

Civil Schizophrenia

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[Brief abstract: In this chapter, I explore schizophrenia as a dysfunction (or set of dysfunctions) of a dynamical system, specifically, a recurrent neural network. This is consistent with recent proposals that the illness is a “disconnection syndrome” (as opposed to a specific regional dysfunction). More important, disruption of recurrent circuits in the brain will alter properties fundamental to the background awareness of temporality, and contribute to the struggle to maintain a subjective sense of reality that individuals with schizophrenia face.]

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Some farm houses in a farm yard time
With a horse and horseman time
Where going across the field as if they're ploughing the field time
With ladies or collecting crops time work is
Coming with another lady time work is
And where she's holding a book time
Thinking of things time work is
And time work is where you see her coming
Time work is on the field and where work is
Where her time is where working is and thinking of people
And where work is and where you see the hills
Going up and time work is
Where you see the grass time work is
Time work is and where the fields are
Where growing is and where work is

(transcript of patient with chronic schizophrenia describing a farming scene, collected by Heidi Allen and quoted in Frith (1992). Line breaks indicate pauses.)

Schizophrenia is a devastating disorder that affects approximately one percent of humankind. It usually strikes in early adulthood, and by every measure, outcomes of schizophrenia are usually poor: About half of discharged patients will be rehospitalized within a year. Two thirds of first-episode patients will continue to have positive symptoms (like hallucinations or delusions) one year later, and one third will still have these symptoms six to ten years later. Less than 20% of individuals with the illness are gainfully employed. Subjective and objective measures of the quality of life with schizophrenia are very low, even when compared to other chronically ill patients. One in ten will end their lives through suicide (Robins, et al., 1984; Karno & Norquist, 1995; Hafner & Heiden, 1997; Weiden et al., 1996).

The humane need to address this illness is clear, and there has long been a massive effort to understand and treat it. For example, the PubMed database currently references more than 66,000 papers on schizophrenia. More than three thousand were published last year alone; that's about eight schizophrenia papers every day. Yet, despite all this effort, and despite significant progress in managing the illness, schizophrenia has been singularly resistant to explanation. It is elusive for every discipline, including philosophy, phenomenology, cognitive science, and neuroscience. Its elusiveness is frustrating, but also fascinating. Many psychological disorders and diseases have been crucial to discovering the functions of mind and brain in both illness and health. It would seem that a disorder as manifold as schizophrenia would be especially revealing of the machinery of mind, but so far it poses more riddles than answers.

In this paper, I propose that schizophrenic cognition does open a window on the working brain, but what is revealed is seen through a glass darkly. This is in part because schizophrenia is a complex disorder (or group of disorders), and in part because the explanatory frameworks we bring to bear on it are inappropriate for its distinctive complexity. To address its challenges, I'll recommend a double shift of approach, motivated by dynamical systems and phenomenology. The two perspectives illuminate an aspect of cognition that is often overlooked, but which may be important in understanding schizophrenia.

I. The Deficit Schema and Its Dysfunctions

Cognitive neuroscience is in some ways the oldest of the disciplines of cognitive science. It can be traced to 19th Century neuropsychology, and the clinical genius of researchers like Broca and Wernicke. They and their colleagues inaugurated a search for a physiological implementation of a much older faculty psychology. Their overarching hypothesis was that the faculties reside at specific anatomical addresses, or in other words that the brain was predominantly organized around functional localization. The logic of localization was a logic of lesions, linking the loss of specific brain regions to specific deficits in behavior. If insult to some region *R* led to a deficit in the behaviors supported by some function *f*, then, conversely, *R*'s normal function would seem to be *f*.

