


Spatial Module and Mental Rotation

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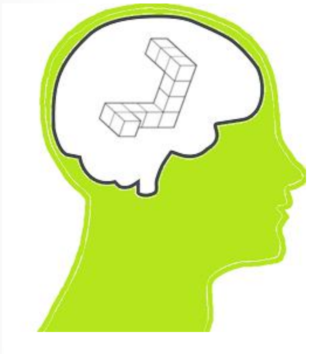
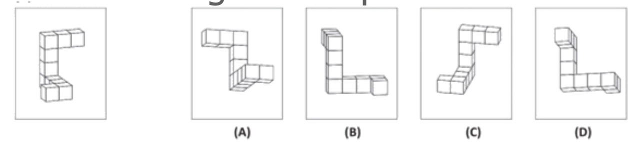
Spatial Capabilities

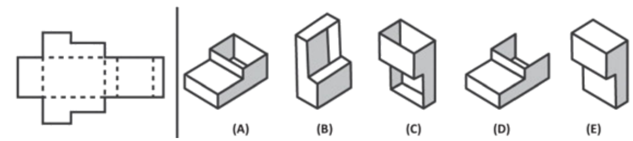


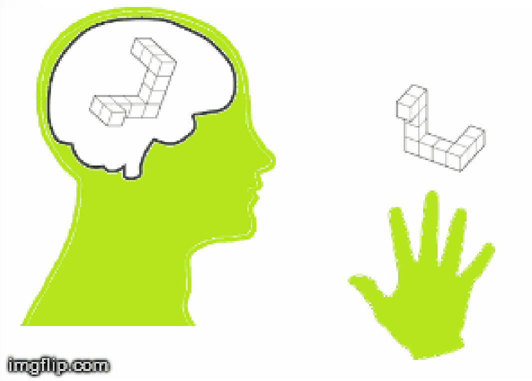
Mental representations & Planning of Manipulations

- Mental Rotation

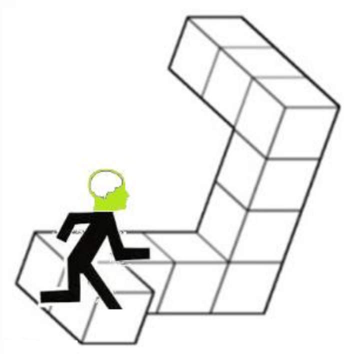


- Mental Folding



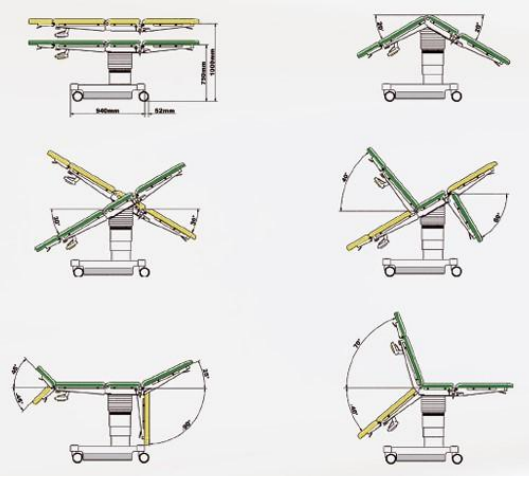


Manipulations of Objects in the environment



Influence of spatial configuration on task performance

Mental representations & Planning of Manipulations

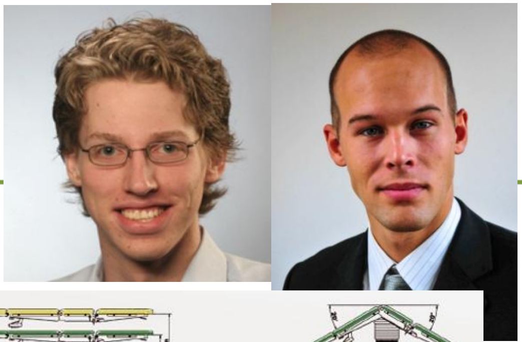


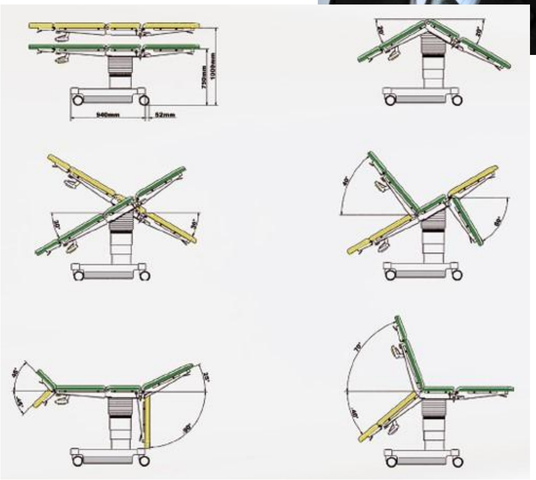
Manipulations of Objects in the environment

Influence of spatial configuration on task performance

High Workload because of inconvenient System / Interface configuration?

Mental representations & Planning of Manipulations (Fabian Joeres & Alexander Lotz)





To control larger technical systems is complex and requires a lot of practice.

We want to understand, what cognitive steps are necessary for such planning processes.

