Consciousness and co-consciousness, binding problem and schizophrenia

Petr Bob

Center for Neuropsychiatric Research of Traumatic Stress & Department of Psychiatry, 1st Faculty of Medicine, Charles University, Prague, Czech Republic.

Correspondence to: Petr Bob, Ph.D.
Department of Psychiatry
Charles University, 1st Faculty of Medicine
Ke Karlovu 11, 128 00 Prague, Czech Republic
PHONE: ++420 224965314; FAX: +420 224923077
EMAIL: petrbob@netscape.net

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Summary

At this time is thought that binding of synchronized and distributed activity is crucial for the mechanism of consciousness. There are suggestive findings that disturbances in this feature binding produce disintegration of consciousness in schizophrenia. It leads to disturbances in reflection of the self and dissociated psychic fragments may be experienced as parts of the external world. Disturbances in the feature binding that lead to disintegration in neural communication among some parts of the brain thus seem to be a neurophysiological counterpart of psychological dissociative processes related to stress response and cognitive, affective and neuroendocrine dysregulation.

REVIEW

BINDING PROBLEM AND CONSCIOUSNESS

Because of changing stimuli or internally generated activity the brain continuously changes activity patterns of functionally synchronized and integrated groups of neurons. Mechanism that enables functional binding of neurons is not known, but it is supposed that this mechanism is functionally connected to mechanisms of consciousness.

Crick and Koch (1992) in the paper concerning the visual consciousness deal with the problem that a seen object is in the brain represented by groups of synchronized excited neurons located in different parts of the brain. There is growing evidence about these synchronized processes and in any study was not found a special place in which distributed information comes together. This hypothetical place was dubbed Cartesian theatre. Different attributes of visual information are processed in many different parts of the brain but likely without full neuroanatomical convergency, from the classical point of view, necessary for synthesis of processed information (Crick and Koch, 1992; Singer, 1993, 2001; John, 2002). This distributed neocortical processing is according to modern evidence necessary also for other sensory and motor functions (Singer, 1993, 2001).

A solution of the binding problem is an important topic of many approaches to the problem of consciousness. A common traditional view of many scientists is that consciousness emerges from a dynamical nucleus due to persisting reverberation and interactions of neural groups (Singer, 2001; John, 2002). An example is approach by Libet, who thought that subjective experience represents field emerging from neural synchronization and coherence (John, 2002). Physical explanation proposed Freeman, who suggested that images of the world in the human mind emerge due to creating order from non-linear chaotic activity of large groups of neurons (Freeman, 1991; John, 2002). Similarly, also other studies connect consciousness to complexity

and entropy in the central nervous system (Tononi and Edelman, 2000; Sporns *et al.* 2000, 2002; John, 2002; Seth *et al*., 2006). There are also approaches that tend to explain the feature binding as a process with zero-lag correlation ("instant action at distance") without material physical field mediating the interaction. This approach to understand consciousness is based on processes in the brain structures that in principle could be explained using the quantum theory and its concept of the quantum wholeness that means physical process of time independent entanglement between initially interacting and spatially distributed subsystems called quantum nonlocality (Marshal, 1989; Penrose, 2001; John, 2002).

The binding problem presents unresolved problem of neuroscience, which strongly suggest that consciousness represents unity of different parts of the brain and different aspects of locally processed information. In this context, psychopathological processes that cause dysregulation and disturbances in the unity of conscious experience could be closely linked to disturbances of neural binding and coherence in the brain. Historically, consciousness and disturbances of its unity are related to the term dissociation that means disintegration and disassociation of mental contents that constitute memory, consciousness and identity.

DISSOCIATION AND CO-CONSCIOUSNESS

The term dissociation has its origin in the work of Pierre Janet (Janet, 1890; van der Hart, Friedman, 1989) but even before him, in the year 1845, Moreau de Tours used the term psychological dissolution (désagrégation psychologique) (Ellenberger, 1970; Hilgard, 1974). Analogically Hughlings Jackson (Ellenberger, 1970; Meares, 1999) used the term "dissolution" and also the term "dreamy state" that mean splitting consciousness leading to many symptoms, such as depersonalization, derealization, hallucinations and other. Morton Prince, one from Janet's contemporaries, for the first time used the term "co-conscious" in the sense that two consciousness may be isolated from one another (Ellenberger, 1970; Hilgard, 1974). Max Desoir identified two main streams of mental activity as upper or lower consciousness, where the lower one may emerge – for example, in hypnosis (Ellenberger, 1970; Hilgard, 1974). F. Myers introduced the term subliminal Self that was later used also by Wiliam James (Ellenberger, 1970; Hilgard, 1974).