Neuropsychology is full of lesion studies, which provide much of the foundation of modern cognitive neuroscience. An old example that remains germane is the case of H.M., whose hippocampi (and more) were ablated to control his epilepsy. Following his operation, H.M. suffered from severe anterograde amnesia. He was never again able to create long term episodic memories. His case demonstrated the role of hippocampus in memory, and subsequent experiments, many with H.M. as their subject, teased apart distinctions between declarative memory and procedural memory, among others. Many of the lessons of H.M. remain central to cognitive neuroscience and cognitive psychology (Corkin, 2002).

In the case of H.M., it was not hard to fill in the blanks of the deficit schema. A distinct external cause (his surgery) resulted in a specific and observable single lesion in his hippocampi in both hemispheres, and as a further result brought about specific deficits that could be readily observed and described. None of these clean distinctions hold in schizophrenia. It is multiform at each stage in the deficit schema. First, schizophrenia arises from the joint effect of several causes, none of which is fully understood. One factor is genetic. If your identical twin has schizophrenia,

your chance of acquiring it will be around 50%; risk tails off as one moves along the branches of the family tree. For example, if you have a cousin with schizophrenia, your own chances double from the baseline rate of 1%. But even as these ratios point to a genetic contribution, they just as clearly indicate that something else is also involved, affecting some stage of pre- or post-natal development, or arising in the environment or experience of those who ultimately acquire the disease. Moreover, there may be multiple paths to schizophrenic disorders. Many potential contributing causes have been discussed, but there is no consensus yet.

The multiple ambiguous causes of schizophrenia lead to multiple and ambiguous differences in the brain. Early in the last century, it seemed that schizophrenic brains were anatomically indistinguishable from healthy brains, but more careful measurement revealed an enlargement of cerebral ventricles in those with the disorder. This then seemed to be due to smaller volumes of gray matter overall, but particularly in the frontal lobe, but also in the temporal lobe. At this point, statistically significant variations in volume have been found in parts of all four lobes, the basal ganglia, and cerebellum (Niznikiewicz, et al., 2003). These volume differences may (or may not) be related to observed differences in cytoarchitecture in several regions (Frith, 1992). Relating all these variations to their expression in the illness would be complicated in any case, but are additionally confounded from two directions. On the one hand, it's not clear that schizophrenia causes all these differences, as individuals with the illness are also affected by chronic medication and a very different life experience. On the other hand, it's also unclear that any of these anatomical differences reflect mechanisms of schizophrenic cognition. Many people exhibit similar anatomical variations – siblings of schizophrenics, for example – without developing the illness. Emblematic of both confounds is the relationship of gray matter loss to schizophrenic symptoms. Individuals with schizophrenia have less gray matter volume than those without, but then, between ages twenty and sixty, the average healthy individual will lose around 15% of his or her cortical gray matter (Lim, et al., 1992). Loss of gray matter in itself does not give rise to schizophrenia, fortunately.

In short, the root causes and neural expressions of schizophrenia are both obscure. But perhaps the most perplexing aspect of the illness is its symptomatology. Only in the 1980s were the symptoms organized into positive and negative categories (Crow, 1980). More recently, the positive symptoms were further divided, leading to a “three-compartment” conception of the illness (Liddle, 1987). These are, first, the positive symptoms including delusions of various types and hallucinations. Second, there are the “disorganized symptoms,” including disorganized speech and behavior, impaired attention, or catatonia. Third, there are the negative symptoms, including diminished speech, decreased ability to initiate goal-directed behavior, flattened affect, inability to express pleasure, and social isolation. (These diagnostic symptoms are frequently accompanied with numerous cognitive deficits. See Barch, 2005.)

