A Topological Interpetation of Cognition

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The human brain consists in broad outline of the neocortex, the limbic system, and a midbrain core. The neocortex is connected to the limbic-midbrain system B by many back-and-forth projections, a structure consistent with Pribram's three primary brain systems: the modality-specific posterior intrinsic systems P, the projection systems, and the frontal intrinsic system F. Topologically, such a structure constitutes a fibration, or fibre bundle p: P Æ B, consisting of a base space B and overlying it, a total space P made up of tubular neighborhoods that project down to the base space B. There is also a "lifting map" from the base space to the total space. In the perceptual application, the lifting map consists of afferent nerve signals transmitting sensory stimuli to Short Term Memory, while the projection maps are embodied in efferent and corticortical nerve flows. This structure is consistent with neuroscientists' current general agreement that cortical structure is at the same time "topographic" (e.g., retinotopic), laminar (cytoarchitectural layers), and (micro)columnar. The latter have both a local directional ("orientation") response and an areal one, which together generate visual contours, for example, as "lifts' of retinal stimuli.

The posterior intrinsic systems "mediate invariant properties of specific sensory modalities," e.g., the psychological constancies, shape memory, and the Gestalt "laws." Many researchers in psychology have recognized that cognition requires continuous transformation (Working Memory); some (Berlyne, Cassirer, Culbertson, Dodwell, Hoffman, Palmer, Piaget, Pitts & McCulloch, Rashevsky, Wiener) have further recognized that continuous transformation groups G x P $\rightarrow$ P ("continuous symmetry") are required for such invariances. In particular the invariances of the psychological constancies: shape, size, color, motion, pitch, loudness, and binaural localization, are structured in this way. In the perceptual case this leads to the LTG/NP ("continuous transformation groups constrained by neuropsychology") theory. The group G's action, which "drags the flow" along the path-curves or "orbits" (e.g., visual contours) of the perceptual field via the local action of the group's Lie derivatives, corresponds to proprioceptor/teleceptor inputs. The result is an "orbifold" made up of visual contours representing such orbits. The Lie derivatives have the proper local morphology to be embodied in the stellate and pyramidal cells of isocortex. Also appearing is a cotangent functor T* generating a local orientation response similar to that of cortical microcolumns.

Cognition consists of two primary entities: percepts and concepts. Percepts represent the outcome of attention (efferent blocking) upon perception. Concepts consist of the semiotic aspects of percepts, procedural and declarative memory, and rational thought, and are colored by emotions imparted by the limbic system. The frontal intrinsic system processes complicated sequences of actions or trains of thought that are consonant with limbic system processing to minimize cognitive dissonance. Such processing has the character of the symmetric difference operation - "one or the other but not both together" - plus its complement, in the familiar paradigm of differences (discriminations and classifications) and similarities (commonalities) and context. This structure is isomorphic to the category of simplicial objects, whose organization is like that of information processing psychology. It then follows that Riegel's dialectical psychology and information processing psychology are, at least for paired comparisons, isomorphic. The fibre bundles of the posterior intrinsic systems constitute a (mathematical) category, which is mapped functorially into fibrations in the sense of Kan in the category of simplicial objects characteristic of the frontal intrinsic systems.

References

W. Hoffman (1985). *Internat. J. Man-Machine Studies* **22**, 613-650.

W. Hoffman (1994). pp. 363-382 in: O. Ying-Lie et al.(Eds.), *Shape in Picture*. Springer-Verlag.