Implicit and Explicit Artificial Grammar Learning

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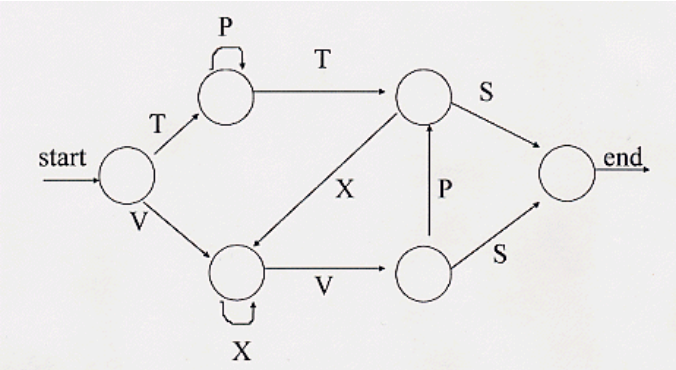
Implicit Learning

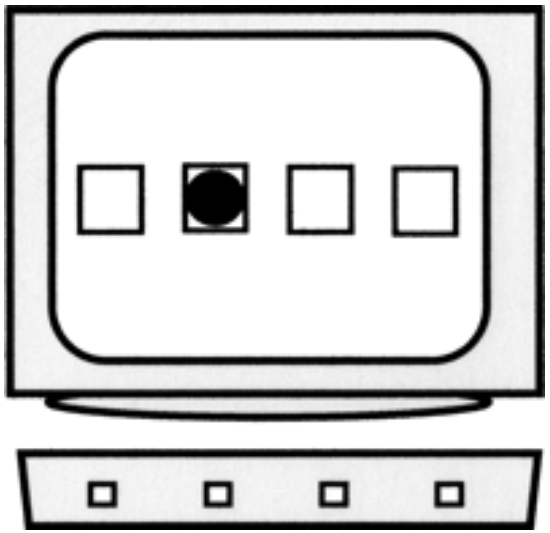
- Everyday phenomenon
- e.g. Learning first language, motor skills, procedural knowledge
- Constantly active process, does not require awareness
- Generates implicit knowledge
- Implicit Knowledge can beome explicit(Sun et al. 2001)

Testparadigms

- Artificial Grammar Learning



- Serial Reaction Time Task



- Process Control Task

Artificial Grammar Learning

- Learning Phase: Subjects learn strings, which are generated by a Finite-State Grammar
- Performance-Test: Subjects classify other strings, whether they are grammatical or not
- SLD-Test: Presentation of grammatical stems; Subjects try to predict, which letters can be added
- Free Report: Subjects report all rules that have been recognized

Serial Reaction Time Task

- Subjects are placed in front of a monitor
- When a stimulus appears, the subject presses the corresponding button
- As the subjects learn the sequence, in which stimuli appear, the Reaction Time improves

State of the Art

- First paper on AGL: Reber 1967
- Standard Paper on Implicit Learning: Dienes et al. 1991
- Influence of the instruction (implicit vs. explicit search): Contradictory evidence
- Influence of the presentation mode (Strings vs. 2D vs. 2D + Motor): Dual Coding Theory (Paivio 1971)

Design

- Learning phase: Presentation of strings
- Strings were generated from a grammar
- Participants received different instructions at the beginning of the learning phase

Instructions

- Instruction for implicit learning: experiment is a simple memory experiment
- Instruction for explicit learning: items were generated base of rules, which should be detected by the participants

Presentation Mode

- String Presentation
- 2D: Representation as boxes in a 2d grid
- 2D+Control: 2D+typing the items

Variables

- Dependent Variables
  - Classification-Performance: Stating if a item was generated based on the grammar
  - SLD Test: Stating if a shown letter is a valid continuation of a given stem
  - Free Report: Giving all detected rules and remembered items
- Independent Variables
  - Presentation Mode: String, 2D, 2D+Control
  - Instrcution Mode: implicit, explicit

