

# The value of VR and AR in developing anatomical competence

## Hope or Hype?

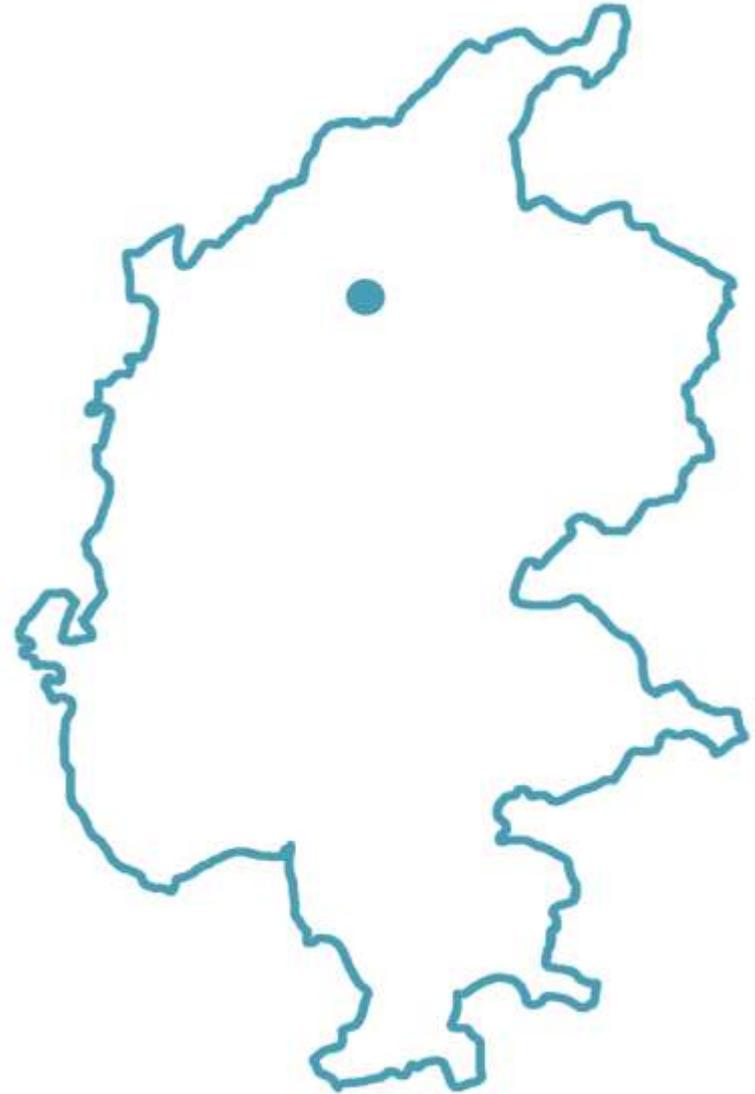
80th annual meeting of the SSAHE

Fribourg, Switzerland, 7th September 2018

Marc Vorstenbosch, PhD, Associate professor of Anatomy, Nijmegen, The Netherlands

# Have a quick look at this image

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(don't ask, I need it later)

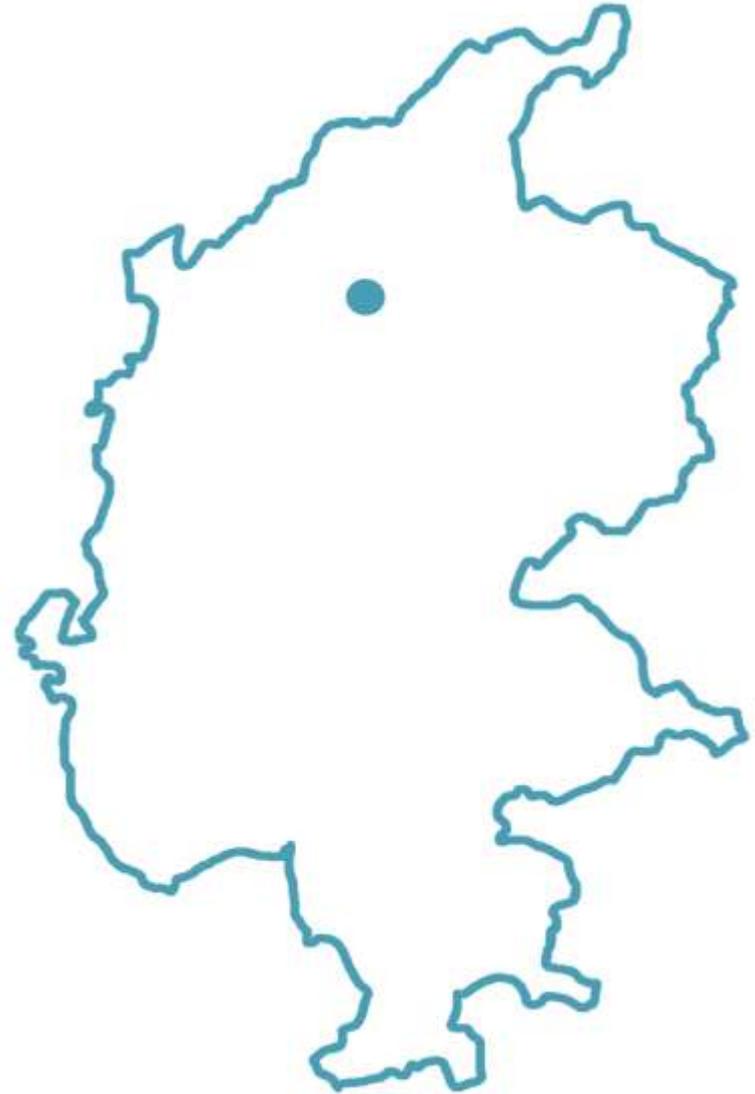
# What to expect...

