Mind-Brain Relations, Geometric Perspective and Neurophenomenology

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Abstract

Rationale for creating geometrical approaches that may help to understand mental processes and relate them to neural processes, is presented. Current phenomenology for describing mental processes is not sufficient to create first person science. Models exploring relations between neurodynamics, geometric representation of mental events and inner perspective are the best chance for progress in this area.

Understanding the mind

Two general approaches to mental processes responsible for consciousness and behavior are currently pursued. Psychologists approach the problem with verbal theories based on high-level concepts, such as "intelligence" or "working memory", that are useful to characterize behavior but quite hard to precisely measure and link to neural activity of the brain. Neuroscientist tend to think that more details are needed, and once they will be known cognitive mechanisms will become clear. Michael S. Gazzaniga, a pioneer of cognitive neuroscience, does not share this opinion:

> Understanding how each and every neuron functions still tells one absolutely nothing about how the brain manufactures a mental state.
>
> The trick for any level of analysis is to find the effective variables that contain all the information from below that are required to generate all the behavior of interest above (Gazzaniga 2010).

This is what I have been advocating for a long time (Duch 1994-2011), trying to create a new intermediate level of description between neuroscience and psychology. Brain processes described by parameters derived from neuroimaging show activity of individual neurons and neural cell assemblies that are difficult to relate to mental events and inner experience. Psychological description of mental events is largely a confabulation that ignores the real neurodynamical forces responsible for activation of mental states. Consciousness will seems less mysterious if good metaphors will be found to talk about models of mental processes, metaphors that will help to imagine what really goes on in our minds.

We are visual beings, cortex engaged in analysis of visual information takes a significant part of the brain, and thus the most satisfactory way to understand is to see or imagine. Geometrical model of the mind providing space in which mental events take place, linked with neurodynamics that is responsible for these events, could have a great explanatory power.

Inner perspective

Detailed simulations of the brain will not necessarily help to understand the mind in a conceptual way. On the other hand attempts to describe inner experience, or phenomenal consciousness, started in the 19th century by introspective psychologists (Fechner, Wundt, Titchener, Würzburg school), and followed by phenomenological movement originated by Husserl, failed to agree on such basic issues as the existence of imageless thought. Phenomenology led eventually to a deep analysis of perception by Merleau-Ponty. Heidegger has focused on embodiment and situated cognition, paying attention to affordances. Varela formulated experimental phenomenology and neurophenomenology program trying to link the first person approach to the objective science (Varela 1996).

However, recent experiments with random descriptive experience sampling technique (Hurlburt and Schwitzgebel 2007) and Schwitzgebel's (2010) discussion of phenomenal experience cast serious doubts on the feasibility of science of inner experience. The main reason for this difficulty is rather clear: metaphorically speaking, mind may be seen as a shadow of neurodynamics. Almost all processes that determine our thoughts and behavior are hidden behind the scenes, inaccessible to conscious introspection (Lewicki & Hill 1987). The richness of neurodynamics makes the verbal description of inner experience possible only in restricted way, using symbols for commonly encountered categories suitable for communication.

Modern platonic view

In the famous allegory presented in the "Republic" of Plato prisoners in a cave are able to see only shadows of real things projected on the wall, while the task of the philosopher is to perceive the true form of things. Mental events resemble such shadows of reality, but instead of idealized forms what we are able to experience can be best described at the level of neurodynamics. Mental events reflect in an active way those features of the environment that are important for survival, and with the modern "mind reading" techniques based on various forms of neuroimaging (EEG, MEG, fMRI, NIRS) our ability to reconstruct mental experience from brain activations is improving (see for example Nishimoto et al. 2011). Although many genetic and biochemical processes that change glia and neural cells and their interactions are relevant to understanding behavior neural correlates of mental experiences are probably captured with sufficient accuracy at more coarse level of neurodynamics, rapid changes of electrical activations of neural assemblies in the brain.

Biochemical processes responsible for changes in the brain at the molecular level, including neuroplasticity, determine potentially accessible brain states. At this moment mental states that I may experience are determined by general structure of my brain (evolutionary factors), neural pathways that have been formed as a result of development in infancy followed by the life-long learning, recent priming by experiences (including thoughts and feelings) that changed the landscape of potentially accessible brain activations. All these factors determine the space of my potentially accessible mental states at this moment. Let's called the current mental state $M(B(t))$, where $B(t)$ is the brain state at time t and M is a function mapping brain states to mental states.