The clarity of the three compartments is somewhat illusory, however. Individual patients will express the illness in idiosyncratic ways, and furthermore the form the illness takes changes over time. Moreover, under scrutiny some of the symptoms themselves take on the enigmatic cast of the disease overall. For example, a commonsense understanding of delusions might define them as patently false beliefs held by persons who are unaware of that falseness. Bill Fulford has pointed out that the differentia of this definition fail to capture what seems to have gone wrong in delusion (Fulford, 1994). First, delusions are not simply false (or many of us would be in their

grip, most of the time) nor are they necessarily false. Someone may suffer the paranoid delusion that the government is spying on him, but the belief may nonetheless be true. More important, Fulford points out that individuals with delusions often have a great deal of insight into their beliefs. They know that they hold the belief and can appropriately relate it to many other beliefs, some delusional and some not. They often know that the delusion is exceptional, that it is denied by everyone around them, that it is radically dysfunctional in the context of practical action and social life, and that it has made life hell for them. Even more perplexing, it's not even clear that delusions are beliefs. Deluded patients often fail to act on their delusions or to register appropriate affect about them. Citing observations like these, Stevens and Graham propose a unique propositional attitude, the "delusional stance" (Stevens & Graham, 2004). In short, schizophrenic delusion has something to do with falsehood and evidence, something to do with a lack of insight, and something to do with belief, but a precise description of the cognitive dislocation turns out to be elusive.

One indicator of the complex symptomology of schizophrenia is the proliferation of diagnostic tests for the illness and its variants, like "schizotypal disorder" and "schizoaffective disorder." Some of these can be revealing of assumptions about the subjective experience of schizophrenia. For example, consider the opening questions of the Schizotypal Personality Questionnaire:

1. Do you sometimes feel that things you see on the TV or read in the newspaper have a special meaning for you?
 2. I sometimes avoid going to places where there will be many people because I will get anxious.
 3. Have you had experiences with the supernatural?
 4. Have you often mistaken objects or shadows for people, or noises for voices?
 5. Other people see me as slightly eccentric (odd).
 6. I have little interest in getting to know other people.
 7. People sometimes find it hard to understand what I am saying.
 8. People sometimes find me aloof and distant.
 9. I am sure I am being talked about behind my back.
- (<http://www-rcf.usc.edu/~raine/spq.htm>)

Indirect questions dominate this and other tests. Imagine, by analogy, a diagnostic test for pain that asked not "Does it hurt a lot?" but instead asked "Do you find yourself saying 'ouch' a lot?" or "Do other people often offer you aspirin?" The circumlocutions imply that self-awareness is impaired in schizophrenic disorders, even in comparison to other mental illnesses. This failure of insight is one facet of the common view that individuals with schizophrenia suffer a "break with reality." The break with reality, then, is the subjective counterpart of the breakdown of communicative abilities. Many of the signs listed in the three compartments of schizophrenic symptomatology are variants on the twin themes of mistaken perception and derailed expression. Excerpts from schizophrenic discourse, sprinkled through every textbook treatment, offer many particular examples of delusional belief and fractured language. At the limit, the break with reality can seem to exclude schizophrenic experience from any normal understanding. Karl Jaspers, following Franz Brentano, referred to "genetic understanding" to denote the understanding of how one mental state arises from another, and claimed that the mark of madness was the failure of the sane to achieve a genetic understanding of the mad attempts to

communicate (Jaspers, 1963). In Jaspers' account, regarding severely delusional patients the failure was absolute.

Quoted out of context, individuals with schizophrenia will express beliefs that can't easily fit into the spectrum of typical world views, c. 2006. With all these assumptions – the break in perception and communication and the failure of insight — in mind, then, let us consider the dialogue below, a transcription of five minutes of a hospital interview of a woman with psychosis:

Interviewer: I want you to tell me something about what's been happening to you.

Patient: Well, I've been exposed to guerilla warfare, and some of these Dutch Confusia...

I: Dutch Confusia?

P: Yes, Dutch Confusia, that's what he is, he's a con-fus-ia. He will cause confusion. A great deal of British and Dutch use those people in nations where they want to break into, create some strife, oftentimes steal something, or do something, get away with something. They've done it for thousands of years. They planned and plot world conquest. About every thousand years, my grandmother says, the confusia overrun the world. They break into nations: that's what Russia is, and they're doing it in South America. They're to blame for the trouble in South America. They will deceive our Royals and Royals cannot fight back and do the things they do. We have to return good for evil—

I: What are Royals?