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- 1) Starting point – anatomical competence
- 2) Reasons to study new technologies
- 3) Difficulties to reckon with
- 4) TO DO list

# Have a quick look at this image

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(don't ask, I need it later)

# My starting point: Anatomical competence

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The objective of **learning** anatomy for a medical student is to become able to adequately use this knowledge to interpret clinical findings

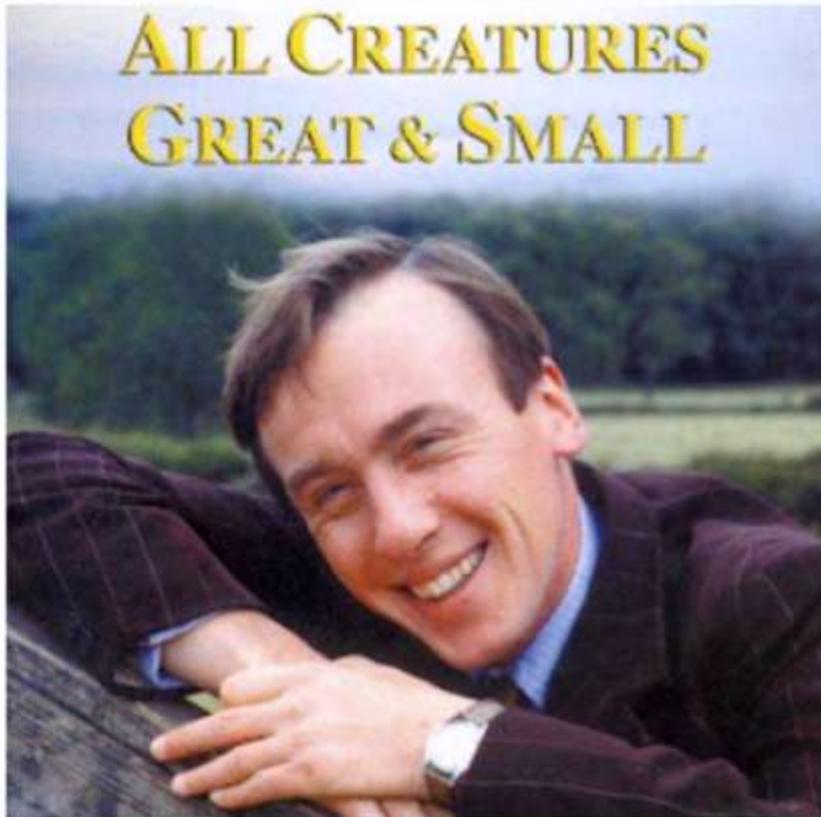
The goal of **teaching** anatomy is to produce medical students that are able to adequately use this knowledge to interpret clinical findings

Basu, S. (2004). "Competence in the musculoskeletal system: assessing the progression of knowledge through an undergraduate medical course." 38(12): 1253-1260.

Albanese, M. A., et al. (2008). "Defining characteristics of educational competencies." Medical Education 42(3): 248-255.

# Anatomical competence?

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(c) BBC (cover DVD-box)

*“I learned a lot of anatomy,  
but I hardly use it  
anymore in daily  
practice”*

# Anatomical competence?

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# Anatomical competence?

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*“Ooh! But I know what’s under the skin... I know where the nerves are that I need to block and how to avoid the arteries, but I don’t remember any of the names”*



taken from SlideShare

**Do you think this vet is anatomically competent?**

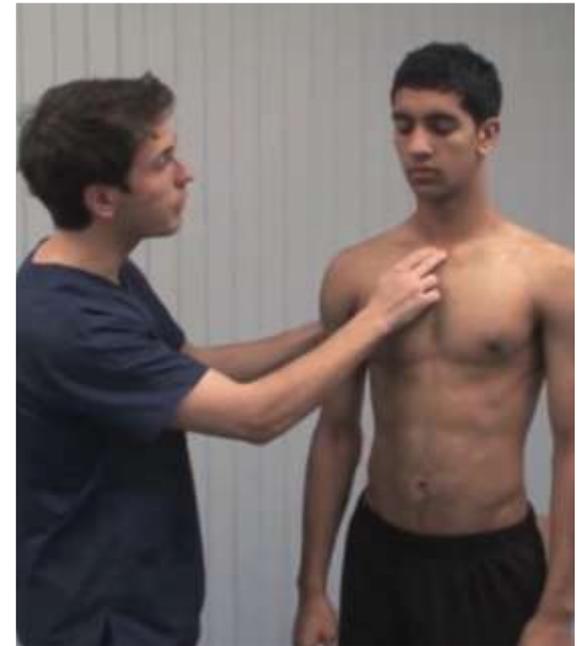
(he sure has adequate visual memory of the anatomy of the horse’s leg)

# Anatomical competence in junior MD's

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## Research Methods

- 10 young medical doctors volunteered in a 'Stimulated recall' experiment
- Consultation with a standardized patient (shoulder complaint)
- Recorded on video
- Direct viewing of consultation video
- Verbalize recalled thoughts during the consultation
- Recorded on video → verbatim transcripts
- Analyses of cognitive processes



# Anatomical competence in junior MD's

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## Results

*JMD 1: "There is a image in my head and my hands know what they are supposed to feel"*