John Locke (1690) defined consciousness as "the perception of what passes in a man's own mind". What we are able to perceive are just peaks of neural activity that are sufficiently persistent to be internally categorized, so that the brain may know what is going on. This process requires association of quasi-stable brain activity patterns at a given time with motor activity that allows animals to react, and with activation of symbolic representations (manifested as speech or silent thoughts) in human brains, including representations of self (Damasio 2010).

Mapping continuous activations of the brain $B(t)$ to mental states $M(B(t))$ leads to information compression, simplifying the decision making process. Perception needs to be invariant, ripe red apples should look red independent of the illumination conditions. Although information about the spectrum of light reaches the brain it is not a part of mental experience. Object recognition allows to recognize functional categories, discover affordances and prepare for action. Recognizing mental states of other people serves similar purpose. The number of categories has to be limited to be useful, therefore we cannot have infinite number of symbols to describe precisely all mental states. Although most of the time general categories are sufficient to make decisions brains may focus on particular experience, experiencing *qualia*, specific brain activations that may be only roughly categorized at the symbolic level. Strange qualia may be created in unusual situations (Schwitzgebel 2010; Duch 2011), in dreams, hallucinations, visual illusions, peripheral vision, through imagery, strong emotional experiences or by direct transcranial stimulation of the brain with magnetic field. Brains need to learn through repetition how to categorize new experiences, give them labels and "explain the experience away" so there is no need to waste time on detailed analysis anymore. Names put the mind at ease, suck neural activation and relief anxiety.

Brains and experience

Most animals have little brains and therefore can distinguish only relatively small number of ecologically important quasi-stable brain states reflecting their observations and controlling associated actions. Humans with much bigger brains have many parallel competing processes and thus much higher capacity for diverse mental experiences. Quasi-stable brain states are categorized, associated with other states that win the competition (the Self grabs all the credit calling this process "I pay attention") and comments are generated: this is a great wine, with a rich taste, smell and a deep red color. These comments are intentional, pointing to something in the shared space out-there in the world. In fact they always refer to physical activation of the brain that makes them. They are brain reactions, subjective experiences of qualia that cannot be reduced to discrete categories labeled by finite set of words. The brain-like systems, by their very construction, have to claim qualia and experiences (Duch 2005).

Brains are truly the meaning machines that physically change themselves. They are changed by top-down causal processes – mental events caused by environment, or by inner activity – and bottom-up processes that may either be initiated by subliminal stimuli or have physiological or genetic origin. We do not have experience with building such systems and analyzing their behavior in conceptual terms. Our conceptual understanding of what brains do is not expressed in terms that are natural from brain perspective. While the function of the primary sensory cortices may be partially understood using such concepts as spatiotemporal filters for specific information (orientation of the edges, specific frequency, movement, color), we do not seem to have concepts that could be mapped to activation of some brain areas. For example, initially it seemed that area V2 responds to simple visual characteristics (we see what we look for), but now it is known that it responds also to complex shape differences, orientation of illusory contours, and can distinguish between the same stimuli in foreground or background position. Higher visual areas V3-V5 have functions that are associated with some combination of motion, shape and color, but it may be easier to create a working model than to describe it in conceptual terms. The same is true for other sensory modalities.

Maybe we have not learned yet to pay attention to the kind of information that these intermediate areas are extracting because it may not be that useful in communication. This could be an interesting area of research for neurophenomenology (Varela 1996).

Information in brains

All signals that reach and change the brain carry some information, although it's value may not be immediately accessible at the mental level. Shannon information simply estimates signal entropy and thus is not a good measure of what is intuitively regarded as information relevant for a cognitive system. Calling entropy "information" created a lot of confusion. The amount of change that is induced in the brain (or in any cognitive system) by incoming signals may be used to quantify information (Duch 2007). Information is not only relative to cognitive system, but also may have different value depending on its influence on different functions of that system. From a formal Bayesian perspective cognitive system S that has probabilistic model of its environment $p(S)$ is changed by a new observation X to a posterior model $p(S|X)$. The difference between $p(S|X)$ and $p(S)$ measures how big was the change induced by the new observation. It may be understood as the value of the information in observation X relatively to the model S. This is not a static quantity, the change in cognitive system may be temporary, it may suddenly restructure the system or slowly grow in time. New information may be generated by the internal flow of brain activations, thinking processes that change the pathways through which neural activation is spread.