P: A Royal is a human being as God created him, that lives by God's law, that will not slay another man, will not touch his person. Lives by the Bill of Rights, in other words, as God gave the commandments for man to conduct himself. It's come down to us, it's called the Bill of Rights today, because William the Bastard and the Duke of York came over during the American Revolution and overran this continent, and they meddled around in our civil affairs over here and now we call it the Bill of Rights. He renamed that and they've written in death penalty, which is forbidden by God – any man can err, he can change hands, but you cannot take his life. Disprove that, my grandfather the Baptiste's first wife — he detected Christ's human rights —

I: What do you mean, your grandfather—

P: Great grandfather, John the Baptiste, St. John.

I: I see —

P: John the Baptiste, great great great grandfather. I can't repeat the number of patterns of removal, but he is a great great grandfather and really the head of the American, as we say, the house of Aabel, the American nation over here. He was the founding father —

I: What do you mean, the house of Aabel?

P: Aabel — it's the clan of Aabel, our tribe, as you would say —

I: Would you explain that word, Aabel?

P: The body of Americans carry Aabel blood more than they do Cain and Satan blood —

I: What does that word Aabel mean?

P: Abel, Abel, A with the first Adam and Bel means one that lived by the Bell of Rights, that set down the eighty marked lands by the acorn and the oak, and the acorn became the symbol of our Liberty Bell and that Bell of Rights, or law, set of commandments as God gave us, become known as the Bell of Rights, because they would call Congress, they would ring that bell, they would call, gather ye, hear ye, hear ye — town crier, or the first bell in the harbor up there, holds a torch aloft. Our grandfather was the first to be given light by God. That happened right down

here in the Cove of Anton, that's one reason that we came to this home —

I: The what?

P: The Cove of San Anton is a cave, a volcanic formation, and our grandfather, the first Jo-an and the first Adam—

I: The first what?

P: My great grandfather is Adam. The first Adam, and his son Jo-an and his wife, and his son's wife. He had a small child already, he had Anton. The T means a crucifix in ancient hieroglyphics.

I: Tell me more about the meaning of the letters —

P: They had wandered around the United States — I'm coming to that — they came down here, to, they call this the Fountain of Youth region. This water here will mend bones, and they had discovered, God said, "Seeking my light and the right water to heal" — our people were homeopathic. Now if you want to cleanse your system, you seek the right water. If you have an ailment, you have to first seek the right water. And some of our people heal with the sun, but they sought this water because if they had broken bones or sores or anything that wouldn't heal, this water flows through limestone here, the famous Bell Fountain in Ohio here — you've heard of that I suppose — those were Grandpa Bell's Fountains, and the mineral lode is the best right down where we are, and those 13,000 acres were an ancient reserve that belonged to my grandfather when he went to the other side, the General —

I: Now why are you here?

P: I don't know why I'm being routed out here. I understood some tests were to be made.

I: What kind of place is this?

P: This is Mountain View, a hospital for mentally deficient, or mental patients.

I: Are you a mental patient?

P: No, I am not, but they're trying to make it appear that I am. The British and Dutch are doing that, the Confusia...