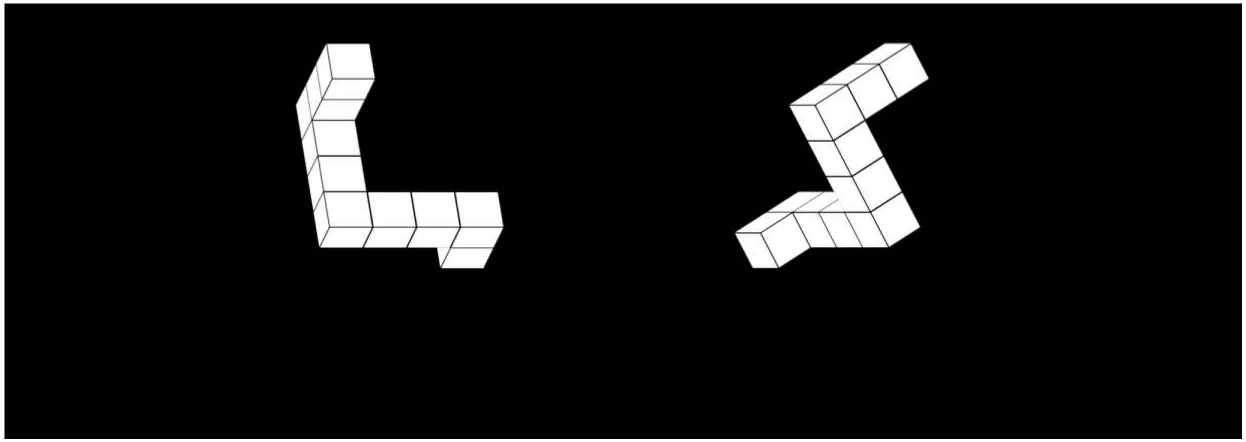
Then it would be possible to develop less demanding and safer interfaces (probably apply new technologies)

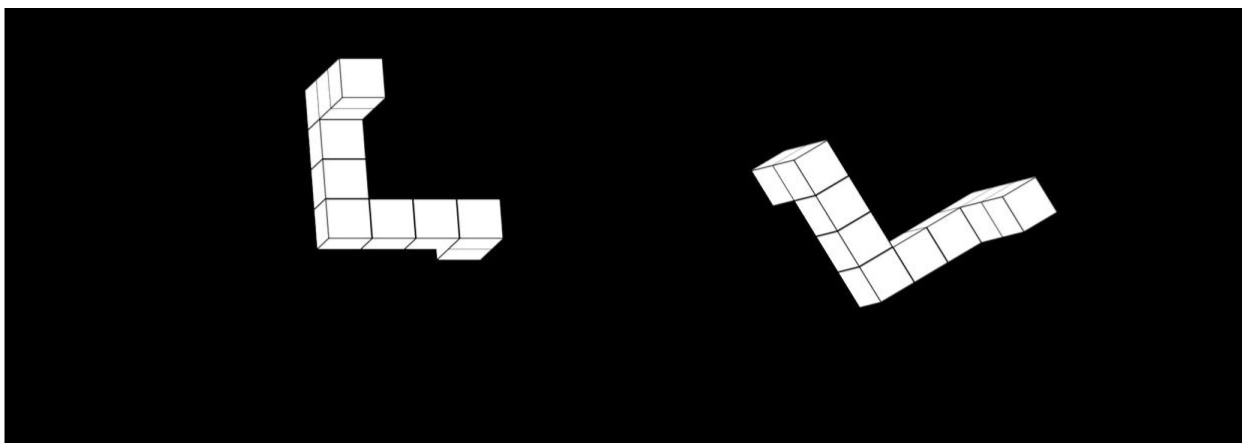
Requirements

The module should be able to capture effects on mental rotation of:

- Difference of simple and complex objects
- Reaction time
- Learning (process or object)
- Errors
- Visual attention (not detailed scanning but switching)