The space of potentially accessible mental states evolves in time, reduced due to the brain damage or enhanced due to learning and experiencing new stimuli. These changes may have profound influence on mental states, but the space of all potentially accessible mental states in a lifetime of a person is always limited. Imagine a space $IB=\{B(L)\}$ of all potentially accessible states that a particular brain may go through in a lifetime L. Individual life history forms a single trajectory $B(t \in L)$ in this space, describing actual activation states of the brain and resulting in corresponding trajectory of mental experiences. All human brains and their potential states span a space HB of potentially accessible brain states and the corresponding space HM of mental states. Billions of individual trajectories go through this space, but it is still constrained by human brain capabilities, although potentially it may expand enormously due to the brain-machine confluence. The limits of this expansions are not yet fathomable.

The mapping from neural activity to various categories of mental events is slowly elucidated by cognitive neuroscience and it seems feasible that thoughts could be made audible – auditory cortex activation has already been analyzed to reconstruct speech signal (Pasley et al. 2012). Understanding information flow in the brain will be greatly boosted by the Human Connectome project. Models showing how inner, first-person point of view develops in complex systems, have not been created yet. In "Self Comes to Mind" Damasio (2010) argues that autonomous systems represented their internal body images and patterns of the environment, reacting emotionally to stimuli that perturb their homeostasis. Self is based on such emotional reactions and in complex brains memory and feelings, subjective experiences of emotion, combined with symbolic representations, create conscious, mental perspective. However, the road from such general understanding to detailed working model is long.

How can complex processes creating the inner perspective be noted in the overall activity of the brain? I have proposed (Duch 1994-2011) to use visualization based on transformed brain activity signals for bridging the infamous "explanatory gap" between brain and mind, with neuroimaging of neural activity on the physical side and the description of mental events from the phenomenological, first person perspective on the other (Lutz & Thompson 2003). Visualization should lead to a geometrical model of mental events, showing mind state trajectories that may be linked to neurodynamics, information flow in the brain, and the subjective experience. Mental events, "shadows of neurodynamics", may be seen in low-dimensional feature spaces where each dimension represents phenomenological property, a specific quality extracted from neural processing.

What kind of phenomenology should be used for such models? It is quite likely that current ways of describing our mental experience will not be sufficient and that we shall have to invent quite new concepts. Description of cognitive systems from this perspective should be more detailed and faithful to the underlying neurodynamics than our current folk psychology allows for.

Language in the brain

Dynamical system approach to cognition has deep roots in cybernetics. It has been mainly focused on description of external behavior (Kelso 1995), including infant's development (Thelen & Smith 1994; Smith and Thelen 1994), and sensori-motor activity. In "Mind as motion" book edited by Port and van Gelder (1995) other perspectives on the use of dynamical system theory for description of cognitions have been introduced, including language.

Flexibility of knowledge representation by patterns of brain activity has not yet been matched by any other knowledge representation framework in artificial intelligence. Jeffrey Elman (Port & van Gelder, Chap. 8) treats representations of concepts as regions in the space of brain activations, and grammatical rules as restrictions on the possible trajectories in this space, leading to the attractor dynamics responsible for language structure. Simple recurrent neural networks serve him as a model of linguistic systems, predicting next word in a sentence. The activity of the internal (hidden to the observer) neural units displayed in the principal component coordinates shows the dynamics of this process. Gilles Fauconnier introduced "mental spaces" (Fauconnier 1985) and later conceptual blending (or integration) as a general theory of cognition (Fauconnier & Turner 2002).

Visualization of neural processes during reading shows how associations are made (Dobosz & Duch 2011). Transitions between thoughts are due to the neural fatigue, depletion of energy needed to synchronize neural activity (fixing of attention, in psychological terms). Those groups of neurons that are only slightly active may increase their activity and shift the pattern to associated concept, forming a new coalition. Thoughts may jump to seemingly unrelated subject when a new pattern of neuronal interactions is formed, giving earlier coalition time to refresh. There are many transition pathways between concepts, the dynamics of the process is influenced by noise and many uncontrolled factors, including the history of previous activity. The order of learning matters. Teaching students ancient concepts at the beginning of the curriculum, as it is usually done in philosophy, creates a tendency to evaluate new ideas in terms of the old ones. Mapping from brain activity to events in mental spaces to behaviors and verbalizations is where the "continuity of mind" will reveal itself (Spivey 2007).