Janet initially elaborated the concept of dissociation in his work 'Psychological automatisms' (Janet, 1890; Ellenberger, 1970; Havens, 1966; van der Hart and Friedman, 1989), where he sketches his notion of psychic functions and structures. He dealt with psychological phenomena often observable in hysteria, hypnosis, states of suggestion or possession. From 1889 his work was greatly influenced by his collaboration with J.M. Charcot in the Parisian hospital Salpetrière.

Janet considered many of the psychopathological symptoms as a defect of the psychic wholeness. He described many forms of abnormal states of consciousness with their own memory that are inaccessible for the normal state of consciousness. These dissociated elements called fixed ideas that may produce many psychopathological symptoms. Janet and French school in Salpetrière became the source for the following development of psychoanalysis and other trends in depth psychology.

Similarly as disorder of integrity ('splitting') was defined also schizophrenia by classic Swiss psychiatrist Eugen Bleuler (Ellenberger, 1970; Scharfetter, 1998; Bottero, 2001). It corresponds to some modern findings (Tononi and Edelman, 2000) and also to them that examine dissociation in schizophrenic patients (Bernstein and Putnam, 1986; Spitzer *et al*., 1997; Startup, 1999; Read *et al*., 2001).

New interest in the theory of dissociation appeared after the Second World War along with a restoration of interest in the study of hypnosis in the work of Ernest R. Hilgard that continued in Janet's tradition. His neodissociation theory is sketched in the work 'Toward a Neodissociation Theory: Multiple Cognitive Controls in Human Functioning' (Hilgard, 1974) and is described in detail in his book (Hilgard, 1986). According to Hilgard, the secondary dissociated consciousness is characterized by the hidden observer that has the quality of a central stream of consciousness, in which information converges from many secondary streams or secondary personalities.

According to modern definition dissociation is understood as a special form of consciousness in which events that would ordinarily be connected are divided from one another (Li and Spiegel, 1992). It may be also less generally understood as inability to integrate some (co-conscious) psychic contents into the (dominated) consciousness (Bernstein and Putnam, 1986). Dissociation typically affects memory systems that may lead to memory loss restricted to a circumscribed period of time or category of events within the individual's life that causes exclusion of the experience from consciousness and the inaccessibility of voluntary recall of mental events associated with the trauma (Nemiah, 1991; Bob *et al*., 2005, 2006; Bob, 2007). Typical physiological reactions to traumatic stress and dissociation are disturbances of self-regulatory systems such as HPA axis resulting in hyperarousal, tachycardia or other symptoms of autonomic nervous system instability (Newport and Nemeroff, 2000; Teicher *et al*., 2003; Read *et al*., 2001). HPA axis is functionally closely related to neuroendocrinological balance, control hormonal levels, energetic metabolism, neuroimmunomodulation and disturbances of memory during stress reaction (Newport and Nemeroff, 2000; Mason *et al*., 2001; Payne *et al*., 2006; Plotsky *et al*., 1998; Teicher *et al*., 2003; Gavrilovic and Dronjak, 2005; Nakayama *et al.* 2005; Takahashi *et al.* 2005; Umegaki *et al*., 2006). According to neurodevelopmental research are most serious disturbances of HPA axis caused by traumatic events such as childhood abuse or neglect in

the first years of life and often have long-term impact on emotional, behavioral, cognitive, social and physiological functions and vice versa love and social care also may influence these functions and improve dissociative disturbances (Teicher *et al.* 2003; Read *et al.* 2001; Esch and Stefano, 2005; Stefano and Esch, 2005).

SCHIZOPHRENIA AND CONSCIOUS INTEGRATION

Modern findings suggest that disturbances of integrity or dissociative processes in schizophrenia occur due to similar disturbances of integrity at the level of brain functions connected to feature binding (Tononi and Edelman, 2000). In several studies have been proposed that cognitive disintegration may be a functional counterpart of defective patterns of interactions among specialized brain areas. Conscious disintegration in this sense means disturbance of coherent neural process that underlies the unity of perception and cognition (Tononi and Edelman, 2000).

