An Integrative Theory of Spatial Orientation in the Immediate Environment

b.riecke@vanderbilt.edu • www.kyb.mpg.de/~bernie

Bernhard E. Riecke & Timothy P. McNamara

VANDERBILT UNIVERSITY

• Introduction & Background

How to integrate seemingly different theories on human spatial orientation?

Recently, there has been an increasing interest in theories about human spatial memory and orientation (see, e.g., Burgess, 2006 for a recent review). There is, however, an apparent conflict between many of those theories that yet needs to be resolved.

Here, we outline a theoretical framework that aims at integrating two current theories of spatial orientation:

May (2004): Sensorimotor interference hypothesis

• May (2004) proposed that the difficulty of imagined perspective switches is caused, at least in part, by an interference between the sensorimotor and the to-be-imagined perspectives.

Riecke & von der Heyde (2002): Spatial orientation framework based on logical propositions

• Riecke & von der Heyde (2002) developed a theoretical framework that is based on a network of logical propositions (i.e., necessary and sufficient conditions, see Figure 1). They proposed that automatic spatial updating can only occur if there is a consistency between the observer's concurrent egocentric reference frames (e.g., mediated by real world perception, virtual reality [VR], or imagined perspectives).

• Proposed Integrative Theory

Similar underlying ideas and mechanisms?

We propose that the underlying processes are the same, in the sense that a consistency between egocentric representations (Riecke & von der Heyde, 2002) is equivalent to an absence of interference (May, 2004). Whenever the current egocentric representations of the immediate surroundings are consistent, there should be no interference.
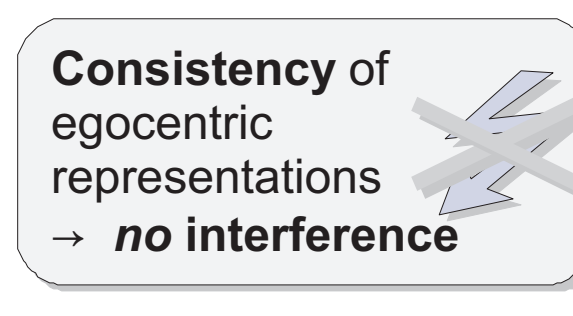
According to Riecke & von der Heyde (2002), this state enables automatic spatial updating in the sense that it is a necessary (but not sufficient) prerequisite (a).

Similarly, we propose that this lack of interference might also be able to explain other important phenomena, such as the relative ease of adopting a new perspective after being disoriented (b) or the occurrence of instant-based, automatic spatial updating/reorientation (despite the lack of any motion cues) when VR users are presented with an immersive, naturalistic view of a new orientation (c).

Conversely, we posit that interference (inconsistency) between the primary, embodied egocentric representation and a to-be-imagined (e.g., experimentally instructed) egocentric representation implies the difficulty of adopting a new perspective, e.g., when proprioceptive cues indicate stationarity (d).
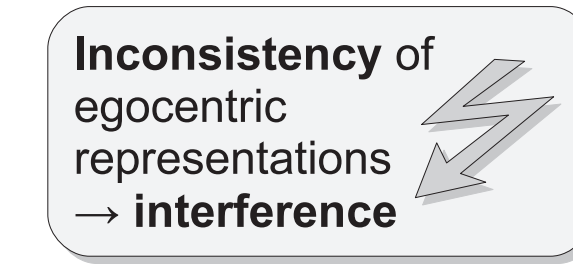
Such an "inhibition of transformation" might also account for the lack of continuous, automatic spatial updating and natural spatial orientation observed for optic flow-based virtual reality (e).

We posit that such interference or inconsistency might also explain the difficulty people have in ignoring bodily rotations, e.g., when physical motion cues trigger an obligatory update of our primary egocentric representation (f).