Undeniably, there is something deeply "off" about this patient's attempt to communicate with her doctor. She seems almost oblivious to the social environment and the pragmatic demands and constraints that normally support successful communication. From this passage one could extract dozens of explicit claims that could serve as textbook examples of deluded belief or logical chaos. But reading the whole passage, slowly, leaves a very different impression. One is struck, I think, by the patient's urgency to explain herself, by an indefatigable need to make sense of her world. Bleuler (1913) originally characterized schizophrenic thought process by its "loose associations," but when we settle in with this transcript the associative paths begin to seem rule-governed and thoroughly explored. By the third reading, the passage almost seems like the theoretical discourse of a systematic philosopher, the ruminations of the Leibniz of Dutch confusionism. As Einstein labored on the general theory of relativity in an office across the street from an asylum, he remarked on a feeling of kinship with the inmates: "They were the madmen who did not concern themselves with physics. I was the madman who did." At the same time, the passage is reminiscent of modernist literature, with echoes of Beckett or Molly Bloom. In short, genetic understanding of this speaker is not impossible. This is not to deny that the speaker's illness is greatly distorting her discourse, which is neither literature nor philosophy (but compare the non-schizophrenic novels of Kathy Acker, or the non-schizophrenic philosophy of (e.g.) Lacan). But, just as with the understanding of any discourse, this text becomes clearer with the

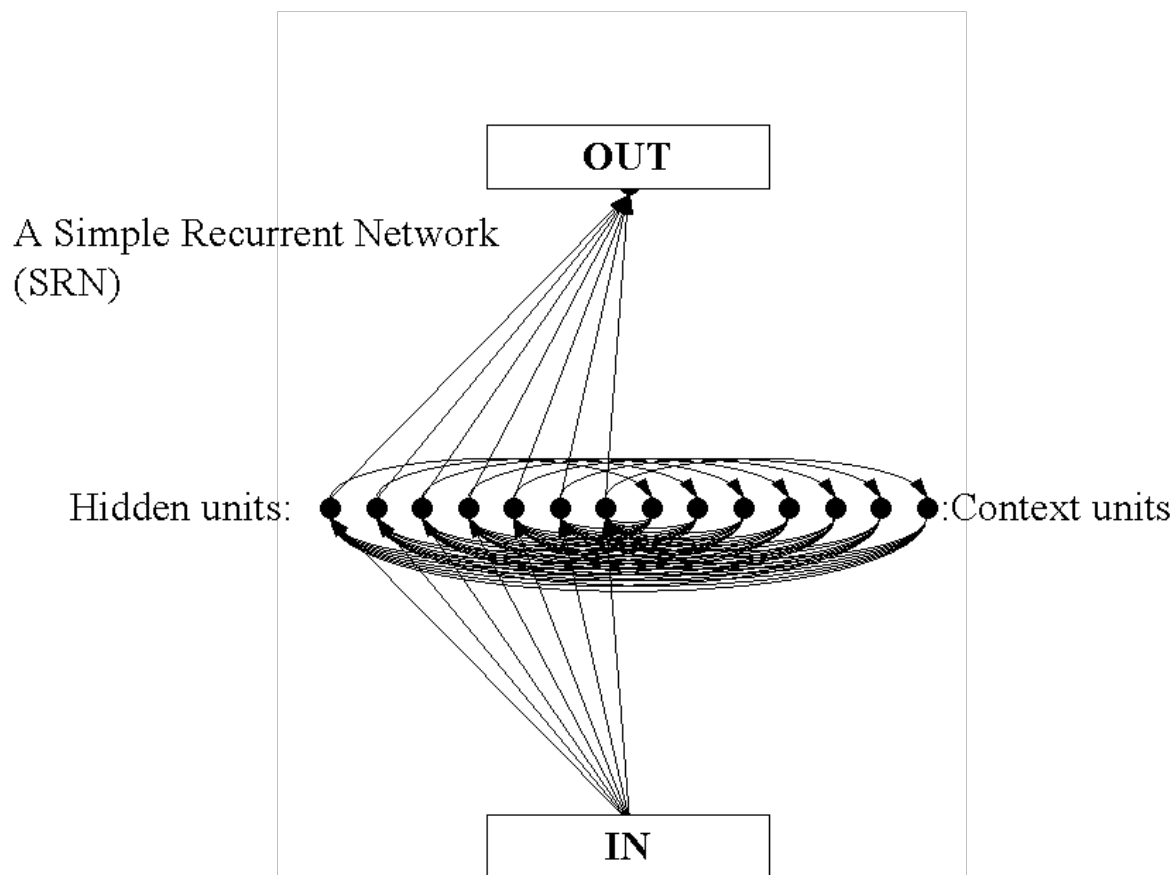
addition of its context. More text yields more understanding, and even the glimmers of the organization of the patient's worldview, as she returns to her first topic at the end of the passage.