This conscious disintegration probably produces defective self-monitoring and self-experiencing, for example during hallucinations (Feinberg, 1978; Ford *et al*., 2001a,b, 2007; Poulet and Hedwig, 2007). Using the PET scan was found that applying the same task to people with schizophrenia, and comparing hallucinators to nonhallucinators, show that the hallucinators have decreased flow in the areas used to monitor speech, such as the left middle temporal gyrus and supplementary motor area (Andreasen, 1997).

Recent findings suggest that the disintegration could be caused by defective communication between the frontal lobes, where speech is generated, and the temporal lobes, where it is perceived (Ford *et al*., 2005). This process likely may occur through the action of corollary discharges (or an efference copy) mechanism that prepares the temporal lobes for the expected sound (Ford *et al*., 2005).

Already Hughlings Jackson pointed out that also thinking may be considered the highest and most complex motor activity (Feinberg, 1978). This Jackson's clinical finding is in agreement with evidence of defective self-monitoring and self-integrity that originates in research of motor brain structures and from studies of corollary discharges (Feinberg and Guazzelli, 1999). Motor commands from these brain structures are associated with neural discharges that alter activity in both sensory and motor pathways. These neural discharges called corollary discharges (or efference copy) enables monitoring and modification of the commands themselves before the effector event. They enable to inform sensory systems that the stimulation produced by movement is self-generated or produced by an environment, which is crucial for the distinction of self and non-self (Feinberg, 1978; Ford *et al*., 2001a,b, 2007; Poulet and Hedwig, 2007). There is evidence that derangement of corollary discharges included in motor mechanisms of thinking produce many symptoms of schizophrenia in the visual or auditory system. Self-generated eye movements generate a "corollary discharge," or "efference copy" of the motor plan, informing the visual cortex that the changing of a visual input results from a self-generated action. A similar mechanism may exist in the auditory system, where corollary discharges from motor speech commands prepare the auditory cortex for self-generated speech, perhaps through a link between frontal lobes, where speech is generated, and temporal lobes, where it is heard (Ford *et al*., 2001a,b, 2007; Poulet and Hedwig, 2007). These findings provide direct neurophysiological evidence for a corollary discharge that transforms sensory responses to self-generated and relative to externally presented percepts. These percepts fail in patients with schizophrenia in comparison to healthy subjects. For example, inner speech is misidentified as external voices (Ford *et al*., 2001a,b, 2007; Poulet and Hedwig, 2007).

Loss of distinctions between internally generated psychic activity and external input is crucial for dissociative states as were formulated by Janet and also for the dreamy states defined by Hughlings Jackson (Meares, 1999). Dissociation represents disturbances of self-identity when own psychic contents are splitted and disintegrated from consciousness by dissociative mechanism, and create the co-conscious (or unconscious) level of psychic functioning.

CONCLUSION

Co-consciousness represents recent evidence of psychopathology and is likely related to disorder of integrity at the level brain processes regarding the feature binding. In this context the binding problem seems to be a very difficult and key problem for understanding of brain functions and consciousness. Its key role may be important not only for understanding of the normal functions of consciousness but also for abnormal functioning in psychopathological states. Recent findings suggest that disturbances of binding correspond to functional disconnection among some parts of the brain as was hypothesized already in 19th century by Hughlings Jackson and called psychological dissolution (Ellenberger, 1970; Meares, 1999). Similar term called dissociation introduced by Janet seems to be a very important for understanding psychopathological processes (Ellenberger, 1970; Meares, 1999). In this context, research following Bleuler's and Janet's tradition confirms significant influences of stress-related events and dissociation in pathogenesis of schizophrenia (Bernstein and Putnam, 1986; Spitzer *et al*., 1997; Startup, 1999; Read *et al*., 2001; Bob *et al*., 2006). Also several research findings in the study of brain complexity and neural synchronization support the hypothesis that specific functional fragmentation of neural subsystems could be linked to dissociation and splitting in schizophrenia (Bob *et al*., 2007). Taken together, these findings suggest that further research

could more comprehensively explain the relationship between psychological disintegration and neural processes and may help to find specific neurophysiological and neuroendocrinological alterations linked to disturbances in brain integrity and binding.