Minds are embodied and studies of motor development are certainly relevant for better understanding of cognition. The ultimate goal of dynamical approach is to describe behavior using differential equations. This, however, is not the same as describing inner experience and in the current form may not be a good candidate approach to bridge the explanatory gap.

Connectionist movement has focused on a low-level brain processes and also did not connect it with mental events. Paul Churchland (1996) has made the best attempt so far to introduce connectionist ideas to the philosophy of mind, but the influence of these ideas on philosophy and psychology has not been significant. "Studies in neurophilosphy" by Patricia Smith Churchland (2002) elucidated many points related to perception, containing diagrams showing how faces change with mouth fullness, nose width and eyes separation, taste space using aggregates sour, representation of male and female faces, salty and sweet cell responses, and relating it to the network and vector representations. Their proposal "that brains develop high-dimensional maps, the internal distance relationships of which correspond to the similarity relationships that constitute the categorical structure of the world" (Churchland & Churchland 2002) follows earlier work of Roger Shepard (1987, 1994) on universal laws and invariants in psychology.

Shepard's dream to create a theory of mind similar to theories in physics pointed him to search for cognitive universals, natural invariances in perception reflecting properties of the world. Indeed, similarity in brain responses in perceptual and conceptual domains reflects similarity or dissimilarity of observed objects and events in the space of salient features. This space is obviously different for different animal species and different people, changing in many ways with different time scales, depending on the age, current goals and motivations that control the focus of attention.

Many faces of dynamical cognition

Similar ideas have been floating around in psychology for a long time. Kurt Lewin (1938), recognized as the father of modern social psychology, wrote a book outlining dynamic psychology in 1938 (Lewin 1938). Psychology should represent and derive psychological processes in conceptual way, but observable facts are not sufficient to achieve it, therefore hidden "constructs", or "intervening concepts" have to be postulated. Inspired by the successes of physics Lewin has introduced psychological forces. Human behavior should be described by a trajectory in physical space, controlled by forces defined in the hidden, psychological space. Both external and internal forces are responsible for individual behavior and group dynamics.

Force Field Diagrams, graphs and tables, introduced by Lewin, are still used is social psychology to analyze factors that push, block or divert people from pursuing their goals, determine balance of power. Lewin's basic idea was that behavioral space should be approximated by discrete meaningful states. Such prototypical states may serve for prediction of behavior, in a similar way as diagnosis of a disease, based on clinical phenotype, serves to select the therapy. Work on probabilistic versions of these ideas is still continued (Rainio 2009).

George Kelly made another step towards visualization of psychological processes in "The psychology of personal constructs" book (1955), proposing explicit geometrical representation of personalities. In his view constructs are a relatively small number of psychological processes that can be described using dimensions based on opposite concepts, such as "good-bad" or "happy-sad", useful for making important distinctions. Personal, individual constructs are dimensions of psychological space that characterize people and their mental states, describe their subjective reality. Results of this analysis are presented in Repertory Grid matrix, with rows representing constructs and columns representing various types of elements, for example people, or mental states (Shaw & Gaines 1992). Personal Construct Psychology (PCP) has been applied to cognitive modeling, and is used in practical applications in social psychology, psychotherapy, personality assessment and human resources in business context.

Peter Gärdenfors (2000) introduced conceptual spaces as a framework for modeling representations, using spaces based on qualities (for example, perceptual qualities), phenomenal dimensions that can be inferred from perceived similarities using multidimensional scaling, as Shepard has done. This approach is also aimed at using high-dimensional geometrical model of cognitive representations for perceptual and linguistic concept representations as an alternative to symbolic and connectionist models. Gärdenfors' book "Conceptual Spaces: geometry of though" has been very popular and, among many other trends, gave rise to formal conceptual space algebra, the Conceptual Space Markup Language (CSML), an exchange format for sharing conceptual spaces (Raubal & Adams, 2010).

Work on knowledge representation in artificial intelligence has brought very similar ideas, for example Conceptual Knowledge Markup Language, developed from the perspective of formal semantics, ontology and semantic networks. Many applications of conceptual spaces have been developed in such areas as cognitive linguistics, analysis of actions and functional properties of agents, and understanding the dynamics of empirical theories as conceptual change in structured collections of dimensions.

In the "Continuity of Mind" Spivey (2007) describes mental events as continuous trajectories in the state spaces based on activity of neurons or neural assemblies. This idea follows "neural spaces" that internalize various regularities encountered in the environment (Edelman 2002), for example tune neurons and sensory organs to respond with maximum discriminatory power to subtle differences found in the environment.