Isolated sound bites from schizophrenic discourse suggest an illness characterized by an incomprehensible break with reality. But the lesson of the passage above is that providing even limited context for those same data suggests a method in the madness, and the possibility of partial understanding. This simple observation, that context renders schizophrenic perception more understandable, is the emblem for the main claim of this paper. Schizophrenia, I will suggest, is a disorder of context (see also Hemsley, 2005). The context in question is the temporal context of episodes of thought and perception, schizophrenic and healthy alike. Time, I'll suggest, is the fundamental structure of our experience (and essential to every aspect of cognition). It is so basic as to be invisible and thus largely overlooked in both philosophy and cognitive science. My proposal here is that schizophrenia can be approached as a partial dislocation in fundamental temporal cognition. Its symptoms reflect a struggle to stabilize and normalize a shifting framework that we who are fortunate in health call reality.

My "brief history of time" will unfold on two levels at once. The first level is that of dynamical systems with reference to a few main theories of the pathophysiology of schizophrenia. The second level is phenomenological, considering the normally invisible structures of temporality and their emergence from the underlying dynamic architecture. The links across levels will then suggest an interpretation for what is both strange and inexpressible in schizophrenic experience.

II. The brain as a recurrent network, in health and illness

In 1990 Jeffrey Elman introduced the connectionist architecture known as the Simple Recurrent Network (SRN; Elman (1990)). Figure 1 depicts the SRN architecture schematically. Essentially, a recurrent network is based on a standard three layer feed-forward architecture, designed for back-propagation learning. Its innovation is a feedback loop, functionally implemented in an auxiliary set of "neural" units that copy the information in the hidden layer, making it available for the next cycle of information processing. Thus at each processing cycle two inputs are available to determine the output: the occurrent input, and a copy of the pattern of activity in the hidden layer from the immediately preceding cycle.



Elman, "Finding Structure in Time," *Cognitive Science*, 1990.

Figure 1. A Simple Recurrent Network.

The simple recurrent network is a generalized computational architecture and a highly abstract model. But it is at the right level of abstraction, in that it specifies a minimally sufficient architecture to support a class of functions no ordinary feedforward net can handle. Elman's 1990 paper is entitled "Finding Structure in Time," and it demonstrated that recurrence gave networks the power to learn temporal contingencies of many sorts. SRNs can accommodate delayed responses, and iterative and recursive structures, like embedded clauses. A moment's reflection reminds us that almost all our cognitive power depends on finding structure in time, that is, building complex representations from the serial presentation of independently ambiguous "takes": language, action planning and execution, scene perception and object constancy, reasoning, narrative, and memory of every sort all presuppose an ability to embed temporal information in perception and cognition. The SRN also illustrates how temporal information could be folded into the general information stream. Parallel distributed processing is characterized, as the name suggests, by distributed representation, in which information is spread across units and connections, each contributing to many separate functions. In a recurrent network distributed representations also encode time. Temporal information is not localized in specialized time-keeping units, but rather is folded into whatever other information the network is processing. This enfolding is ongoing, and as a result the temporal depth of information extends beyond the single cycle mirrored in the feedback loop. The current state of the hidden

layer incorporates the previous state, which incorporates the state before that, and so on into the past. Through a regular backpropagation learning process a recurrent net learns to maintain a “working memory” as demanded by the temporal contingencies of the task at hand.