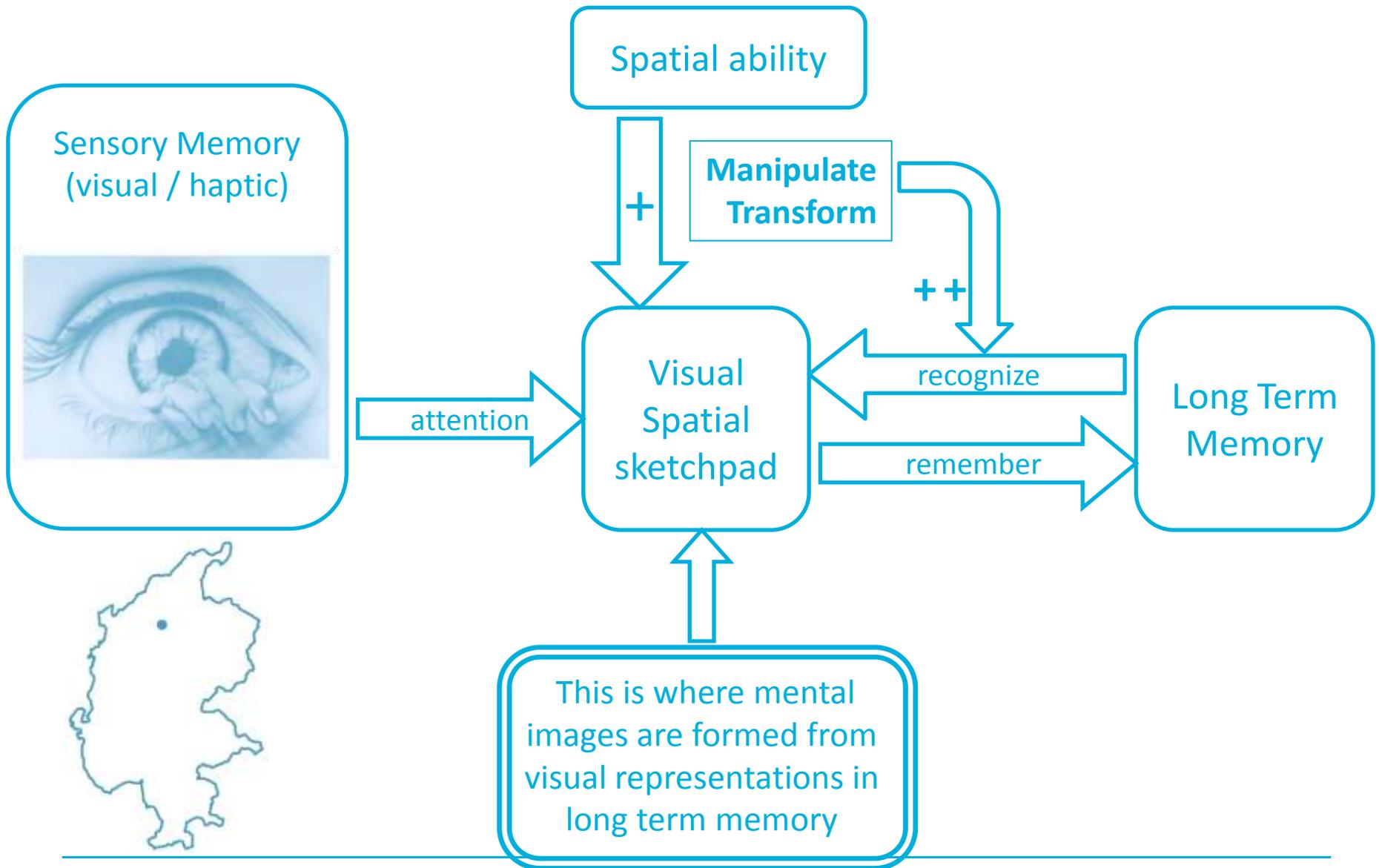
- Anatomical knowledge is used throughout the consultation and especially during physical examination
- The use of anatomical terms is associated with clinical reasoning
- The use of anatomical terms is associated with the use of mental images

## Conclusions

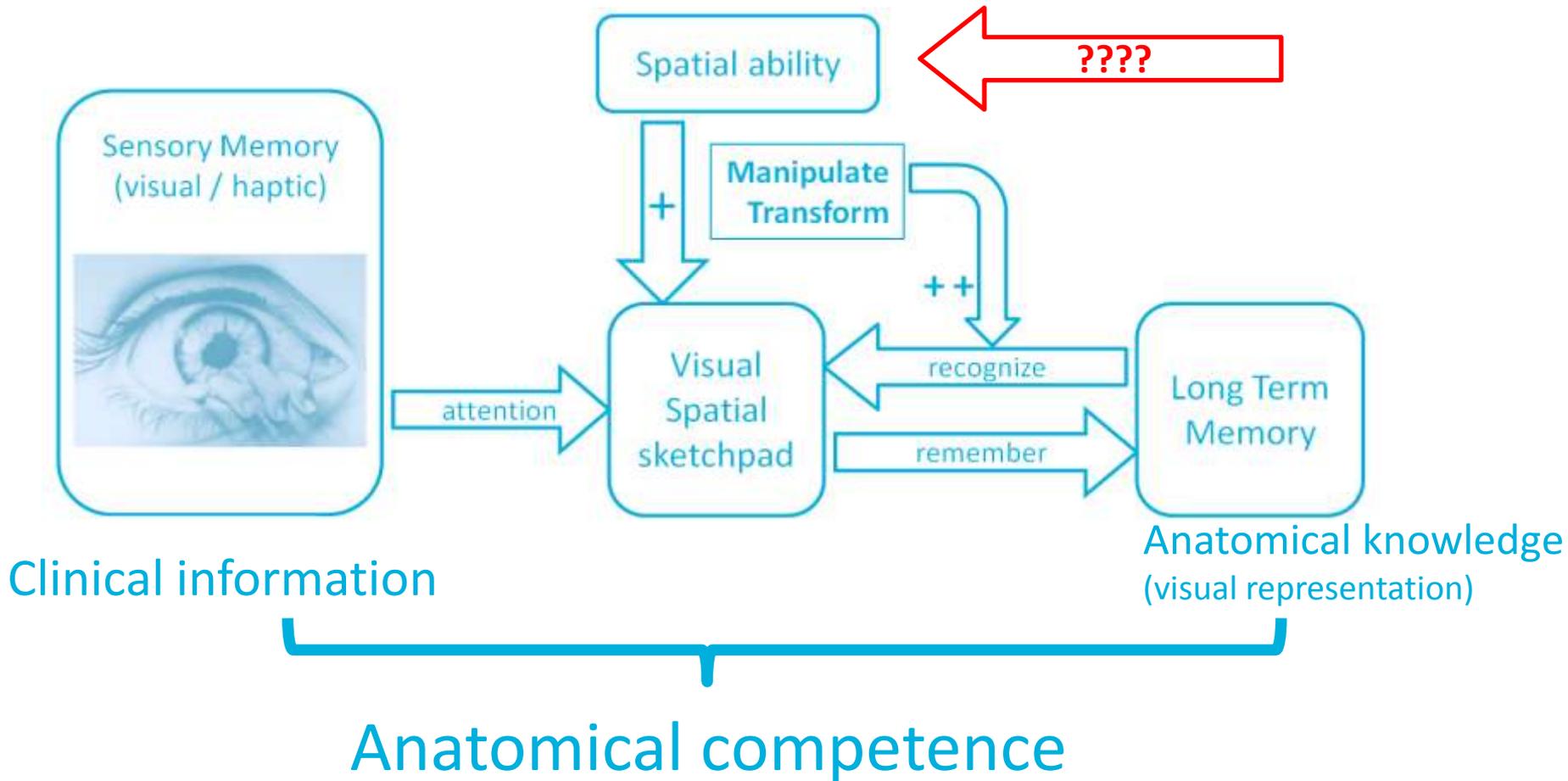
- Junior medical doctors use their anatomical knowledge intensively
- Junior medical doctors frequently use mental images when using their anatomical knowledge

AGAIN: visual memory is used....