Hypotheses regarding implicit and explicit learning

- Performance for explicit learning $\approx$ Performance for implicit learning: $P_I \approx P_E$
- SLD for explicit learning $\approx$ SLD for implicit learning: $SLD_E \approx SLD_I$
- Free Report for explicit learning $<$ Free Report for implicit learning: $FR_E < FR_I$

Hypotheses regarding String- and 2D-Presentation Mode

- Performance for strings $<$ Performance for 2D: $P_L < P_V$
- SLD for strings $\approx$ SLD for 2D: $SLD_L \approx SLD_V$
- Free Report for strings $>$ Free Report for 2D: $FR_L > FR_V$

Hypotheses regarding 2D- and 2D+Control-Presentation Mode

- Performance for 2D ? Performance for 2D+Control: $P_V ? P_P$
- SLD for 2D $<$ Performance for 2D+Control: $SLD_V < SLD_P$
- Free Report for 2D $<$ Free Report for 2D+Control: $FR_V < FR_P$

Material

- Strings and Items based on a regular grammar
- grammar was orientated on the original grammar form Dienes (1991)

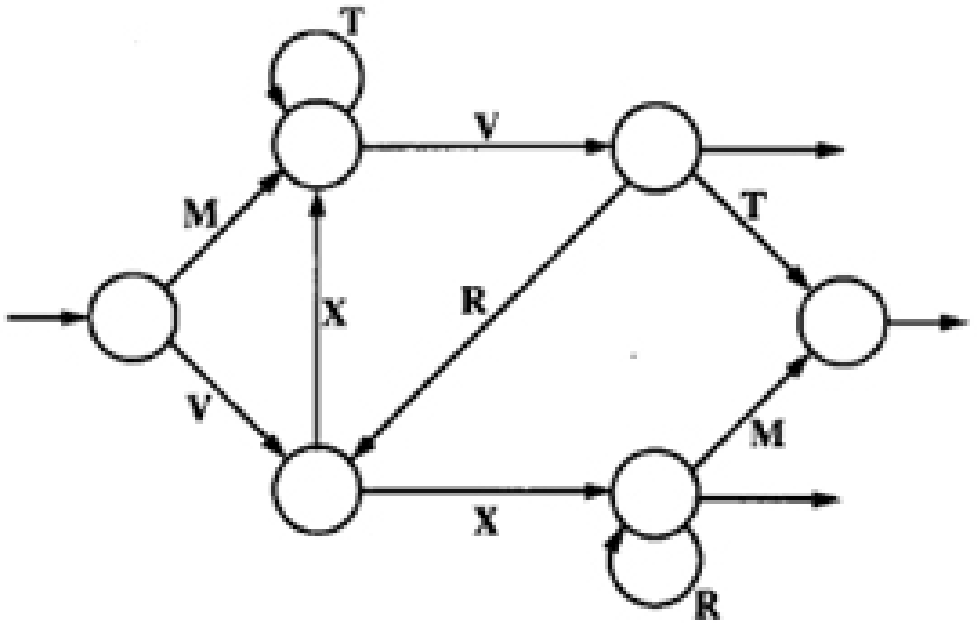


Figure: Automaton for the grammar used by Dienes

Material (cont'd)