Recurrent networks offer a useful framework for thinking about perception and cognition. They also remind us of a pervasive feature of biological brains, in which as many as 90% of all connections are feedback. Figure 1 thus also represents a highly schematized picture of the brain. Even at this level of abstraction, we can think of ordinary brain function as the flow of information through a recurrent network. And we can think of schizophrenia as a modification of that flow.

One usual suspect in the pathophysiology of schizophrenia is dopamine, which was implicated in the disease more than fifty years ago. The “dopamine hypothesis” proposes that schizophrenia is an effect of a dysregulation in neuromodulatory pathways, originating in midbrain areas (in and near the substantia nigra) and projecting to many cortical regions, especially prefrontal cortex and the mesolimbic system (including nucleus accumbens, ventral striatum, amygdala, hippocampus, entorhinal cortex, medial frontal cortex, and anterior cingulate). The dopamine hypothesis has been adjusted over the years, and there is room to question whether the evidence unequivocally points to dopamine dysregulation, but these issues will not be discussed here. (See Byne, et al., 1999.) For present purposes, we need only consider a schematic translation of neuromodulation into the dynamical system architecture before us. Neuromodulatory inputs can be modeled as a tonic bias input to a recurrent network, as in Figure 2.

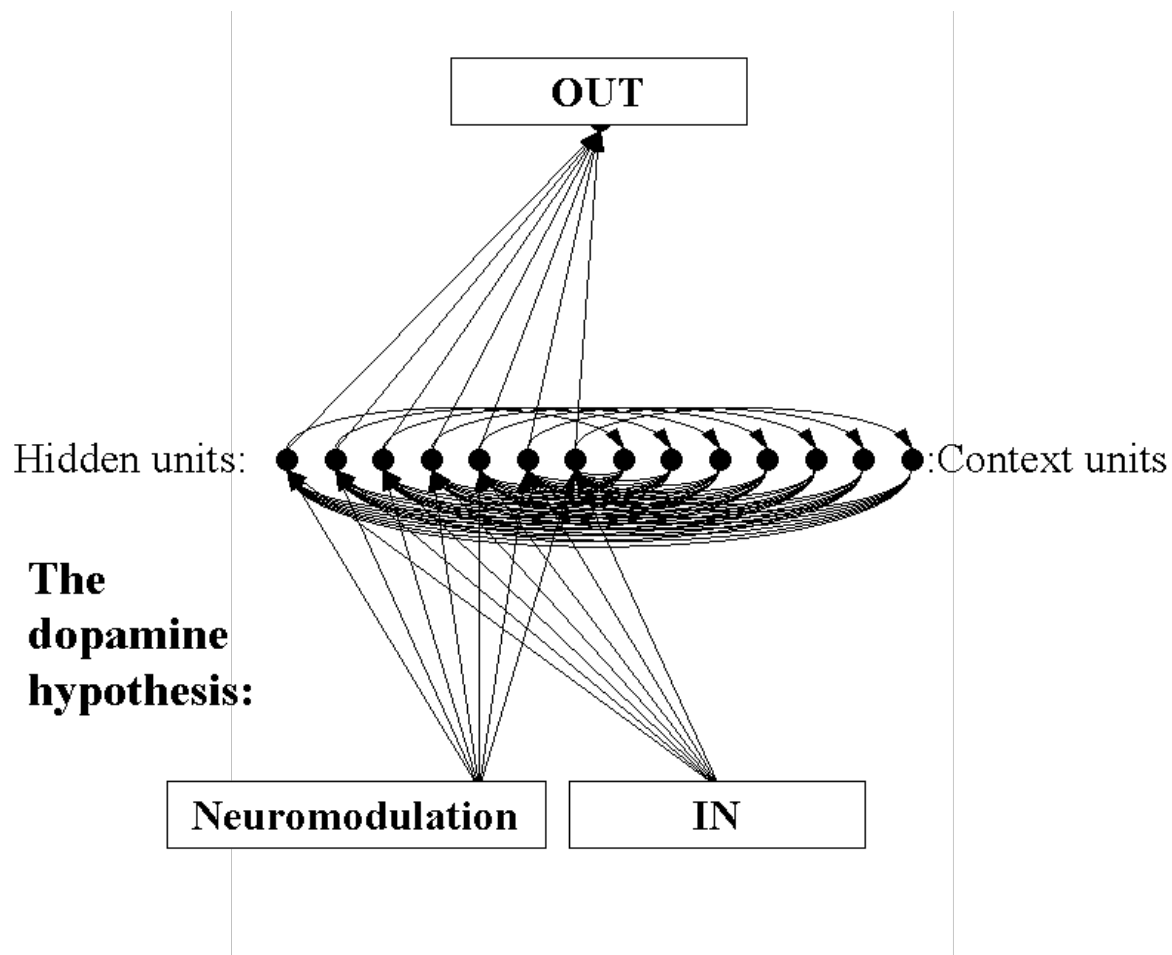


Figure 2. Neuromodulation of a recurrent net.

The schematic leaves unspecified, for now, the manner of modulation, but the overall causal cascade is clear enough: change in the modulator system leads to change in the information processing in the main recurrent loop. Altered neuromodulation translates into a dynamical systems hypothesis as interference or noise in a recurrent circuit. At the dynamic systems level, then, schizophrenia is the expression of dysregulated, noisy recurrent processing. This is oversimplified, but perhaps not grossly, as it will provide a way to think about several interesting recent proposals about schizophrenia. I'll summarize three views, to suggest the range of ideas in play in this literature.

For example, in several papers Nancy Andreasen (1999) has proposed that some of the symptoms of schizophrenia arise through “cognitive dysmetria,” “a defect in timing or sequencing the flow of information as required during normal ‘thought’ or speech.” The flow in question is a loop through thalamus, frontal cortex, and cerebellum. Andreasen points out that just as action requires a fine-grained coordination of sensory inputs and motor outputs, so also thought. On this proposal, then, the motor difficulties observed in individuals with schizophrenia are one expression of dysmetria, and cognitive deficits another.

