The role of visual and spatial representations: What we can learn about large-scale spatial reasoning from experiments in small-scale space

*** FIRST DRAFT – please do not circulate ***

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In her position paper, Merideth Gattis raises the question, whether the cognitive processes in large-scale and small-scale spatial cognition are similar. She argues that the assumption that large-scale and small-scale space involves different cognitive processes seems less justified when we focus on reasoning about space. I agree with this position and will try to show what we probably can learn about large-scale reasoning from reasoning experiments in small-scale spaces. The experiments I will report are concerned with the role of visual representations (visual images) in reasoning. Although it is natural to suppose that visual mental imagery is important in human reasoning, the evidence is equivocal. I will argue that reasoning studies have not distinguished between ease of visualization and ease of constructing spatial models. Rating studies show that these factors can be separated. Their results yielded four sorts of relations: (1) visuospatial relations that are easy to envisage visually and spatially, (2) visual relations that are easy to envisage visually but hard to envisage spatially, (3) spatial relations that are hard to envisage visually but easy to envisage spatially, and (4) control relations that are hard to envisage both visually and spatially. Three experiments showed that visual relations slow down the process of reasoning in comparison with control relations, whereas visuospatial and spatial relations yield inferences comparable with those of control relations. We conclude that irrelevant visual detail can be a nuisance in reasoning and can impede the process.

In another set of studies, subjects had to perform two tasks at the same task. The pattern of interference indicates that spatial secondary task but not visual secondary tasks interfere with spatial reasoning.

In a third group of studies, we used functional brain imaging to investigate the neural correlates of spatial thinking. In these studies, the cortical activity evoked by

relational reasoning depended on the nature of the relations. Visual relations such as ''cleaner'' or ''dirtier than,'' evoke visual images, whereas other relations do not. All relations, however, lead to the construction of models that underlie the inferential process. These models are spatial in form for spatial relations, such as ''north'' or ''south of,'' and for visuospatial relations, such as ''above'' or ''below.'' They may also be spatial for control relations, such as ''better'' or ''worse than.'' This view is consistent both with the finding that visual relations slow the process of reasoning and activate regions in secondary visual cortex, and with the finding that all relations activate regions in parietal cortex underlying spatial representations. The phenomena are consistent with the theory of mental models. A further corollary is that visual imagery is not a mere epiphenomenon playing no causal role in reasoning (e.g., Pylyshyn,1981, in press). In the talk, I will try to translate the findings from small-scale reasoning to thinking in large-scale spaces.