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REFERENCES

1 Andreasen NC (1997). Linking mind and brain in the study of mental illnesses: A project for a scientific psychopathology. *Science* **275**: 1586–1593.
2 Bernstein EM, Putnam FW (1986). Development, Reliability, and Validity of a Dissociation Scale. *J Nerv Ment Dis* **174**: 727–735.
3 Bottero A (2001). A history of dissociative schizophrenia. Evol Psychiatr (Paris) **66**: 43–60.
4 Bob P (2007). Dissociation, forced normalization and dynamic multistability of the brain. *Neuro Endocrinol Lett* **28**: 231–246.
5 Bob P, Susta M, Pavlat J, Hynek K, Raboch J (2005). Depression, traumatic dissociation and epileptic-like phenomena. *Neuro Endocrinol Lett.* **26**: 321–325.
6 Bob P, Glaslova K, Susta M, Jasova, D, Raboch J (2006). Traumatic dissociation, epileptic-like phenomena, and schizophrenia. *Neuro Endocrinol Lett*. **27**: 321–326.
7 Bob P, Susta M, Chladek J, Glaslova K, Fedor-Freybergh P (2007). Neural complexity, dissociation and schizophrenia. *Med Sci Monit* **13**(10): HY1–5.
8 Crick F and Koch Ch (1992). The problem of consciousness. *Sci Am* **267**: 153–159.
9 Ellenberger HF (1970). The Discovery of the Unconscious: The History and Evolution of Dynamic Psychiatry. New York: Basic.
10 Esch T and Stefano GB (2005a). The neurobiology of love. *Neuro Endocrinol Lett.* **26**: 175–192.
11 Feinberg I and Guazzelli M (1999). Schizophrenia – a disorder of the corollary discharge systems that integrate the motor systems of thought with the sensory systems of consciousness. *Br J Psychiatry* **17**: 4196–204.
12 Feinberg I (1978). Efference copy and corollary discharge: implications for thinking and its disorders. *Schizophrenia Bull* **4**: 636–40.
13 Ford JM, Mathalon DH, Heinks T, Kalba S, Faustman WO, Roth WT (2001a). Neurophysiological evidence of corollary discharge dysfunction in schizophrenia. *Am J Psychiatry* **158**: 2069–2071.
14 Ford JM, Mathalon DH, Kalba S, Whitfield S, Faustman WO, Roth WT (2001b). Cortical responsiveness during inner speech in schizophrenia: an event-related potential study. *Am J Psychiatry* **158**: 1914–1916.
15 Ford JM, Gray M, Faustman WO, Heinks TH, Mathalon DH (2005). Reduced gamma-band coherence to distorted feedback during speech when what you say is not what you hear. *Int J Psychophysiol* **57**: 143–150.
16 Ford JM, Gray M, Faustman WO, Roach BJ, Mathalon DH (2007). Dissecting corollary discharge dysfunction in schizophrenia. *Psychophysiology* **44**: 522–529.
17 Freeman WJ (1991). The physiology of perception. *Sci Am* **264**: 78–85.
18 Gavrilovic L and Dronjak S (2005). Activation of rat pituitary-adrenocortical and sympatho-adrenomedullary system in response to different stressors. *Neuro Endocrinol Lett.* **26**: 515–520.
19 Havens LL (1966). Pierre Janet. *J Nerv Ment Dis* **143**: 383–398.
20 Hilgard ER (1974). Toward a Neodissociation Theory: Multiple Cognitive Controls in Human Functioning. *Perspect Biol Med* **17**: 301–316.
21 Hilgard ER (1986). Divided Consciousness. Multiple Control in Human Thought and action. New York: Wiley.
22 Janet P (1890). L'Automatisme Psychologique. Paris: Felix Alcon.
23 John ER (2002). The neurophysics of consciousness. *Brain Res Rev* **39**: 1–28.
24 Li D and Spiegel D (1992). A Neural Network Model of Dissociative Disorders. Psychiatr Ann **22**: 144–147.
25 Marshall IN (1989). Consciousness and Bose-Einstein Condensates. *New Ideas Psychol* **7**: 73–83.
26 Mason JW, Wang S, Yehuda R, Riney S, Charney DS, Southwick SM (2001). Psychogenic lowering of urinary cortisol levels linked to increased emotional numbing and a shame-depressive syndrome in combat-related posttraumatic stress disorder. *Psychosom Med* **63**: 387–401.