Figure 1.
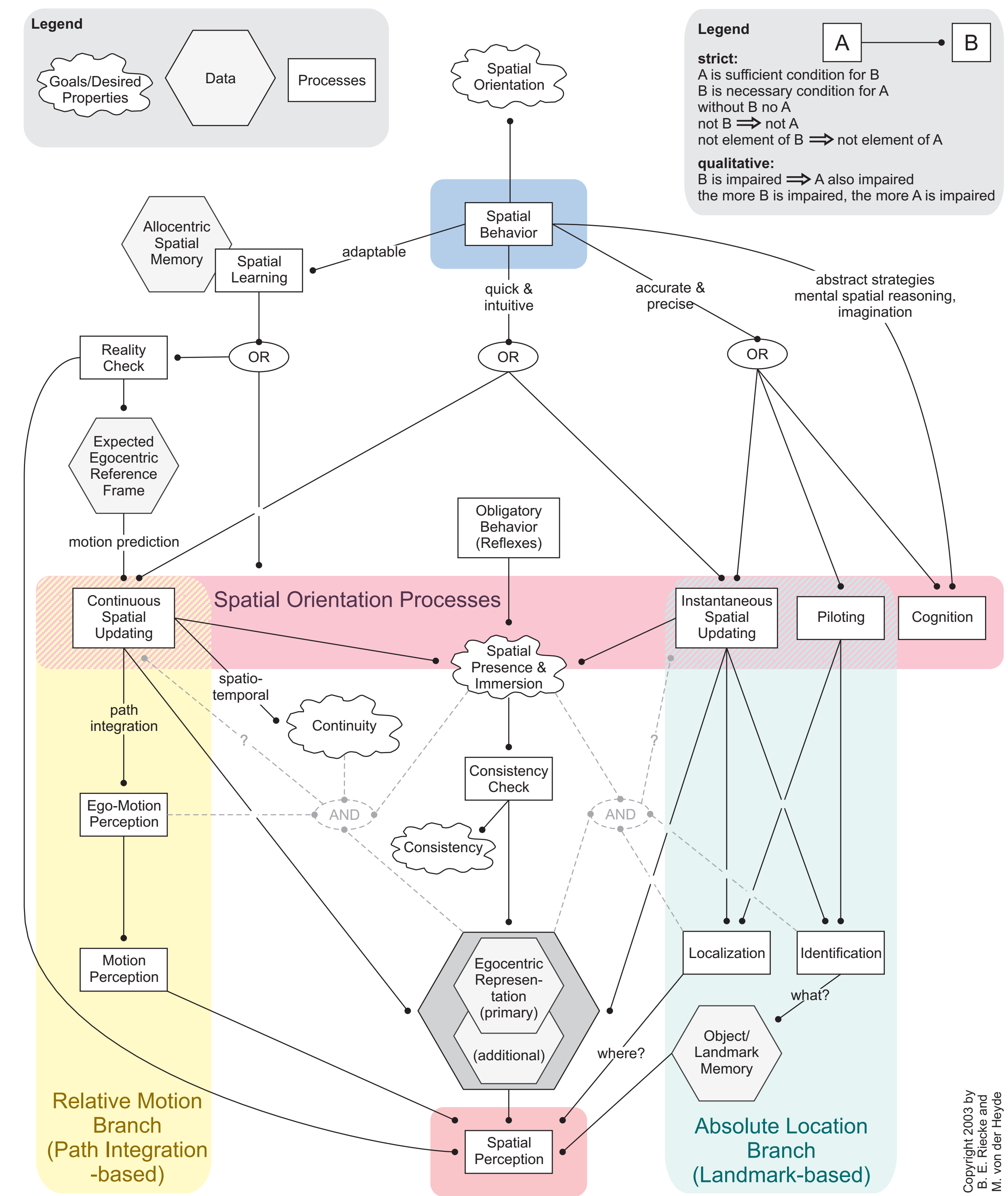