Thinking about temporal dynamics of mental processes, "continuity of mind", moves away from discrete, symbolic representations towards geometric, continuous models. To explain and understand what these models do Spivey (2007) tries to describe trajectories of the brain activations in a symbolic way using technique known as "symbolic dynamics", but this is a crude approximation that suffers from combinatorial explosion of the number of symbols necessary to use it in high-dimensional spaces. Moreover, trajectories in the brain-based state space have to be related first to the qualities of experience that are used for description of inner experience.

Mental models

The field of mental models has been developed with the hope of explaining language and reasoning (Johnson-Laird 1983), with symbolic elements constructed from real and imagined percepts. Large number of possible complex models will of course lead to poor performance. Tendency to focus on a few among many possible models will lead to erroneous conclusions and irrational decisions. Mental models represent explicitly what is true, but not what is false, contributing to systematic errors in thinking. How and why do we reason the way we do? Why should such questions have answers that are independent of neurodynamics? Theory of mental models has ignored many forms of learning, including priming effects that are quite pronounced in experimental psychology and show clearly in computational models.

Conceptual constructions used in mental models may be considered true only if they capture simplified neurodynamical processes, but no systematic attempt in this direction have been made. Mental models could probably be derived by analyzing activations of brain subnetworks resulting from priming (or more general learning processes) by the description of the problem, creating probabilistic models of the flow of neural activation, and discretizing this model to express it in symbolic way. A step towards this has been made using the Fuzzy Symbolic Dynamics (FSD) technique (Dobosz & Duch 2011).

In counterintuitive situations, for example in the inverse based rate categorization experiments, psychological conceptualizations are confabulations with insufficient grounding in reality (Duch 1996). If the empirical results were mislabeled psychological explanations could be still easily created, making this type of explanations not much better than theories of psychoanalysis.

Even simple logical forms of reasoning may be difficult for the brain. Consider the following syllogism:

- All academics are scientist.
- No wise men is an academic.

What precise conclusion follows about the relation between wise men and scientists? Out of 256 possible syllogisms only 24 are valid and thus there is an ample room for making errors. Indeed, students faced with such syllogism make all kinds of errors and have great difficulty to discover true conclusion. Even when they are told the answer after a few month they may give wrong answer during exam. Syllogisms are known since ancient times and with proper training in logic errors may be avoided, but numerous natural biases leading to cognitive illusions and errors in thinking have their roots in brain dynamics.

Cognitive architectures

Cognitive Architectures (Duch et al. 2008; Taatgen & Anderson 2009) are computational models of agents that act and reason using some form of perception. These models are formulated either at the symbolic, conceptual level, using theoretical constructs such as executive controllers, or at the subsymbolic, connectionist or more detailed neural level where complex cognition should emerge from simpler interactions. In practice many models are based on hybrid combinations of various functions modeled at different levels.

This level of modeling is suitable for extended behaviorism, but it ignores the dynamics of the inner processes. Ultimately cognitive architectures should provide insight into relation of computations to mental states, although such programs lack persistent dynamical states needed for brain-like information processing (Duch 2005). Bottom-up constraints are easily built in the cognitive architecture models. Top-down factors that should change mental content and lead to a reconstruction of internal models as a result of interaction with environment, or as a result of internal model dynamics, are not yet well captured in such programs. Cognitive architectures have brains that act as control systems, but no minds, no space to place dynamic processes where mental content, actual percepts, thoughts, stream of associations, all information about itself that the system can directly sense. Concepts do not have proper semantics, they are not grounded in perception and affordances, ontologies are a poor substitute for rich imagery of objects and events.

Perhaps combination of mental models, conceptual spaces and conceptual blending may be quite fruitful and will help to illustrate why we suffer so easily from cognitive illusions (Pohl 2004).

Geometry of mind

In geometrical approaches there is no direct relation between objects and events and their abstract representations, only relative similarity relations are preserved. Representation is thus not on the level of individual objects, but rather the whole domains, called by Churchlands (2002) "domain-portrayal semantics".

Although interesting applications of abstract geometrical models may be found (some mentioned in previous sections) the impact of these ideas on understanding cognition has been limited, no links to cognitive neuroscience have been discovered and very few visualizations that could help in understanding cognitive functions have been made.