27 Meares R (1999). The contribution of Hughlings Jackson to an understanding of dissociation. Am J Psychiatry **156**: 1850–1855.
28 Nakayama Y, Takahashi T, Radford MH (2005). Cortisol levels and prospective and retrospective memory in humans. *Neuro Endocrinol Lett.* **26**: 599–602.
29 Nemiah JC (1980). Dissociative disorders. In: Freedman AM, Kaplan, HI, editors. *Comprehensive textbook of psychiatry* (pp. 1544–1561). Baltimore, MD: Williams and Wilkins.
30 Newport DJ and Nemeroff CJ (2000). Neurobiology of posttraumatic stress disorder. *Curr Opin Neurobiol* **10**: 211–218.
31 Payne JD, Jackson ED, Ryan L, Hoscheidt S, Jacobs JW, Nadel L (2006). The impact of stress on neutral and emotional aspects of episodic memory. *Memory* **14**: 1–16.
32 Penrose R (2001). Consciousness, the Brain, and Spacetime Geometry: An Addendum. Ann NY Acad Sci **929**: 105–110.
33 Plotsky PM, Owens MJ, Nemeroff CB (1988). Psychoneuroendocrinology of depression: hypothalamic-pituitary-adrenal axis. *Psychiatr Clin North Am* **21**: 293–307.
34 Poulet JF and Hedwig B (2007). New insights into corollary discharges mediated by identified neural pathways. *Trends Neurosci* **30**: 14–21.
35 Read J, Perry BD, Moskowitz A, Connolly J (2001). The contribution of early traumatic events to schizophrenia in some patients: a traumagenic neurodevelopmental model. *Psychiatry* **64**: 319–345.
36 Scharfetter C (1998). Dissociation and schizophrenia. Schizophrenias – a dissociative nosopoietic construct? *Fortschr Neurol Psychiatr* **66**: 520–523.
37 Seth AK, Izhikevich E, Reeke GN, Edelman GM (2006). Theories and measures of consciousness: an extended framework. *Proc Natl Acad Sci U S A* **103**: 10799–10804.
38 Singer W (1993). Synchronization of Cortical Activity and its Putative Role in Information Procesing and Learning. *Annu Rev Physiol* **55**: 349–374.
39 Singer W (2001). Consciousness and the Binding Problem. Ann NY Acad Sci **929**: 123–146.
40 Spitzer C, Haug HJ, Freyberger HJ (1997). Dissociative symptoms in schizophrenic patients with positive and negative symptoms. *Psychopathology* **30**: 67–75.
41 Sporns O, Tononi G, Edelman GM (2000). Connectivity and complexity: the relationship between neuroanatomy and brain dynamics. *Neural Netw* **13**: 909–922.
42 Sporns O, Tononi G, Edelman GM (2002). Theoretical neuroanatomy and the connectivity of the cerebral cortex. *Behav Brain Res* **135**: 69–74.
43 Startup M (1999). Schizotypy, dissociative experiences and childhood abuse: relationships among self-report measures. *Br J Clin Psychol* **38**: 333–344.
44 Stefano GB and Esch T (2005). Love and stress. *Neuro Endocrinol Lett.* **26**:173–174.
45 Takahashi T, Ikeda K, Ishikawa M, Kitamura N, Tsukasaki T, Nakama D, Kameda T. (2005). Anxiety, reactivity, and social stress-induced cortisol elevation in humans. *Neuro Endocrinol Lett*. **26**:351–354.
46 Teicher M, Andersen SL, Polcari A, Anderson CM, Navalta CP, Dennis M, Kim DM (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neurosci Biobehav Rev* **27**: 3–44.
47 Tononi G and Edelman GM (2000). Schizophrenia and the mechanisms of conscious integration. *Brain Res Rev* **31**: 391–400.
48 Umegaki H, Yamamoto A, Suzuki Y, Iguchi A (2006). Stimulation of the hippocampal glutamate receptor systems induces stress-like responses. *Neuro Endocrinol. Lett*. **27**: 339–343.
49 van der Hart O and Friedman B (1989). A Reader's Guide to Pierre Janet on Dissociation: A Neglected Intelectual Heritage. *Dissociation* **2**: 3–16.