Mentale Rotation I

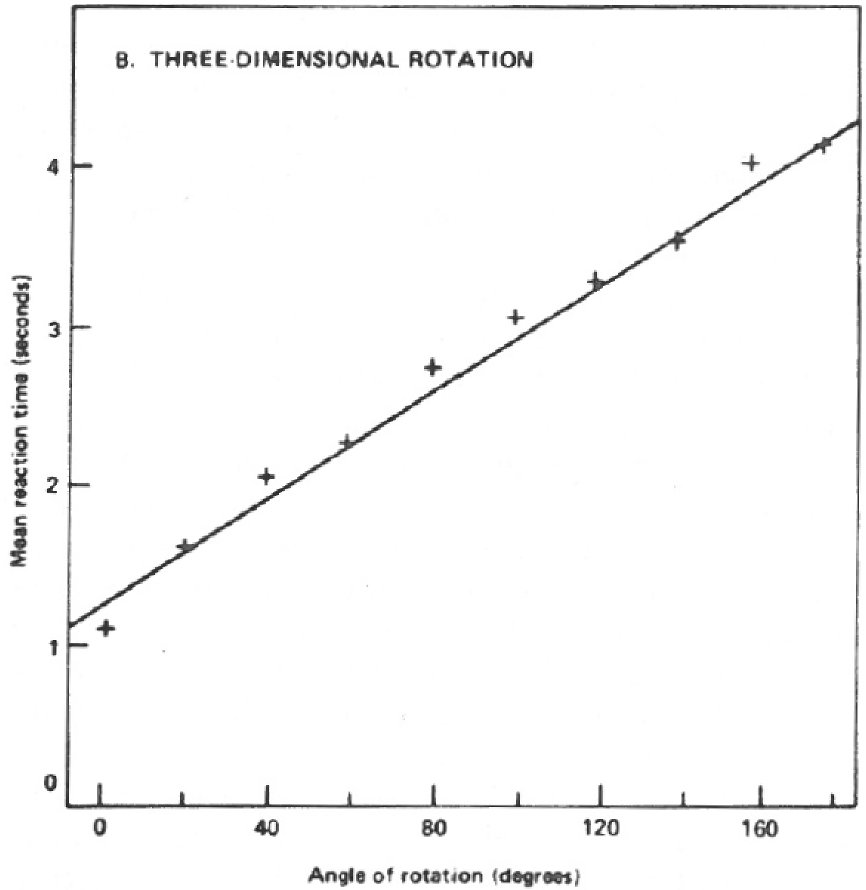




Stimulusmaterial aus Peters und Battista, 2008

Mentale Rotation II

Linear relation between angle of rotation and reaction time (R. Shepard und J. Metzler, 1971)

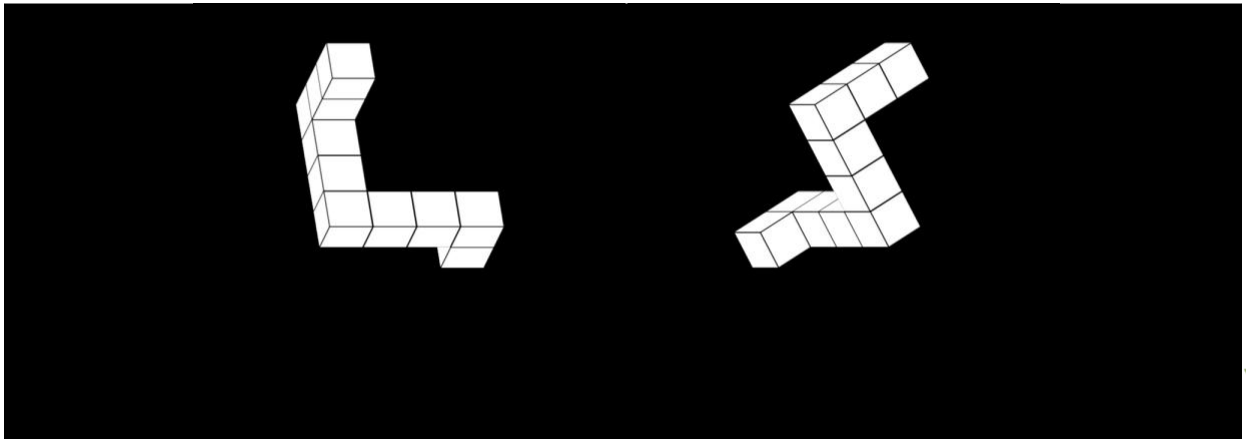


Conceptual model

1. Analogue transformation process of three-dimensional representations. (R. Shepard und J. Metzler, 1971)

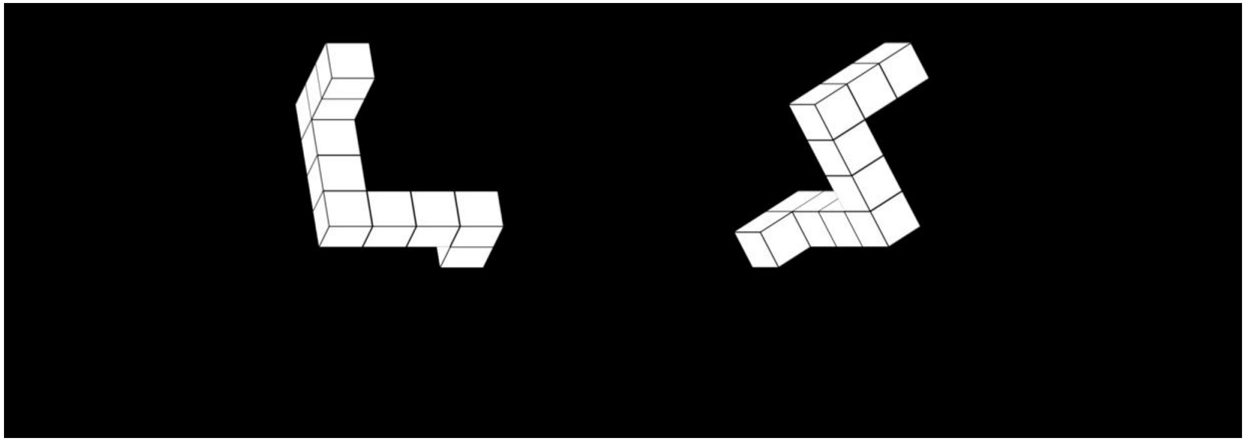
2. Holistic vs. partwise processing depending on complexity and familiarity of an object (Bethell-Fox und Shepard, 1988)

