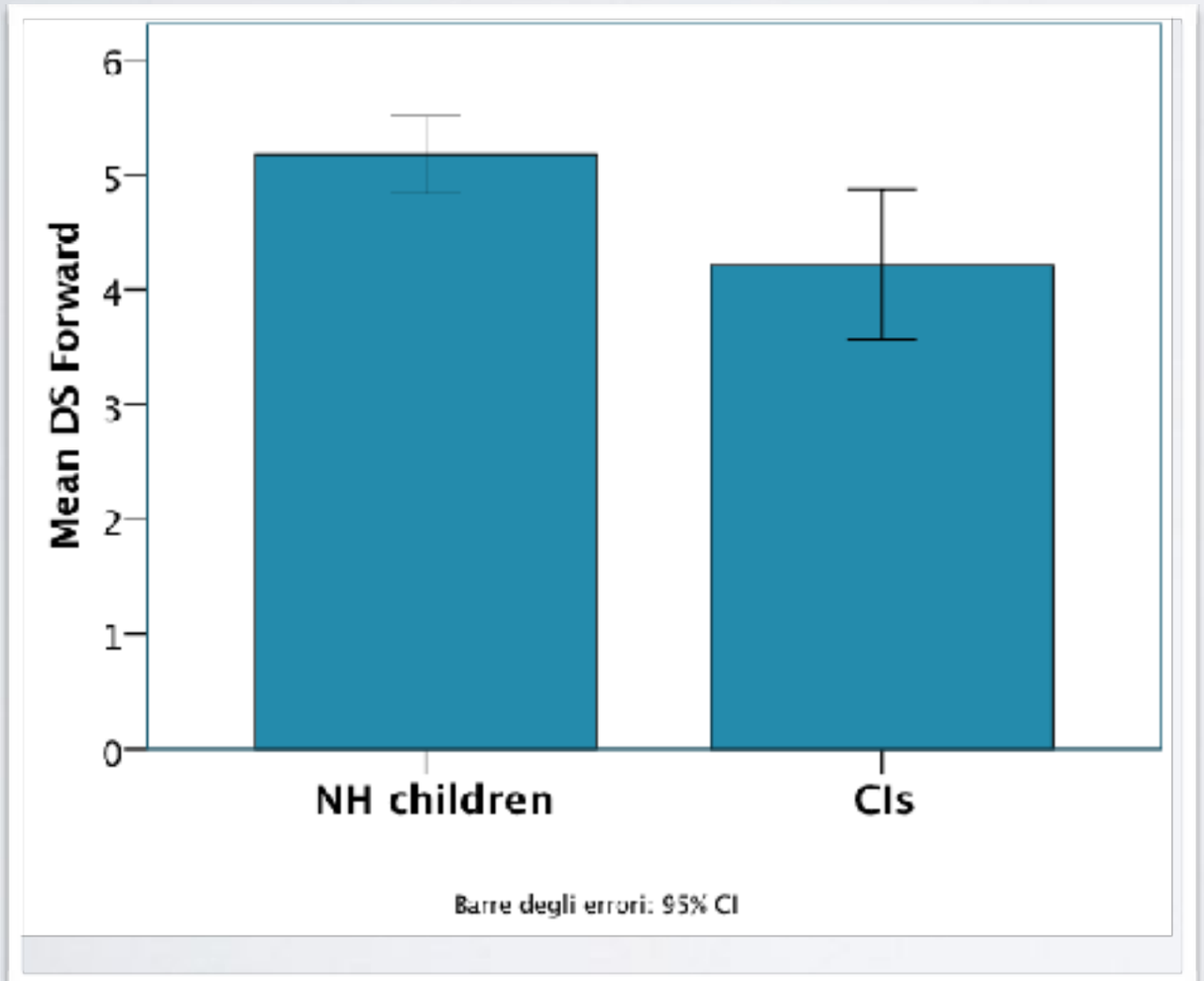
- Only verbal rehearsal skills accounted for variance in language outcomes.