# How does visual memory work?



# Anatomical competence?



## (side step) evolutionary pressure on spatial ability

Spatial ability and spatial memory help us understand and manipulate the world around us.

→ navigating and building shelters

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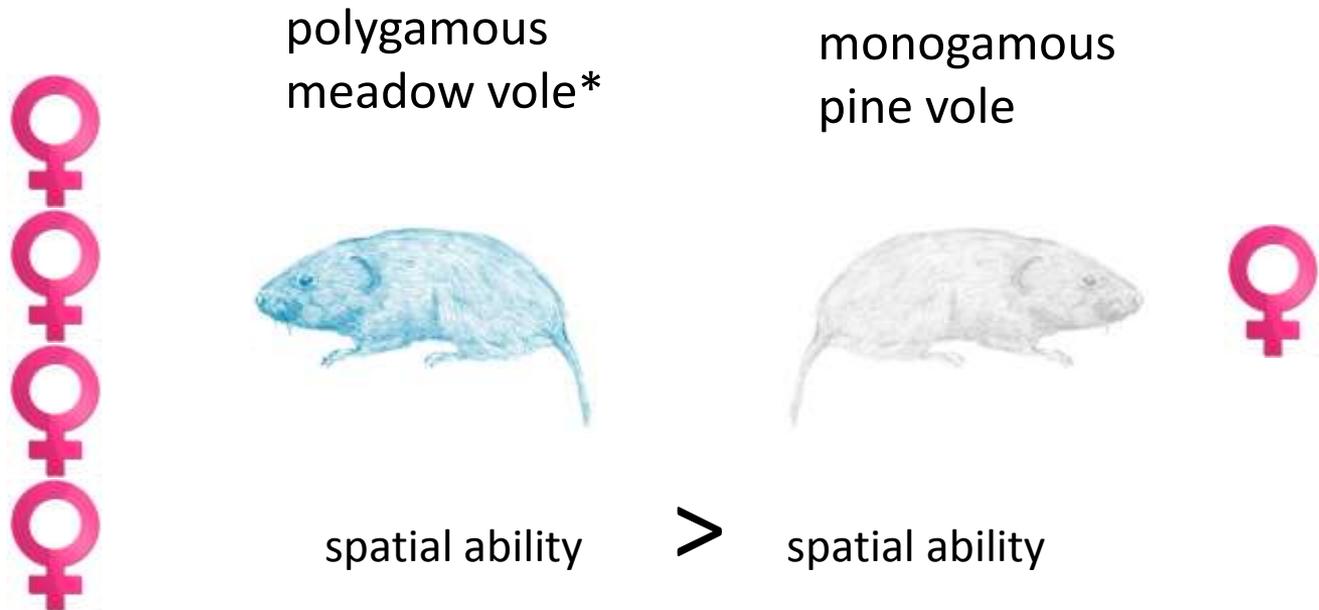


## (side step) evolutionary pressure on spatial ability

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Spatial ability develops proportional to the navigational demands of a species  
(Jones, 2003)

Not only in Humans....

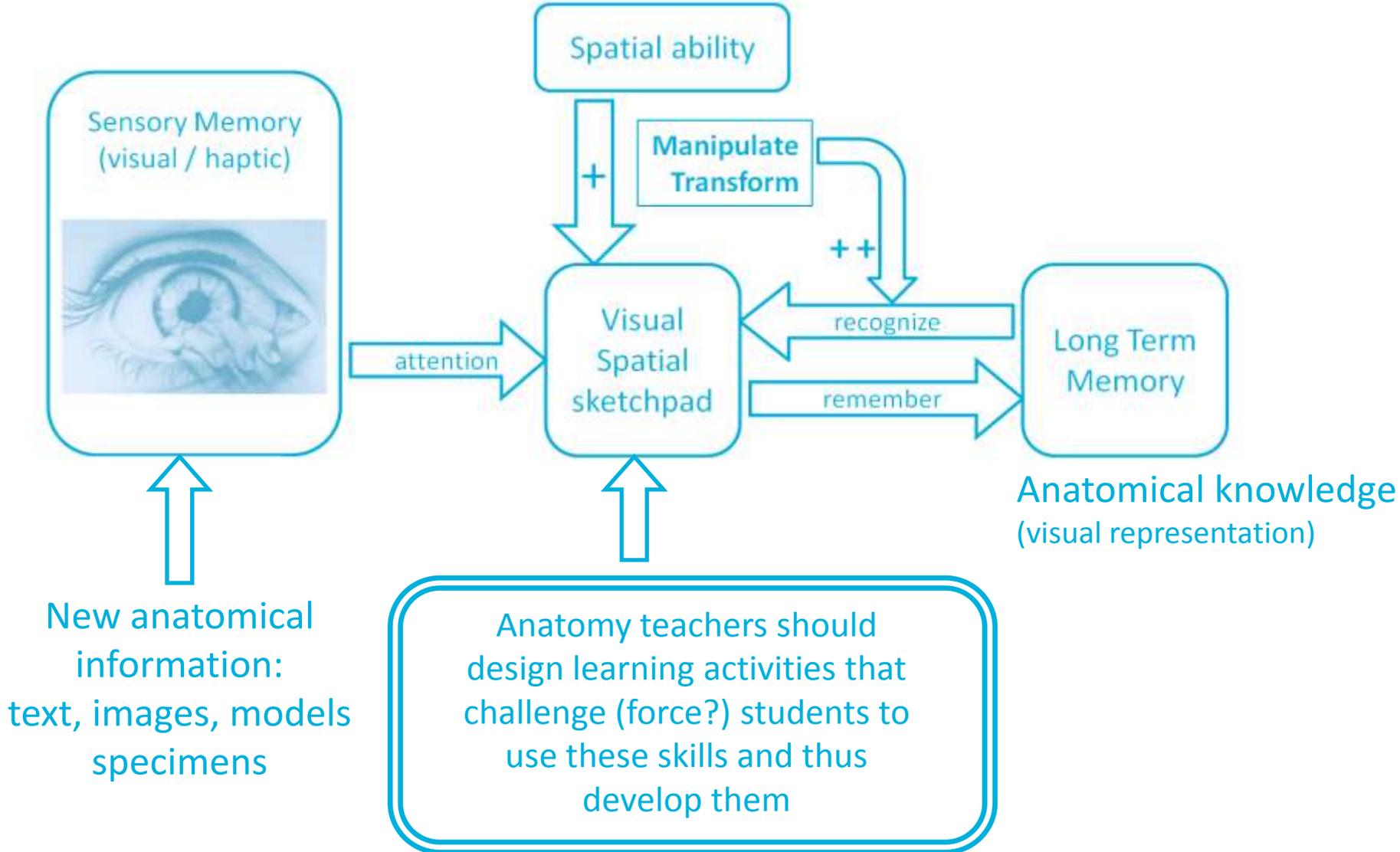


(Jacobs et al., 1990)