$\Rightarrow$ for our project, an adaption of the grammar was necessary

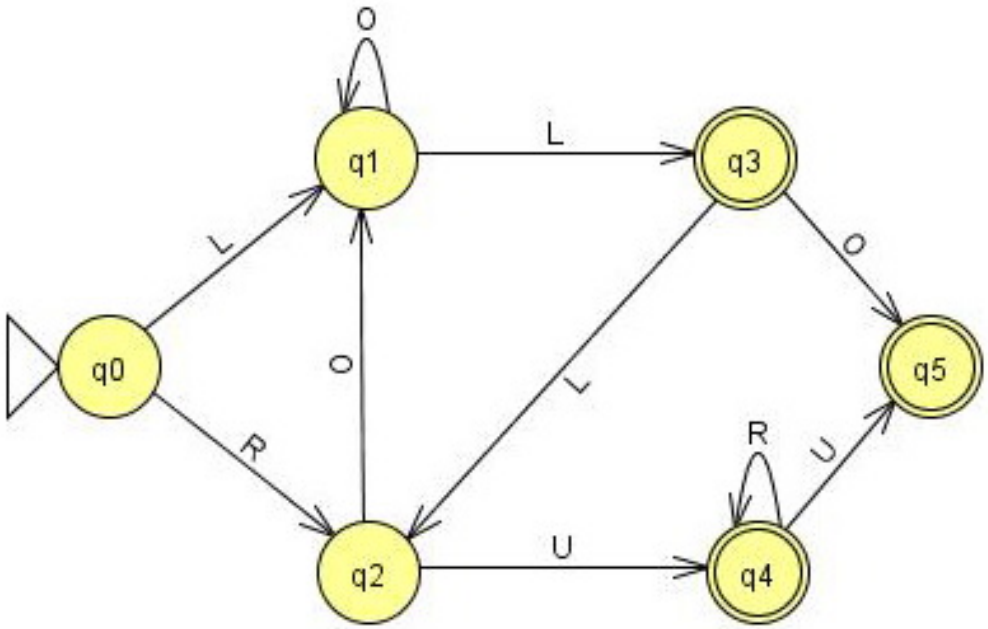


Figure: Automaton for the grammar used in our project