Geometrical approaches have some obvious difficulties. First, mathematical similarity functions are symmetric S(A,B)=S(B,A), but psychological similarity, or relations between brain activations representing concepts, are usually not symmetric. In psychology individual preferences are added to context, therefore similarity from A's point of view may be distinguished from similarity from the B's point of view. As noted in (Duch 1997) the desired properties of similarity measures require the use of Finsler spaces instead of more familiar Riemannian spaces.

The second difficulty is related to high dimensionality of conceptual spaces. As a result analysis of even relatively simple, but counterintuitive categorization phenomena, such as the inverse base rate effects, require at least 5 dimensions (Duch 1996). Such applications shows the danger of conceptual explanations disconnected from neural models that can capture the dynamics of some real cognitive processes: one can invent all kinds of explanations *ad hock*, but the true reasons for behavior may be much deeper and without connecting geometrical models with neurodynamics we will not be able to understand them.

In principle similarity relations between geometrical representation of mental events should reflect similarities between patterns of activations of the brain areas aroused by these events. Understanding high-dimensional neurodynamical systems described by neural activations seems to be hopelessly difficult unless some way of dimensionality reduction is applied.

Neuroscience provides us with only very rough representation of the brain's global state, but reading intentions from the EEG signals, used in the Brain-Computer Interfaces, makes constant progress and shows that transformation from brain-related variables to mind-related variables describing intentions, is possible, although our conceptual framework will not be sufficient to accurately describe it.

On the technical side there are many approaches to dimensionality reduction that preserves important information, with multidimensional scaling popular for visualization of relations in psychology and latent semantic analysis (Landauer & Dumais 1997) used for visual representations of lexical concepts.

Relevance of philosophy

Although the brain matter is a necessary substrate for mental processes detailed neural models may not bring us closer to understanding the mind any more than detailed models of bird wings and feathers would help to understand the dynamics of flight. Cognitive neuroscience is quite young discipline that tries to create a coherent picture of the brain and its functions. Many research groups are attempting detailed brain simulations, but even if perfect simulation of all functions will be achieved, will it help us to understand mental events? The famous Blue Brain project has created precise simulation of cortical minicolumns but it has not proposed any new ideas helpful for conceptual understanding of relations between neural and mental processes.

This is still an area where philosophy, systematic reflection on concepts, can make important contribution, provided that relevant questions are asked. Philosophy has largely ignored reality, staying at the rarefied conceptual level, making itself irrelevant to science. This is true also for many branches of psychology, where theoretical constructs determine the way experts think and analyze experiments. This may be a more subtle extension of folk psychology concepts (Churchland 1996). Like in the joke about the men who was searching for the lost keys near the lantern where there was light, although the keys were lost somewhere else, we search for the knowledge not where it can be found but follow the concepts that structure our ways of thinking.

Neuroscience answer to Searl's Chinese Room (2001) though experiment is to look at what generates in the brain the feeling of understanding, how the brain may learn proper model of relations between the concept, mapping it to what is already known. One does not need special powers of neurons to do it. Certainly scientists are not going to take such conclusions well.

Some fundamental problems of cognitive science, neuroscience, brain-inspired cognitive architectures in artificial intelligence, may be due to the wrong conceptualization. One such example is the proposal to use kernel methods, popular statistical technique for analysis of data, loosely connected to perceptrons that are rough models of single neurons (Jäkel et al. 2009).

Systematic approximations to neurodynamics may provide an alternative, more fruitful approach. Several question should be discussed: in view of the complexity of the mind is geometrical approach possible at all? Can approximations to neural dynamics at the mental level be really successful despite limited knowledge of brain mechanisms? Will geometrical approach indeed help to explain mental processes? Lead to a better method of knowledge representation? How to approach it?

Many (hundreds?) of subspaces connected to specific brain functions may be defined: perception breaks into many components, motor activity memory, social perception, speech – phonemes, prosody, general sounds, emotion and moral reasoning, abstract concepts. Activity in these subspaces is combined in combinatorial way in real time due to the competition for attention.

Thus the final picture of mental processes may be composed of not just one stage with a spotlight of conscious attention, but numerous flashlights that in a coordinated way illuminate important elements on the grand stage of mental space. Sometimes specific lights may be missing and the phenomenological interpretation of the resulting becomes difficult or even impossible (Schwitzgebel 2010, Duch 2011).

There is no phenomenology ready to be used for relating the mental scene to existing knowledge. New concepts have to be invented and learned. The final question is: how can we know about ourselves, what may be learned from internal information flow in the brain and what has to be learned from observation of results of our own action in the world?

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