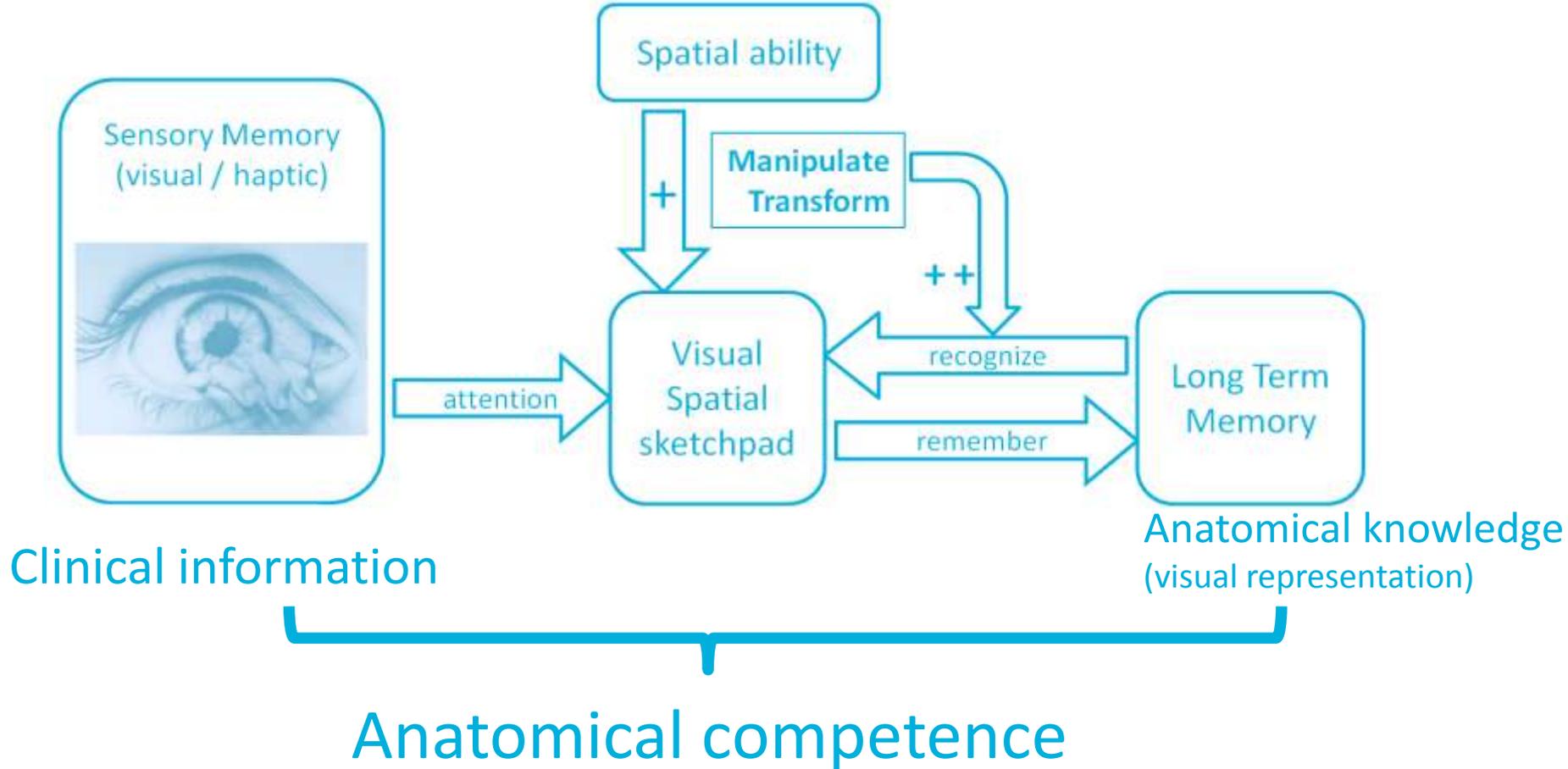
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\* feldmaus, souris de champ, mouse di campo