Material (cont'd)

Generation of

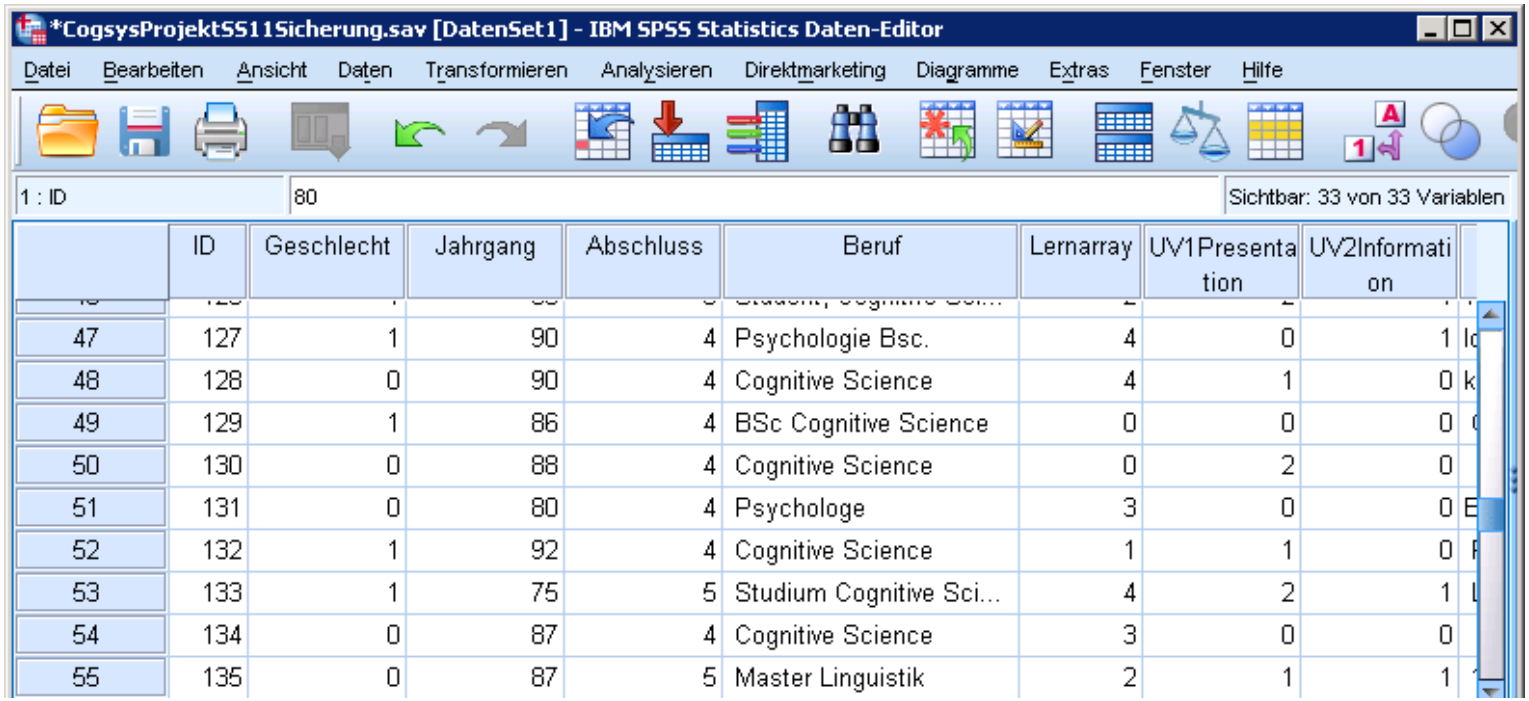
- 20 correct Items for Acquisition
- 25 correct Items for Testing
- 25 non-correct Items for Testing