3. Mental Images underlie activation processes. (Kosslyn, 1996; Just und Carpenter, 1976)



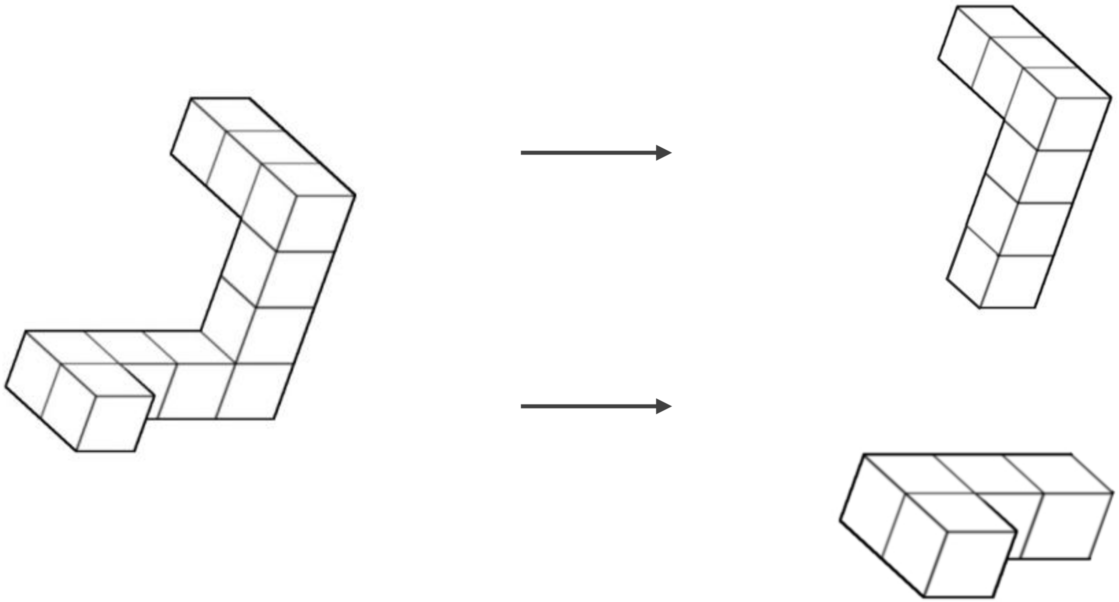
Model assumptions – analogue transformation