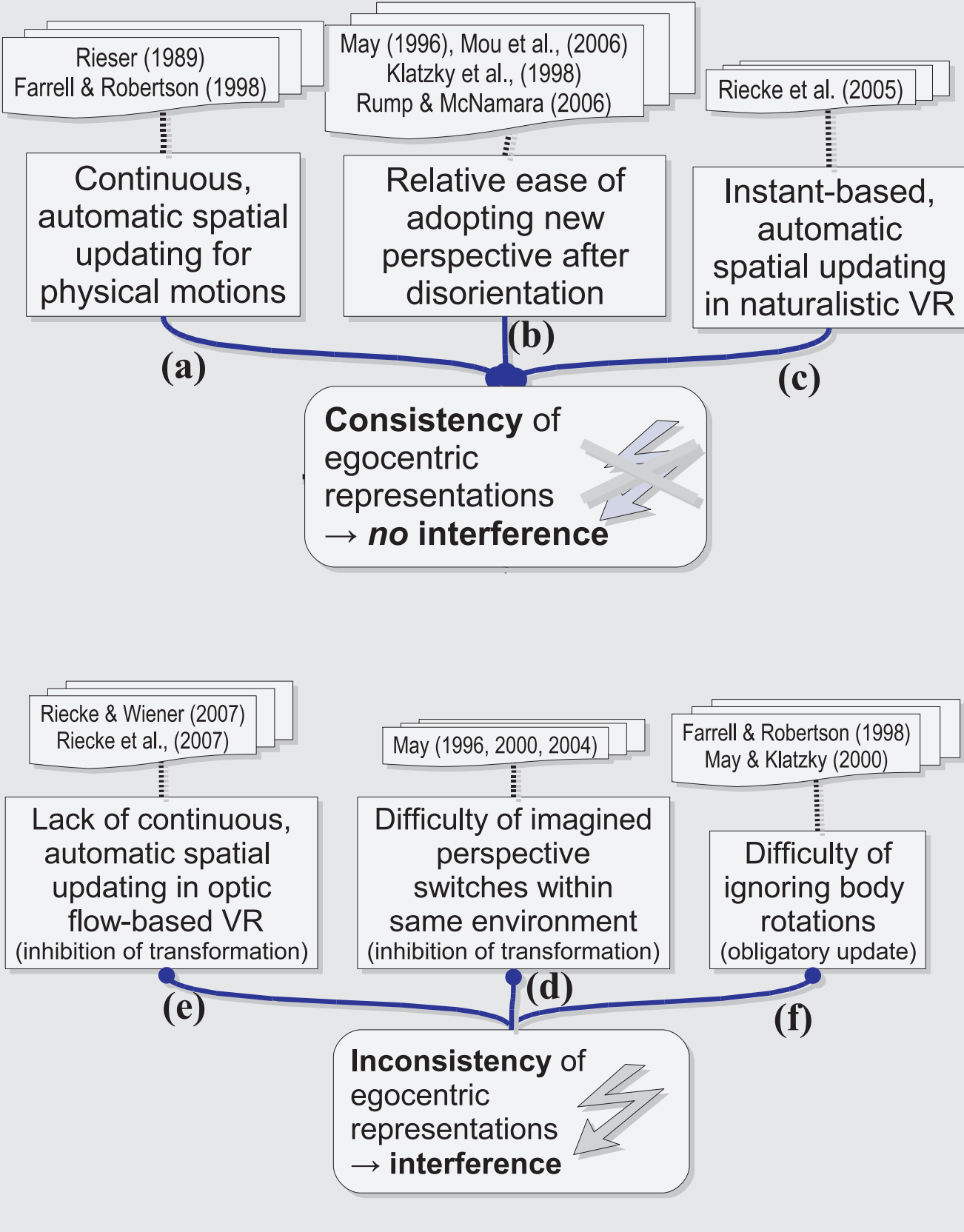
• Conclusions