of a length of 3 - 6 characters

- 36 stems

of a length of 0 - 5 characters

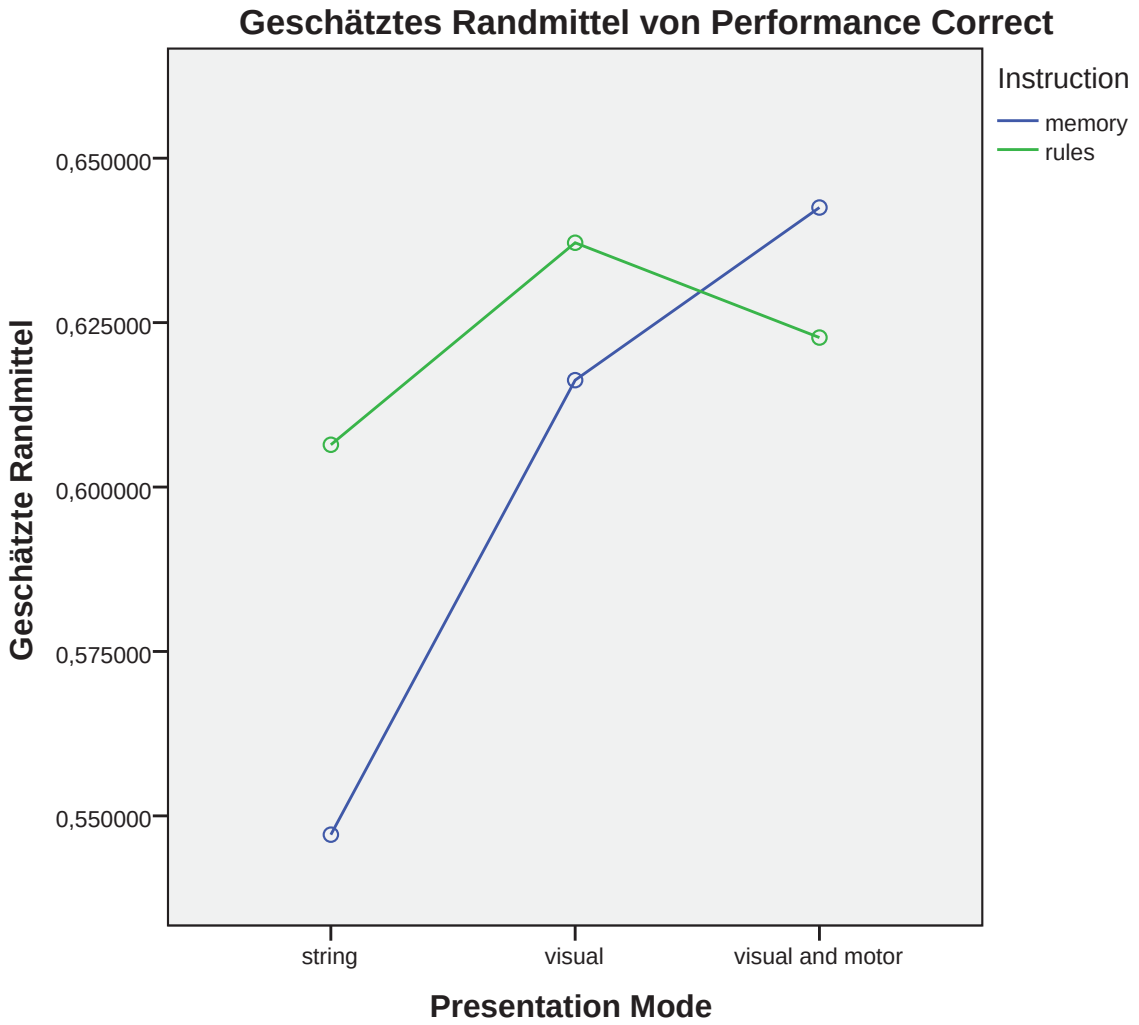
Analysis



	ID	Geschlecht	Jahrgang	Abschluss	Beruf	Lernarray	UV1Presentation	UV2Information
47	127	1	90	4	Psychologie Bsc.	4	0	1
48	128	0	90	4	Cognitive Science	4	1	0
49	129	1	86	4	BSc Cognitive Science	0	0	0
50	130	0	88	4	Cognitive Science	0	2	0
51	131	0	80	4	Psychologe	3	0	0
52	132	1	92	4	Cognitive Science	1	1	0
53	133	1	75	5	Studium Cognitive Sci...	4	2	1
54	134	0	87	4	Cognitive Science	3	0	0
55	135	0	87	5	Master Linguistik	2	1	1

- After the survey we had to refine the collected data
- 55 data sets which we analysed by using SPSS
- Mainly employed ANOVAs and frequency analysis