1. Analogue transformation process of three-dimensional representations. (R. Shepard & J. Metzler, 1971)



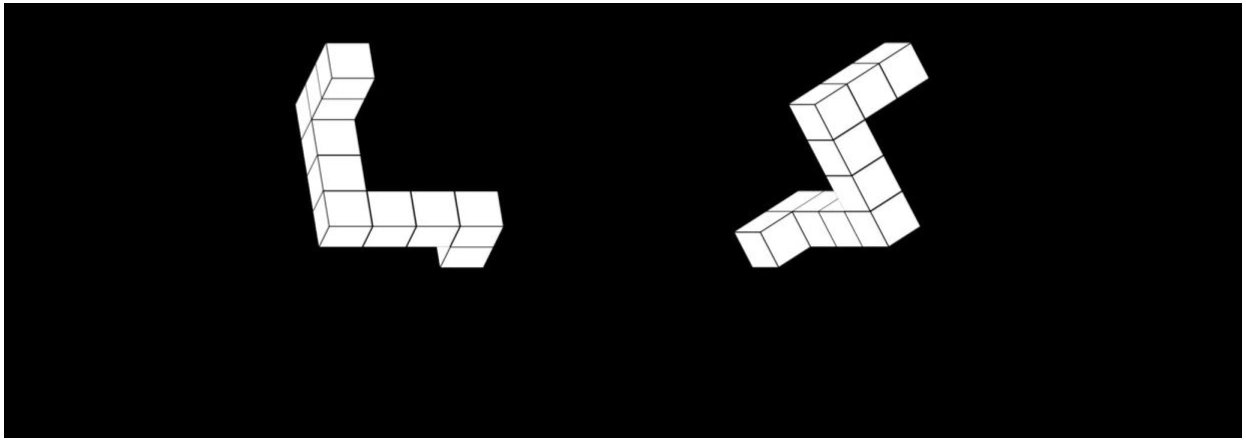
Model assumptions – familiarity effects

2. Complexity and familiarity determine holistic vs. Piecemeal processing.
   (Bethell-Fox & Shepard, 1988)

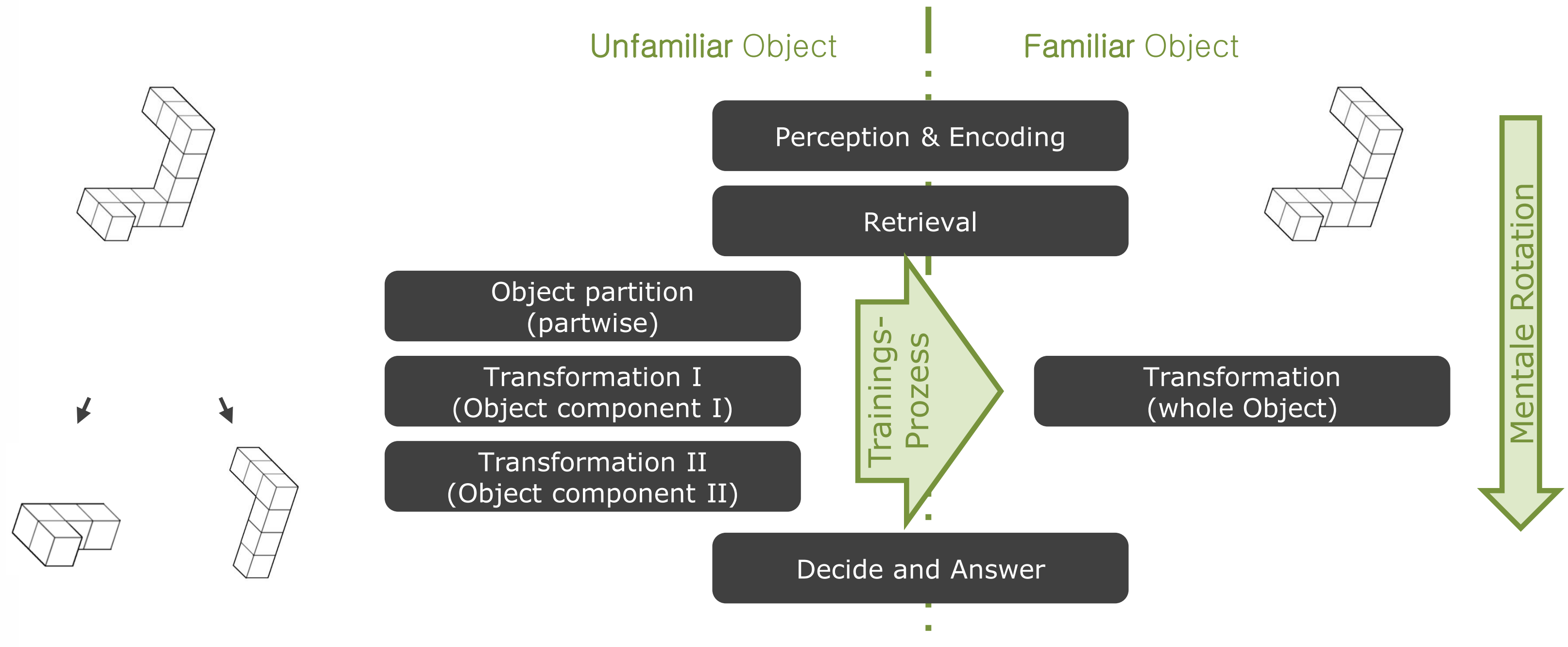


Model assumptions – mental image activation

3. Object representations are subject to activation processes. (R. Shepard & J. Metzler, 1971)



Familiartity of Objects

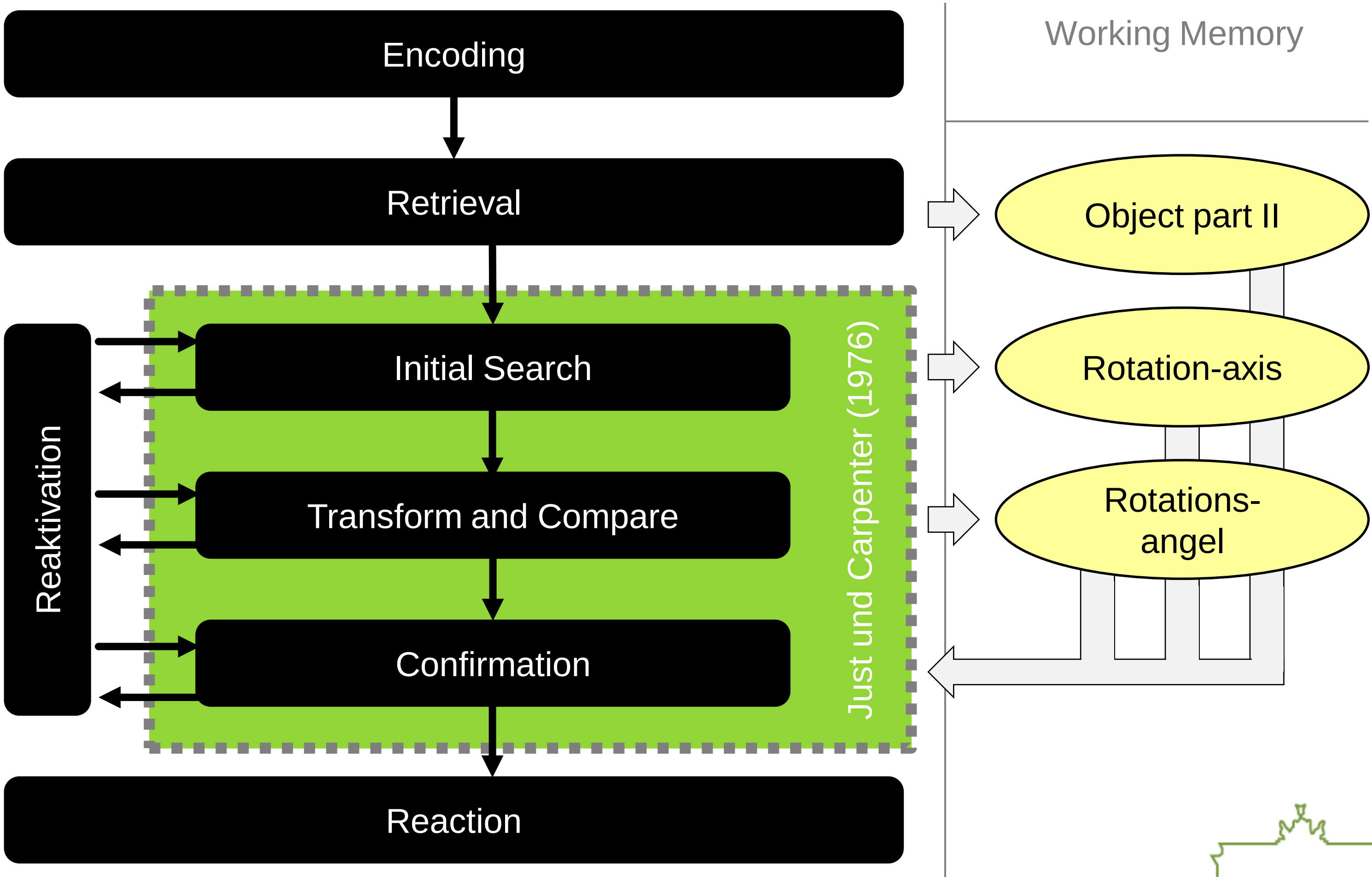


(Joeres & Russwinkel, 2014)

Based on Bethell-Fox & Shepard (1988)

- *Familiar Object* → holistic rotation
- *Unfamiliar Object* → separate rotations

Joeres, F. & Russwinkel, N. (2014). Object-related learning effects in mental rotation. In: Freksa, C., Nebel, B., Hegarty, M., Barkowsky, T. (eds.). *Spatial Cognition 2014:* Poster Presentations. Bremen, Germany.
Joeres, F. & Russwinkel, N. (2014). Introduction of an ACT-R based modeling approach to mental rotation. *Special Issue: Proceedings of KogWis 2014 pp.112-114. 12th Biannual Conference of the German Cognitive Science Society. Cogn Process* 15 (Suppl 1):S1–S158, DOI 10.1007/s10339-014-0632-2. Editors Anna Belardinelli & Martin V. Butz.


Encoding
Retrieval
Initial Search
Transform and Compare
Confirmation
Reaction
Reaktivation
Just und Carpenter (1976)
Working Memory
Object part II
Rotation-axis
Rotations-
angel