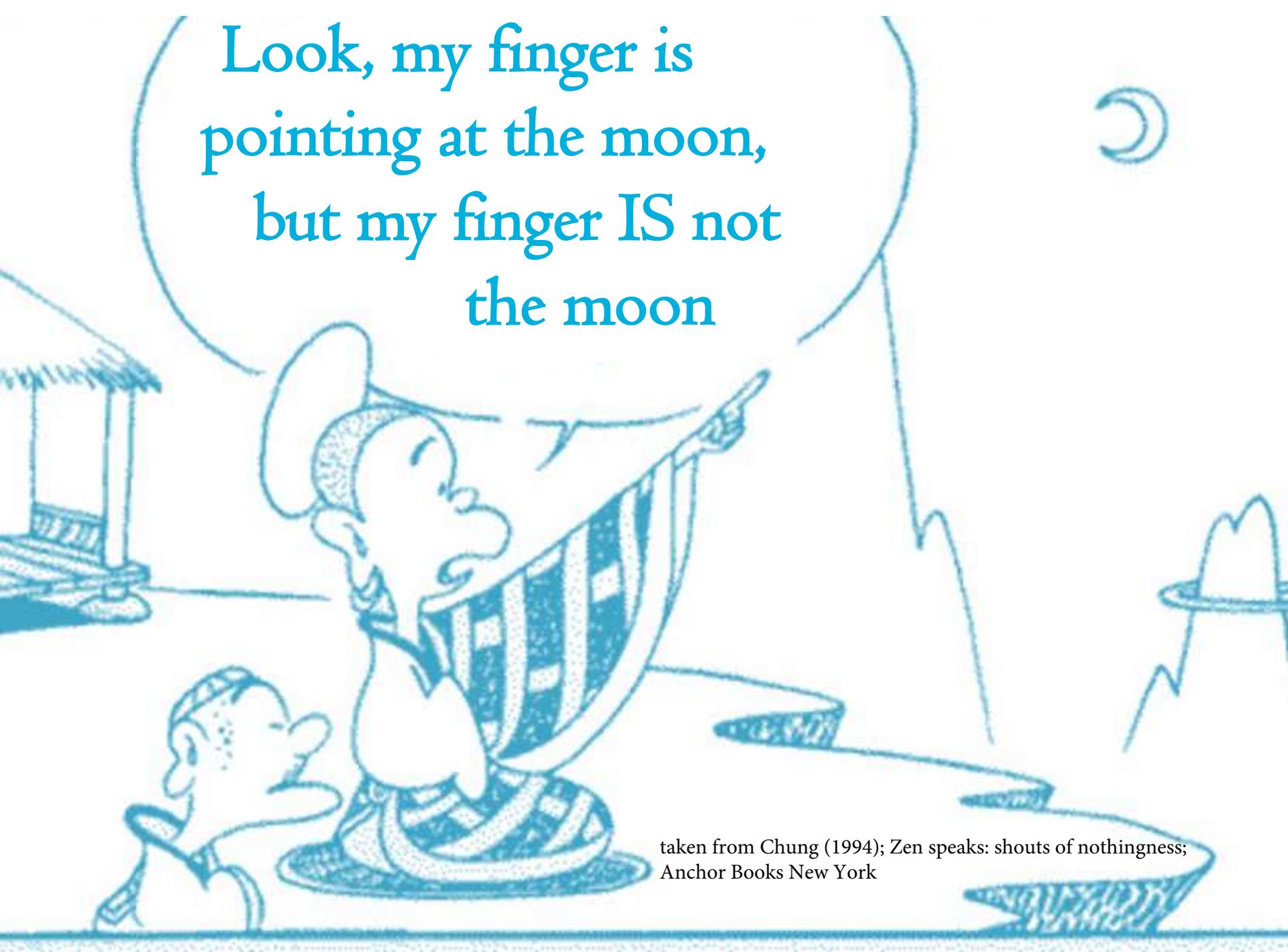
# How to develop anatomical competence?



# Anatomical competence?



Look, my finger is  
pointing at the moon,  
but my finger **IS** not  
the moon



taken from Chung (1994); Zen speaks: shouts of nothingness;  
Anchor Books New York

# Conclusion for now

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Anatomical competence is closely related to the relevance and quality of the mental images in long term memory of doctors and students.

Core questions for anatomy teachers:

How can we assist the students to build these mental images in their brains most efficiently?

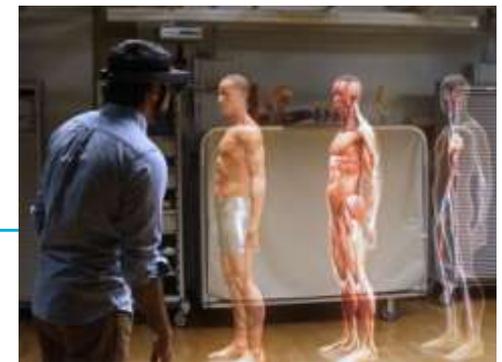
Can new technologies (like VR and AR) be of any help?

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# VR and AR?

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Virtual dissection  
Hololens  
Oculus rift  
3D photography  
Holograms  
3D screens



Radboudumc

# Big review study and meta-analysis

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3DVT – definition: view spatial relationships from numerous viewpoints and angles

This includes:

- 2,5 D (depth perception by perspective and shadow on a normal computer screen)
- 3D with special glasses (like movie AVATAR)
- 3D with special monitors + glasses (mostly polarized glass technique)
- Full immersion VR (with goggles like oculus rift)

36 studies included (with variable ‘comparators’)

3DVT outperforms other means of learning with respect to

- Factual knowledge
- Spatial understanding

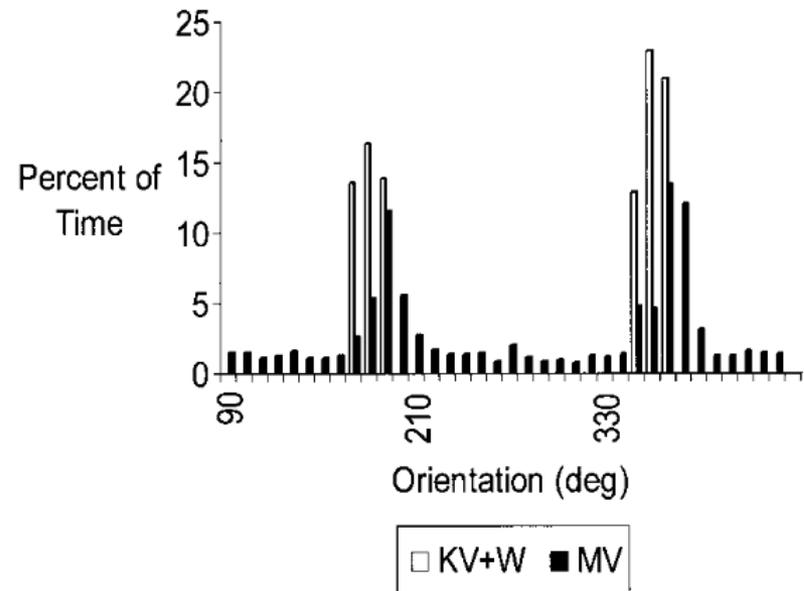
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Yamine, K. and C. Violato (2015). "A meta-analysis of the educational effectiveness of three-dimensional visualization technologies in teaching anatomy." *Anatomical sciences education* 8(6): 525-538.

# Advantage of 3D 'surround' view?

Multiple orientations seem to be hardly used by learners, and do not lead to better learning effects

NB: Post test questionnaire:  
Students claim to remember a key view and mentally rotating that in order to generate answers



A.X.Garg,G.R. Norman,K.W.Eva,L.Spero,andS.Sharan,

“Is there any real virtue of virtual reality?: The minor role of multiple orientations in learning anatomy from computers,” Academic Medicine, vol. 77, no. 10, pp. S97–S99, 2002.

# VR and AR?

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Can new technologies (like VR and AR) be of any help?

Untill now:

- For students, technology facilitates access to learning content at any time and place –
- Rather as a supplement than replacing traditional learning
- For educators it expands their educational impact by not constraining learning to classroom sessions

\* Conclusions mostly based on student preferences and teacher beliefs .