Results: Performance



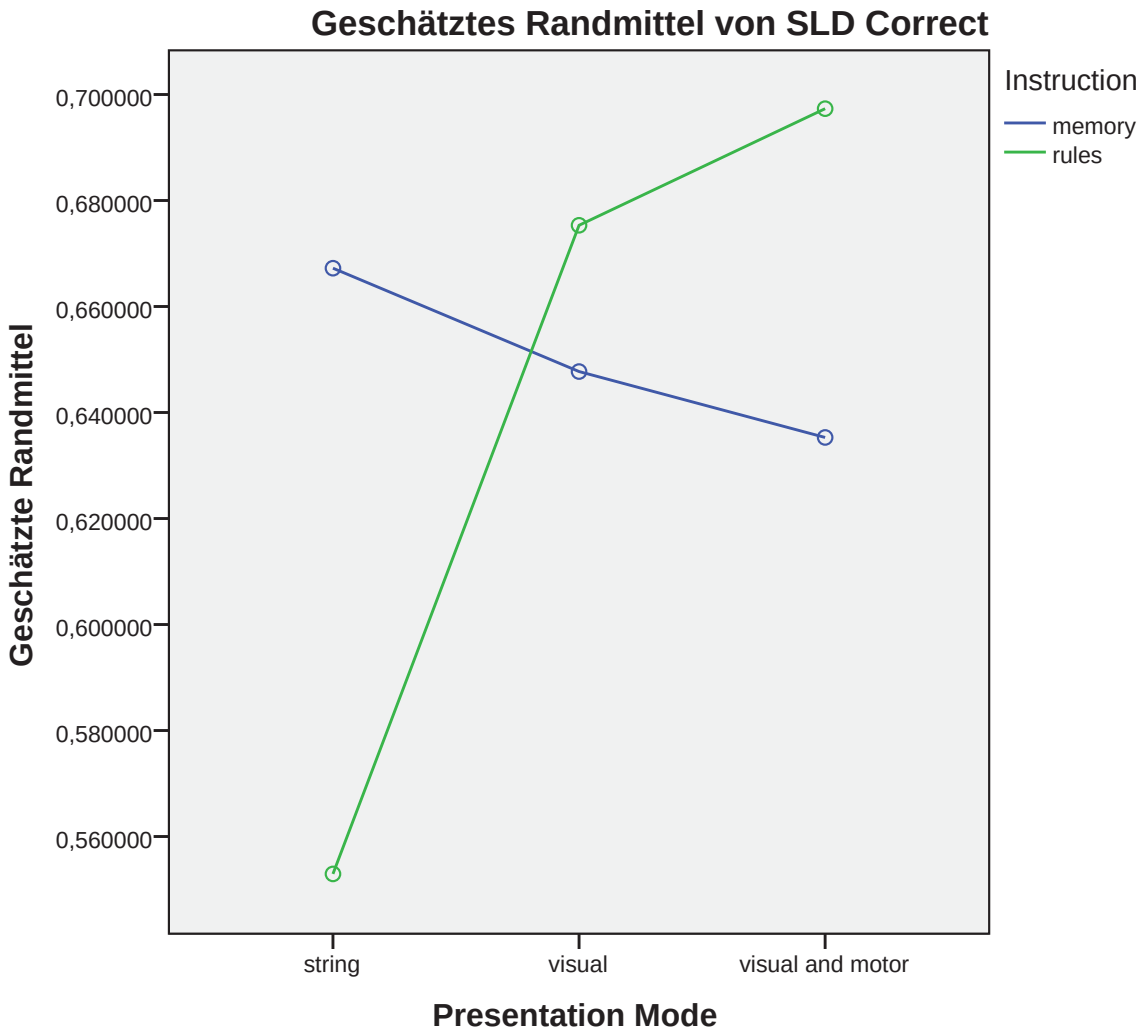
Results: Performance (cont'd)

$\rightarrow$ Great difference between string-based and visual representation

Hypotheses:

- $P_L < P_V$: supported
- P_V ? P_P: depends on the underlying kind of information

Results: SLD


Geschätztes Randmittel von SLD Correct
Geschätzte Randmittel
0,700000
0,680000
0,660000
0,640000
0,620000
0,600000
0,580000
0,560000
string
visual
visual and motor
Presentation Mode
Instruction
memory
rules

Results: SLD (cont'd)