Gunzelmann & Lyon 2007

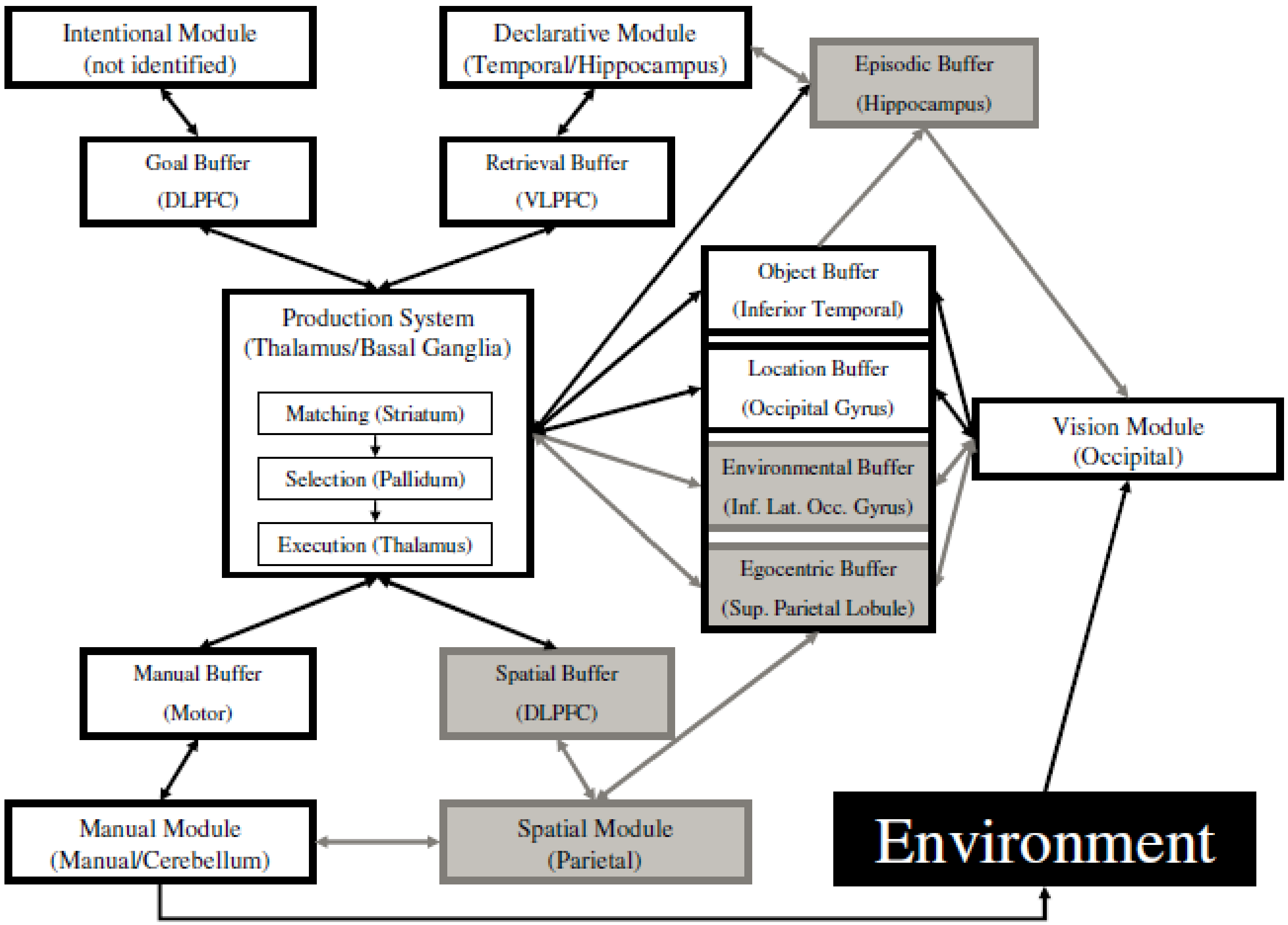
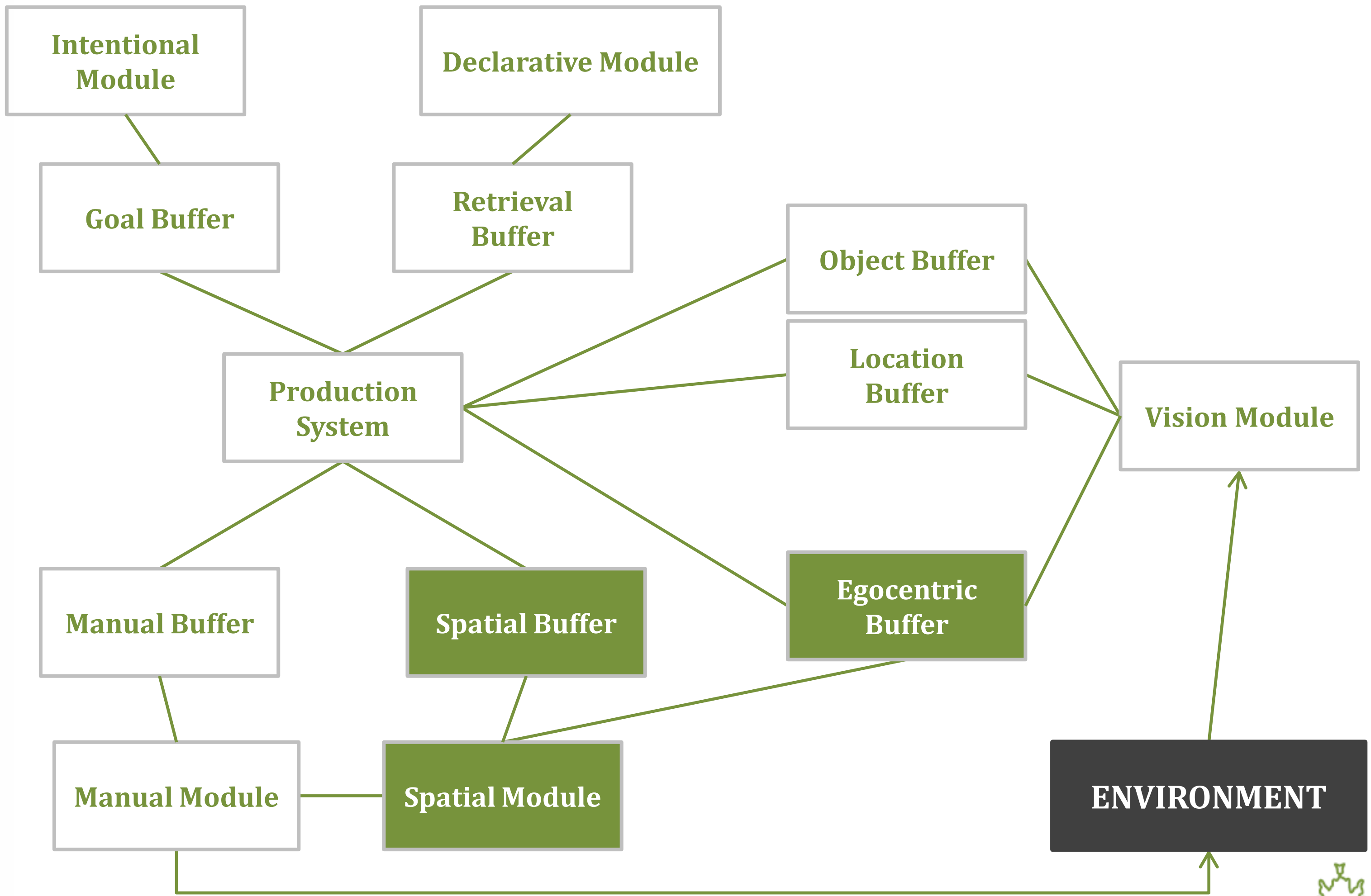


Fig. 1. Schematic illustration of the current ACT-R architecture, with proposed additions included. Structures identified in white represent existing components of the architecture. Grey components represent proposed additions. The *environment* is indicated in black.