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(Goh, 2016; Estai 2016).

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# Why study new technologies in learning anatomy ?

- 1) To see if they work
- 2) To find out how they work best
- 3) To advance our knowledge about learning anatomy  
(re-examining basic ideas)

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Mayer, R. E. (2018). "Designing Multimedia Instruction in Anatomy: An Evidence-Based Approach." Clin. Anat.

Chan, L. K. P., Pawlina, W. (2015). Teaching Anatomy - A Practical Guide; Springer.

Estai, M. and S. Bunt (2016). "Best teaching practices in anatomy education: A critical review." Annals of Anatomy 208: 151-157.

Yammine, K. and C. Violato (2015). "A meta-analysis of the educational effectiveness of three-dimensional visualization technologies in teaching anatomy." Anatomical sciences education 8(6): 525-538.

# Difficulties in studying new technologies

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- 1) **Spatial ability**
- 2) Cybersickness
- 3) Time-on-topic
- 4) Outcome measures
- 5) Levels of educational outcome
- 6) Cognitive load

# Spatial ability

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- 1) Associated with anatomy learning
- 2) Associated with VR 'perception'
- 3) Mixed reports
  - a. Desktop VR works better in students with lower SA (Ai-lim Lee 2010) (ceiling effect?)
  - b. Immersive VR induces a higher cognitive load in students with lower SA, no effect in outcome (own work in progress)

Very probable confounder, precise effect yet unknown → stratify/match

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- 2) **Cybersickness**
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# Cybersickness

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- 1) Very much like motion sickness
- 2) Opposite input from eyes and vestibulum
- 3) Reports up to 80 % of population (Coventry university)
- 4) Seems to be negated collectively

→ Questionnaire in experimental design



(c) vrodo.de



(c) 1reddrop.com

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# Time on topic

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Six year study on CAI in gross anatomy

Reports better test scores of student who also used the available CAI-material

Is it CAI or just the time they spent ?

OR: Are these more diligent students?

Threatens validity

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(McNulty (2009) evaluation of CAI in a gross anatomy course: a six year study

# Difficulties in studying new technologies

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# Outcome measures

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1) Test questions? Or maybe something completely different? → drawing or modelling ?



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Balemans, M. C., et al. (2016). "Actual drawing of histological images improves knowledge retention." *Anat Sci Educ* 9(1): 60-70.

Naug et al (2011; 2016) papers about the blank page

Kooloos, J. G., et al. (2014). "Anatomical knowledge gain through a clay-modeling exercise compared to live and video observations." *Anat Sci Educ* 7(6): 420-429.

# Outcome measures

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- 1) Test questions? Or maybe something completely different?
- 2) Spatial questions / non-spatial questions?

## Table 2.

Examples of the multiple-choice anatomy factual (questions 1–3) and spatial (question 4) questions

1. Which of the following is a paired bone that forms part of the viscerocranium (facial skeleton)?	A. Mandible
	B. Nasal
	C. Occipital
	D. Temporal
	E. Vomer

---

Rochford, K. (1985). "Spatial learning disabilities and underachievement among university anatomy students." *Med Educ* 19(1): 13-26.

Luursema (2018) The relevance of spatial ability for anatomical learning (submitted)

Vorstenbosch, M. A., et al. (2014). "Exploring the validity of assessment in anatomy: do images influence cognitive processes used in answering extended matching questions?" *Anat Sci Educ* 7(2): 107-116.

# Outcome measures

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- 1) Test questions? Or maybe something completely different?
- 2) Spatial questions / non-spatial

4. Which bone of the skull is highlighted in the image below?



- A. Maxilla
- B. Nasal
- C. Zygomatic
- D. Mandible
- E. Lacrimal

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Rochford, K. (1985). "Spatial learning disabilities and underachievement among university anatomy students." *Med Educ* 19(1): 13-26.

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# Difficulties in studying new technologies

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- 1) Spatial ability
- 2) Cybersickness
- 3) Time-on-topic
- 4) Outcome measures
- 5) Levels of educational outcome**
- 6) Cognitive load

# Educational outcome levels

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- 1) Designed by Kirkpatrick (1967)
- 2) used by the BEME initiative to rate the outcome of an educational intervention

We should be looking for level 2b



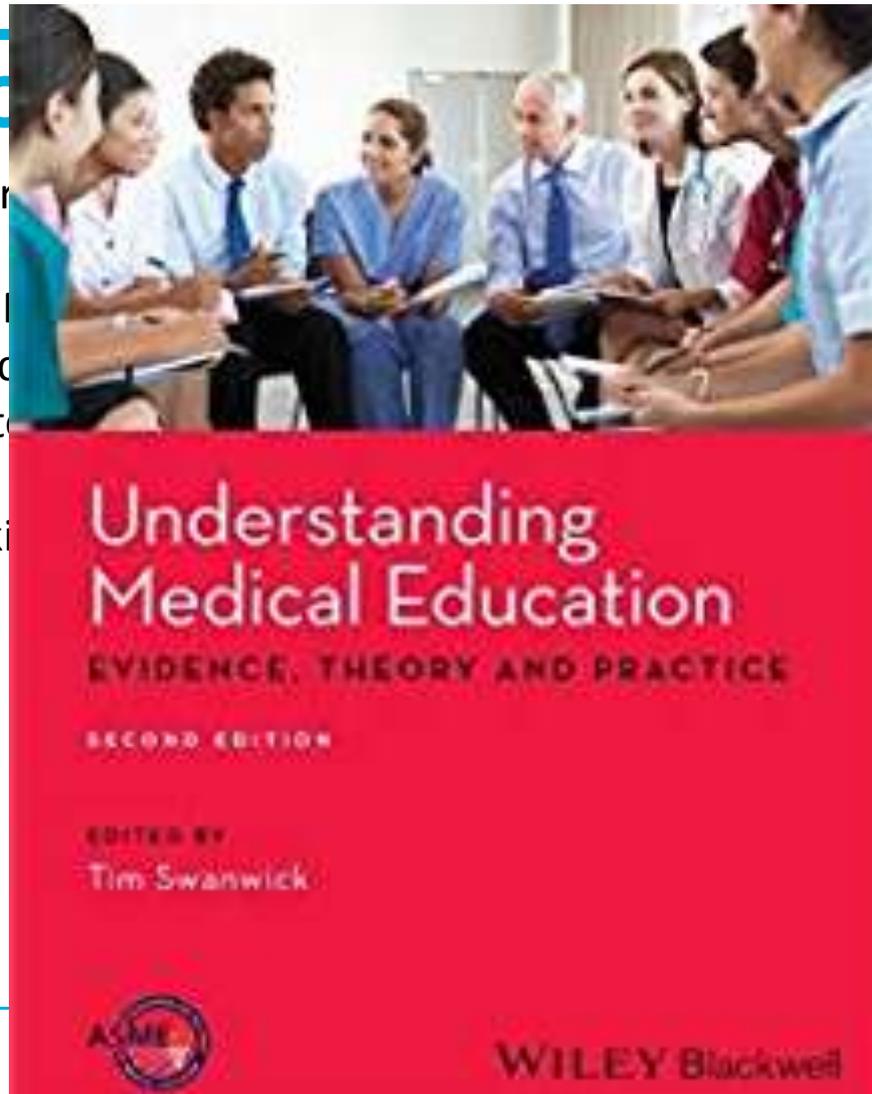
Figure 23.3 Kirkpatrick's hierarchy in medical education.(12)