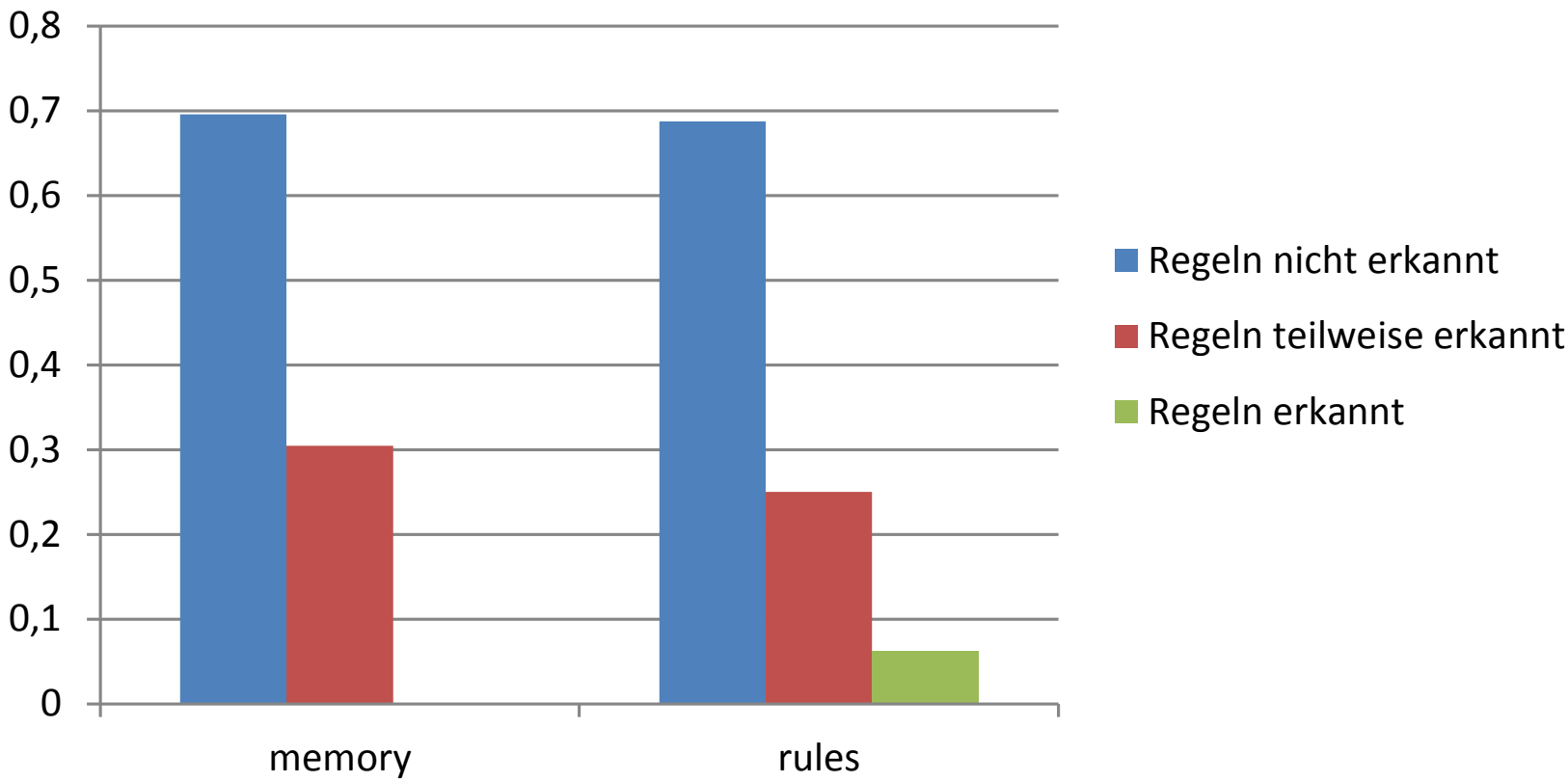
$\rightarrow$ Again great difference between string-based and visual representation (for explizit information)

$\rightarrow$Maybe subjects without information (memory) didn't concern the sequence of letters

Hypotheses:

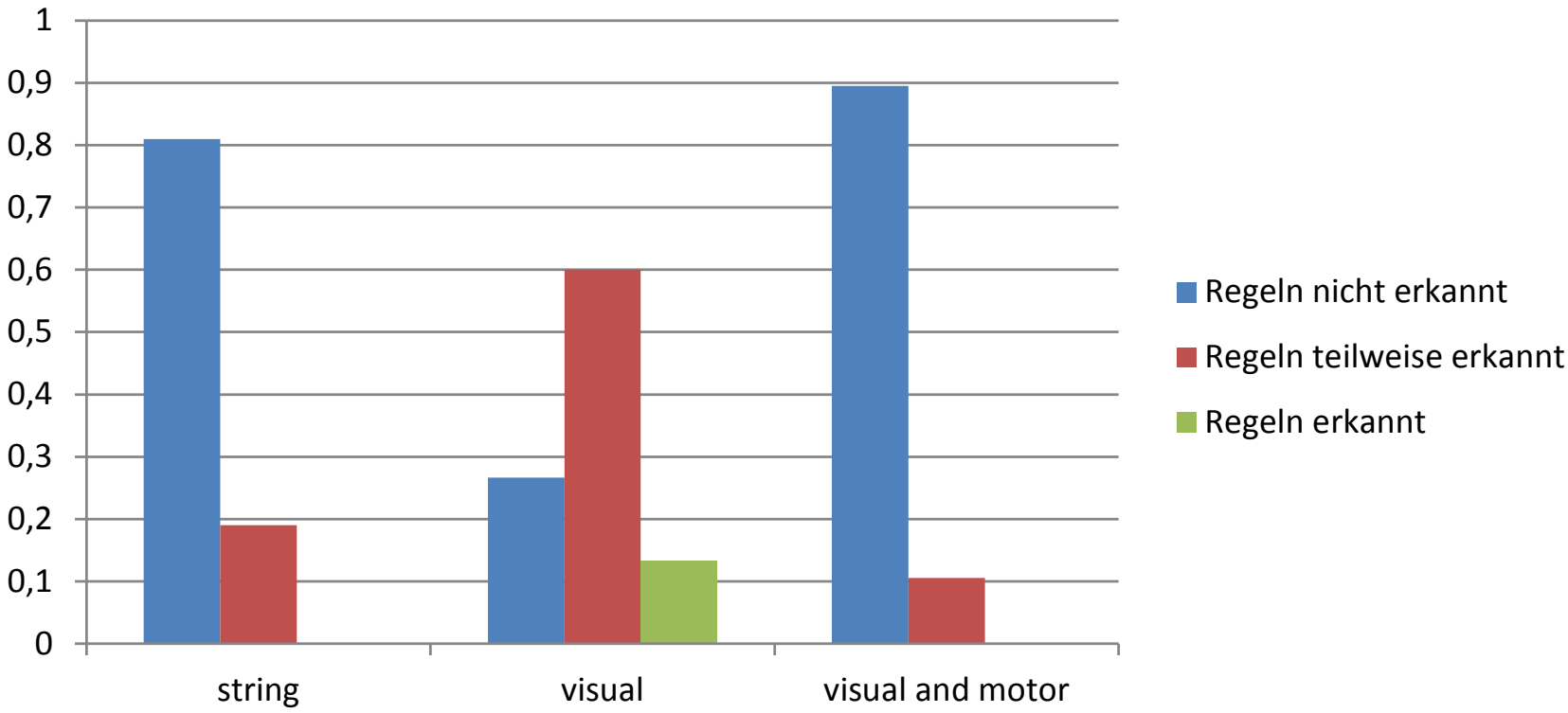
- $S_L \approx S_V$: not supported
- $S_V < S_P$: only for explicit learning supported

Results: Free Report



- $FR_E < FR_I$: not supported

Results: Free Report (cont'd)



- $FR_L > FR_V$: not supported
- $FR_V < FR_P$: not supported

Summary

- Performance mean %: 55 - 64
- SLD mean %: 55 - 70
- SLD-explicit/Perf.-implicit: String $<$ 2D $<$ 2D+
- Visual presentation has a greater impact than motor task
- Dienes 1991: Performance tests implicit knowledge, SLD tests knowledge about relations between letters

Summary (cont'd)

- PSLD-String: Implicit $>$ Explicit
- Performance-String: Explicit $>$ Implicit
- Reversed for 2D+
- Certain tasks can interfere with explicit, but not with implicit learning. (Hayes 1987 vs. Dienes 1991)

Comparison

- Explicit instruction lowers Classification Performance (Reber 1976 vs. Dienes 1991 and others)
- Not reproduced for Performance, but for SLD
- Positive correlation between Performance and SLD (Dienes 1991)
- Could not be reproduced by our experiment!

Outlook

- Bachelor Thesis on Cognitive Modelling
- ACT-R
- Implicit knowledge: Procedural Memory
- Explicit knowledge: Declarative Memory
- Sequence learning: Lebiere et al. (1998)
- Visual representation: Gunzelmann, Lyon (2007)