STUDY II

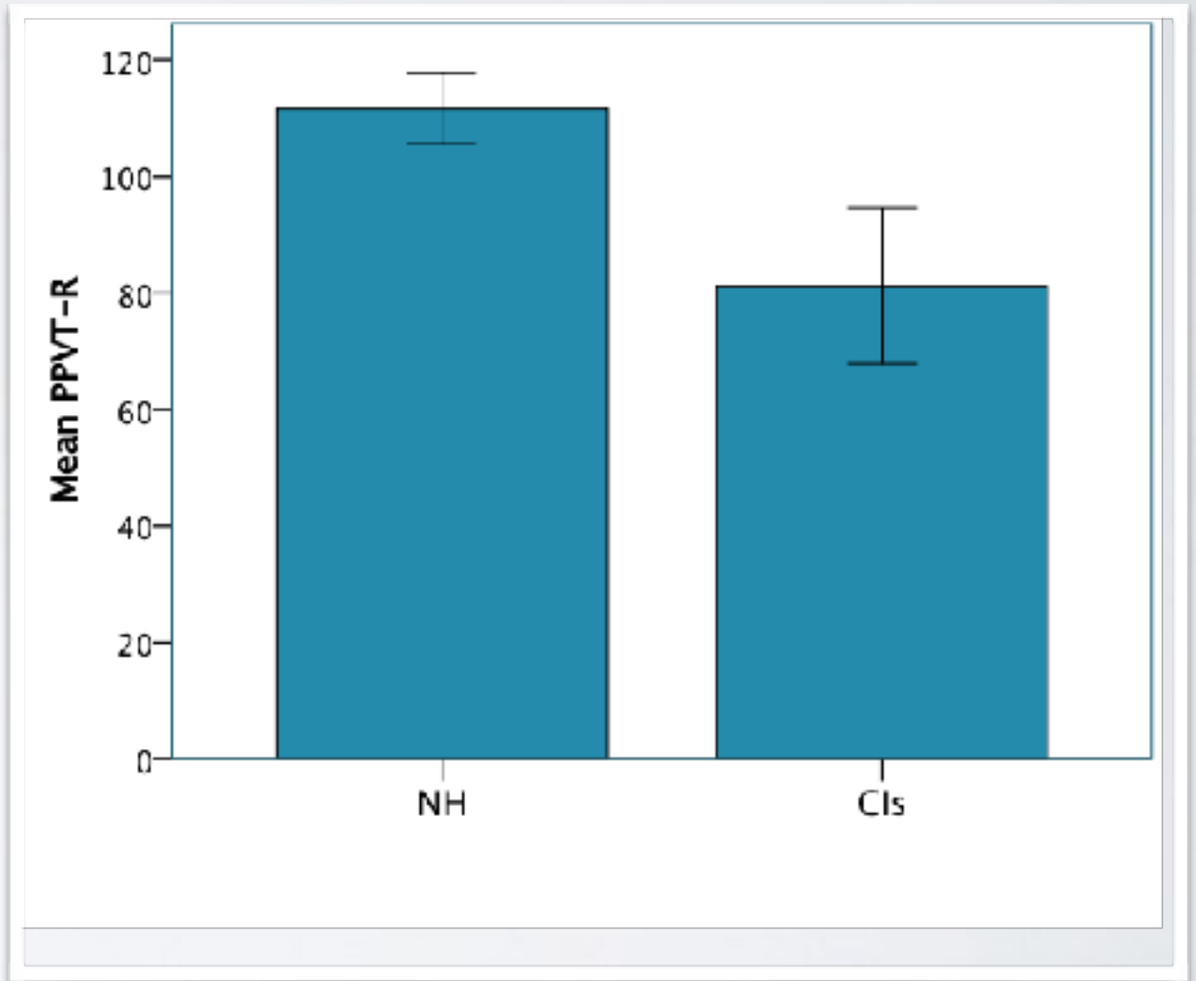
131 children aged 5-11 years old:

- 102 hearing children (M age= 7;7; 46 girls)
- 29 children with CIs (M age=8;4; 15 girls)