Figure taken from Swanwick - understanding medical education

# Education

- 1) Designed by Kir
- (1967)
- 2) used by the BE
- to rate the outc
- educational int

We should be looki  
2b



4

3

2b

2a

1

Figure taken from Swanwick - understanding medical education

Radboudumc

# Difficulties in studying new technologies

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- 1) Spatial ability
- 2) Cybersickness
- 3) Time-on-topic
- 4) Outcome measures
- 5) Levels of educational outcome
- 6) **Cognitive load**

# Cognitive load

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Sweller (1989?) Cognitive load theory

Others: Paas, Leppink, van Merriënboer

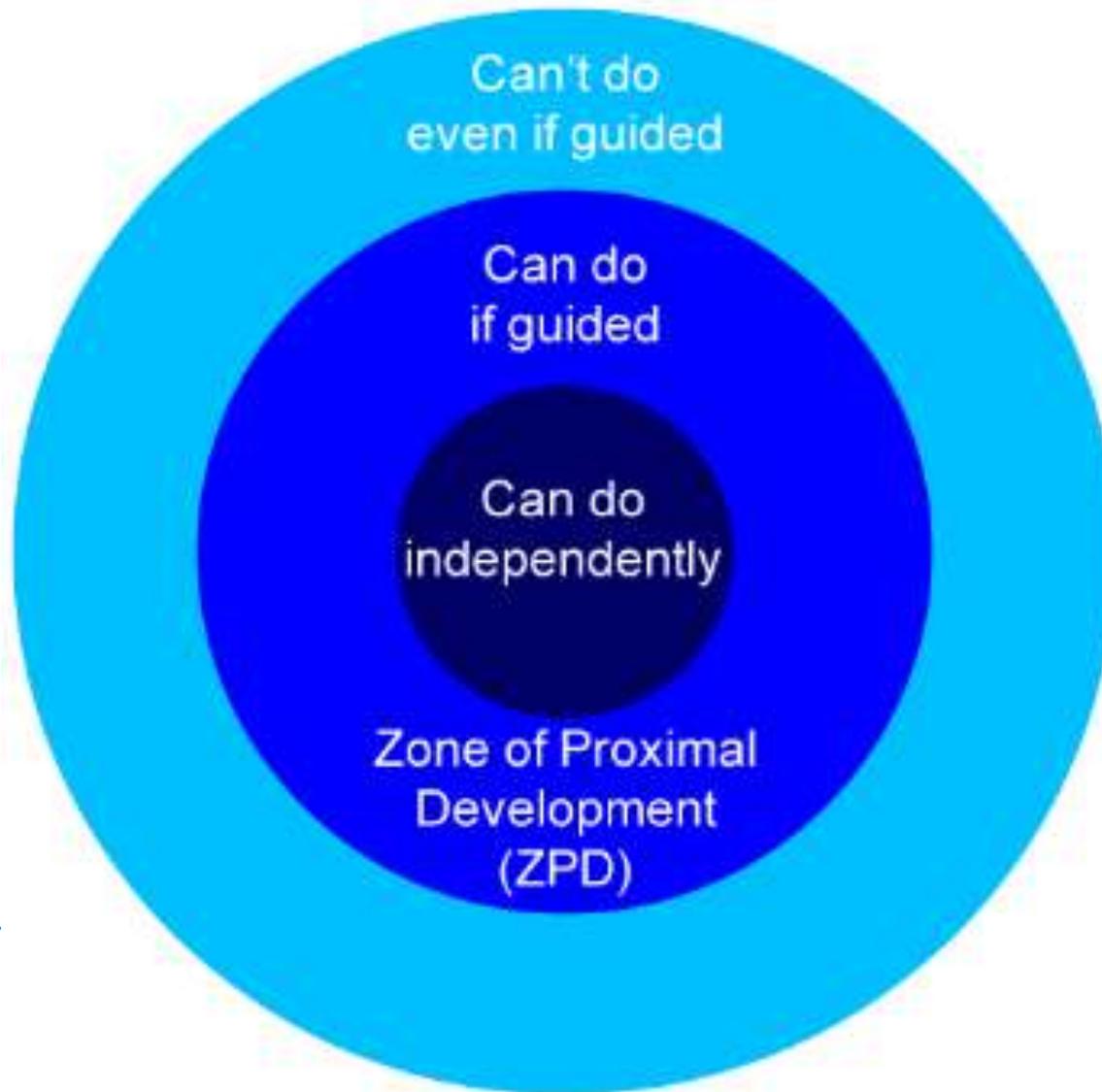
~zone of proximal development (Vigotski)

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(McNulty (2009) evaluation of CAI in a gross anatomy course: a six year study

# Side step Vygotsky

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# Cognitive load

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Sweller (1989?) Cognitive load theory (constructivist theory)

Others: Paas, Leppink, van Merriënboer

~zone of proximal development (Vigotski)

Three types of load on the learning brain

Intrinsic load (content )  
Germane load (helpful didactics)  
Extraneous load (noise)

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(McNulty (2009) evaluation of CAI in a gross anatomy course: a six year study

# My TO DO list

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- Keep teaching
- Wrestle stubborn results of oculus rift experiment
- Develop AR for prosected specimens
- Design a good experiment to investigate its value for learning anatomy

# What is your TO DO list ?

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