To avoid the vagueness that purely verbally defined theories sometimes suffer from, we offer a well-defined graphical and structural representation of our framework. Integrating logical and information flow representations in one coherent framework not only provides a unified representation of previously seemingly isolated findings and theories, but also fosters a deeper understanding of the underlying processes and enables clear, testable predictions.
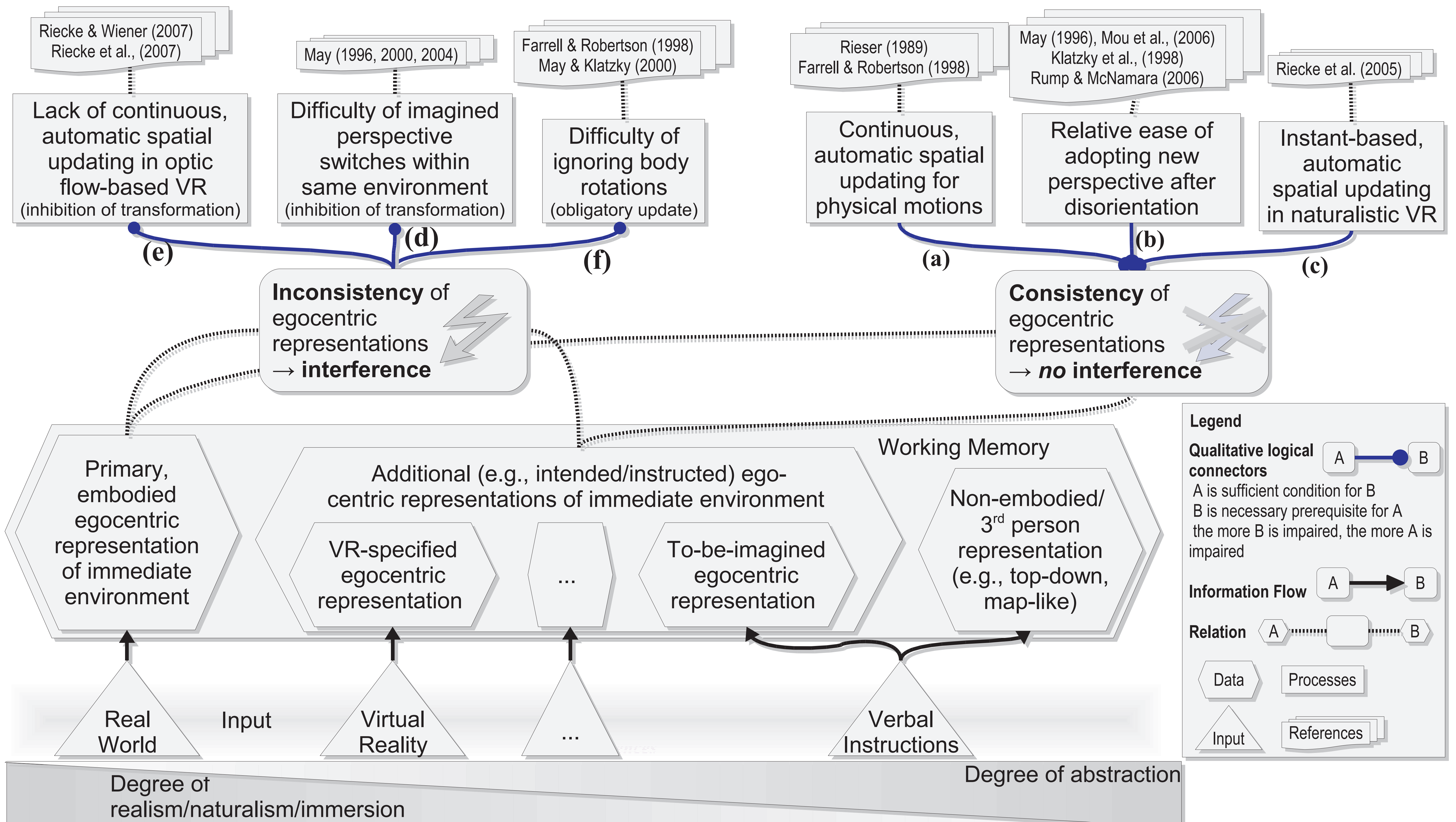
References

Burgess, N. (2006). Spatial memory: how egocentric and allocentric combine. Trends in Cognitive Sciences, 10(12), 551–557.

May, M. (2004). Imaginal perspective switches in remembered environments: Transformation versus interference accounts. Cognitive Psychology, 48(2), 163–206.

Riecke, B. E. and von der Heyde, M. (2002). Qualitative Modeling of Spatial Orientation Processes using Logical Propositions. TR 100, MPI for Biological Cybernetics. Avaiable: www.kyb.mpg.de/publication.html?publ=2021.