VERBAL ABILITIES

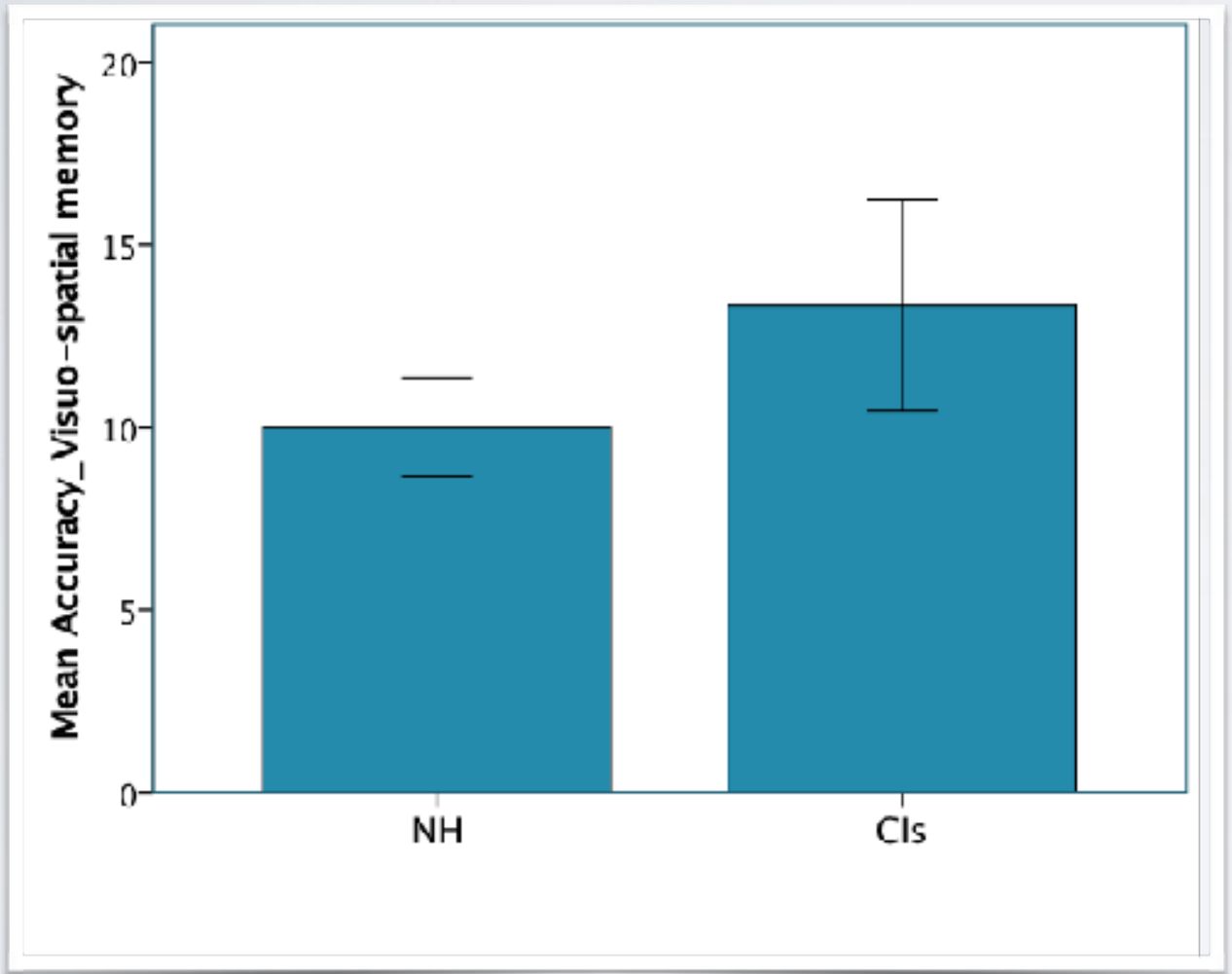


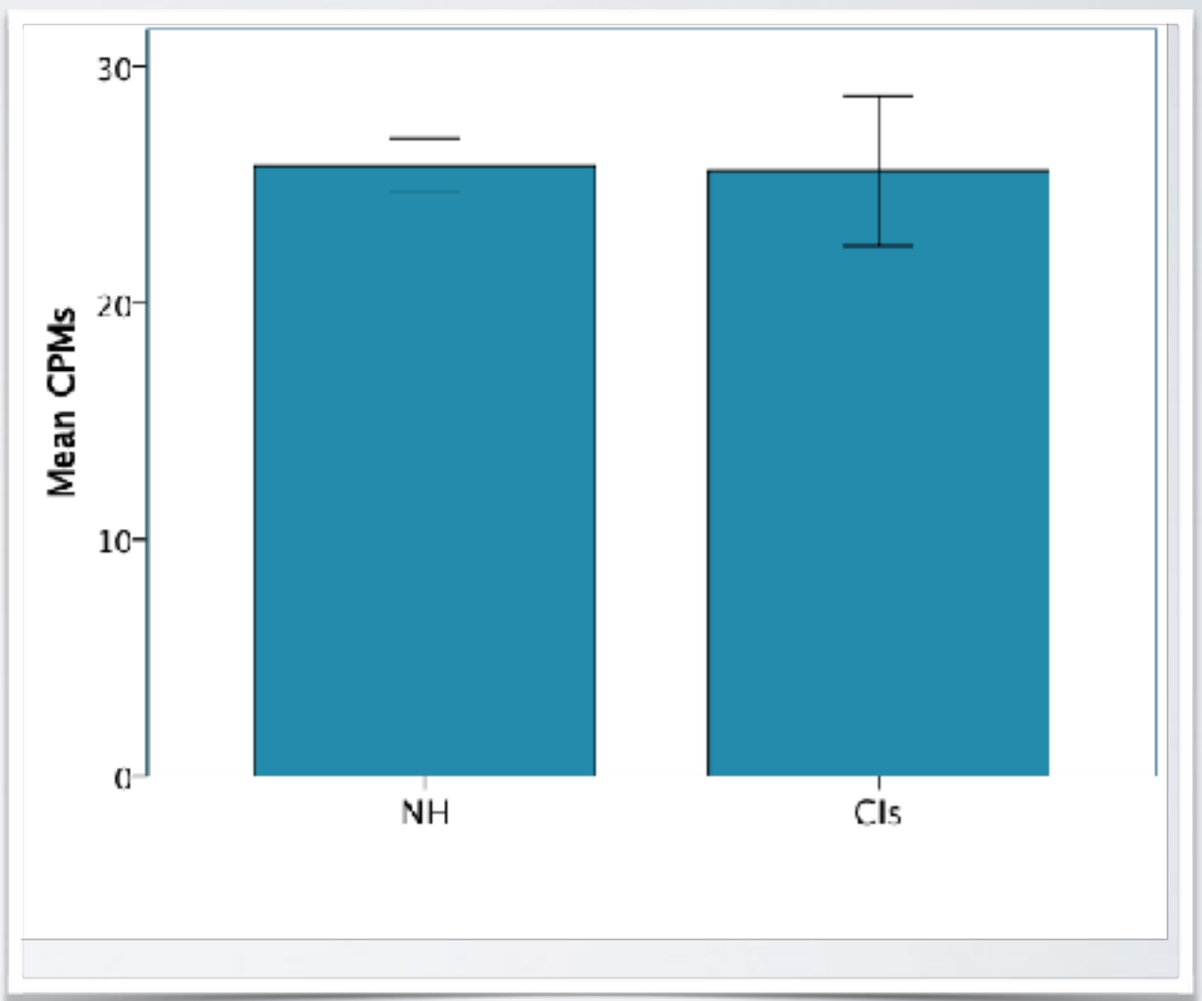
NH children > children with CIs



NH children > children with CIs

NON-VERBAL ABILITIES

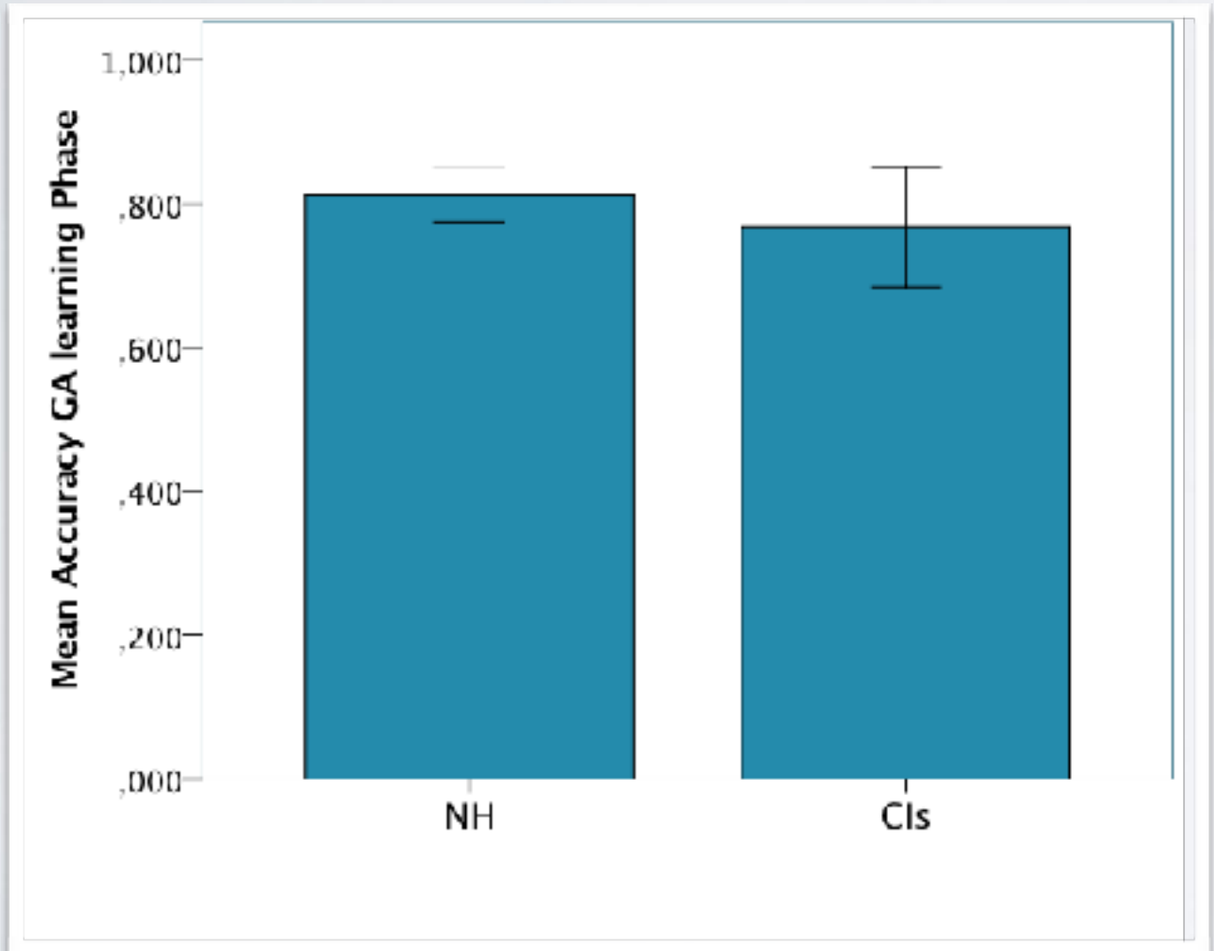




No differences between the two groups

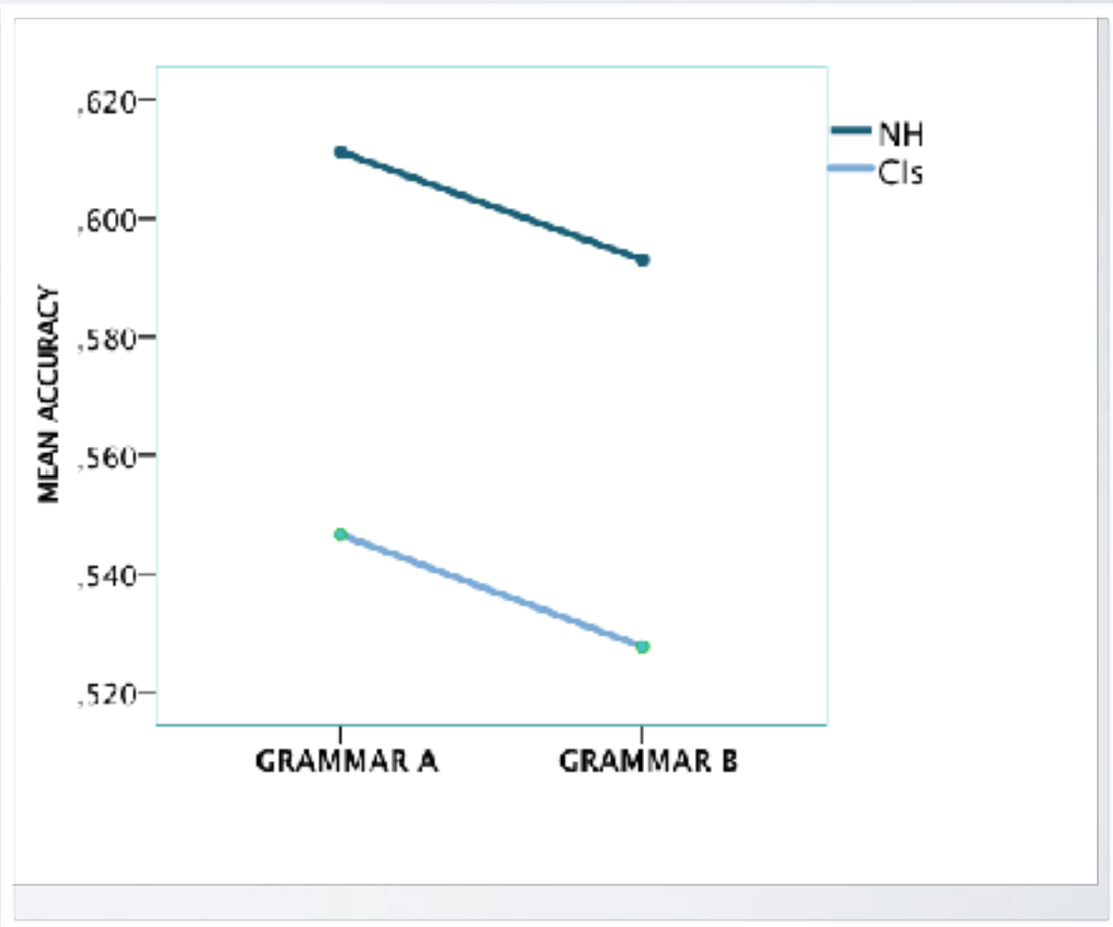
IMPLICIT SL SKILLS

Learning phase



NH children outperform children with CIs

Test phase



Both groups show a SL effects

CORRELATIONAL ANALYSES