Raumkognition in ACT-R



Experimental Design

Dividing learning processes of objects opposed to learning of the process of mental rotation (Shepard & Metzler 1971).

- **One object shown as CAD-Modell for 60 seconds** [**Nine** Objects unfamiliar, **one** familiar]

- **Four angel disparities** (10°, 60°, 110°, 160°)

Set 1			Set 2			Set 3			
O	X	O	O	O	O	O	O	O	
O	O	O	O	O	O	X	O	O	
O	O	O	O	O	X	O	O	O	
O	O	O	O	O	O	O	O	X	Ende Block
X	O	O	O	O	O	O	O	O	
O	O	O	O	X	O	O	O	O	

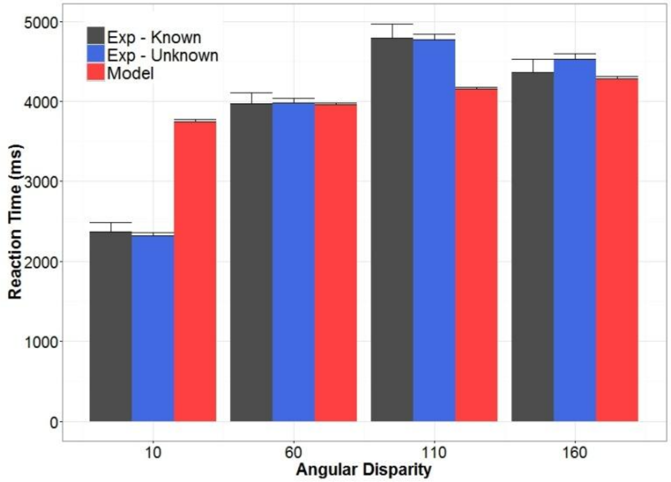
X	Trial – Bekanntes Objekt
O	Trial – Unbekanntes Objekt

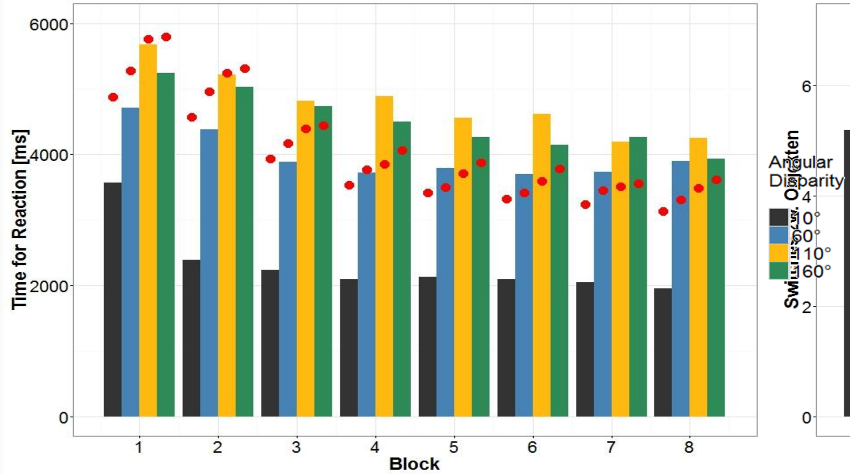
- **Sample:** 27 subjects (13 female, 14 male); Mean = 25.9 years; 1 discarded

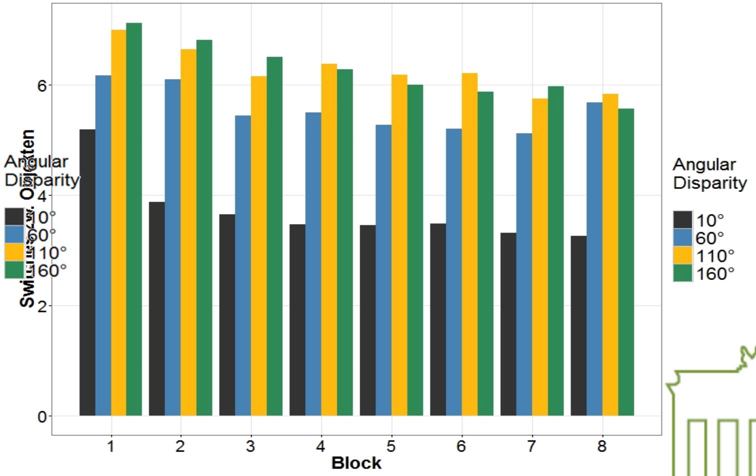
Lotz, A., & Russwinkel, N. (2016). The Role of Familiarity in Spatial Competence. *In: 5. Interdisziplinärer Workshop Kognitive Systeme - Mensch, Teams, Systeme und Automaten, 2016.*

Results second experiment

- No significant difference between familiar and unfamiliar objects
- Angel disparity of 110° shows longer reaction times thane 160° → no linearity
- For small angel disparities we assume a different strategy
- High correlation between RTs and number of switches between stimuli **R^2=0.806**.







Conclusion

The approach should be able to capture:

- Object learning (familiarity) as well as
- Process learning (mental rotation)
- Errors
- Reaction times (quite)
- Visual switches for reactivation

Next steps

Testing a similar task with more realistic objects.

Individual differences in reference frame preferences.

Transfer processes to the folding task.

Thank you for your attention!