- Implicit SL skills did not account for unique variance in language outcomes

- Only verbal rehearsal accounted for children's performance in verbal language tasks in hearing and deaf children.

- SL skills show negative correlations with visuospatial memory skills (but do not approach significance)

CONCLUSIONS

1. Children who experienced an early auditory deprivation show deficits in:

    - immediate sequence recall;
    - verbal rehearsal;
    - not in implicit non-verbal SL

2. Explicit memory processes (verbal rehearsal), not ISL are associated with their language outcomes

CONCLUSIONS

- SL and verbal rehearsal seem independent mechanisms that both hearing and CI children use to process and maintain sequential information.

- Inefficient verbal rehearsal, not inefficient SL skills, explain the language deficits of children with CIs.

- Findings consistent with those of other recent studies using:

  -variants of implicit visual sequence learning tasks (von Koss Torkildsen et al., 2017)

  -different kinds of tasks: i.e. serial reaction time tasks (West et al., 2017)

- **Age effects —> HP: As soon as children start to use explicit memory strategies, implicit SL seems abandoned (RR HPs).**

FUTURE STEPS

- Exploring implicit SL in deaf children by means of other tasks (e.g. serial reaction time tasks)
- Comparing performance in tasks allowing rehearsal or not
- Exploring the relationship between SL skills and EFs
- ……????

THANKS!

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