Christopher Frith identifies recurrent circuits involved in the initiation and monitoring of willed action, and considers the manifold effects of disrupting these loops (Frith 1992). Functionally,

the loop includes a “supervisory attentional system,” responsible for forming goals and plans. This system communicates with a system for selecting which action to undertake next, among competing actions. The resultant choice initiates the action at the same time as it is communicated back to the supervisory system. A disruption of the link between the supervisory system and the action scheduler would explain several of the negative symptoms of schizophrenia. At the same time, action is accompanied by self-monitoring, which Frith proposes occurs through a corollary discharge from the supervisory system. The corollary discharge, then, is the signal of an intention to act. As in Andreassen’s proposal, Frith’s involves an analogy between action and thought. An internal monitoring system compares the corollary discharge to what actually happens, as indicated by proprioception and other forms of self-perception. Disruption of the corollary intention signal would result in actions or thoughts that appear unintended, a common thread among the positive symptoms of the illness. Frith cautiously identifies the brain areas that may implement the loop, relying on lesion studies, animal models, and behavioral experiments with subjects who have schizophrenia. The attentional supervisory system includes the anterior cingulate cortex, dorsolateral prefrontal cortex, and supplementary motor area. The action selector includes the striatum, especially the putamen, and the globus pallidus.

Karl Friston’s “disconnection hypothesis” considers the implications of dysregulated neuromodulation on two areas of the brain which seem implicated in schizophrenia: the ubiquitous prefrontal cortex and the medial temporal lobe, including amygdala, hippocampus, and parahippocampal gyrus (Friston 1999). The effect of aberrant modulation is to alter long-term synaptic plasticity, i.e., learning. Schizophrenia disrupts the learning of contingencies in the environment, including the social environment, and it disrupts the learning of complex action patterns. This could lead to negative symptoms, especially those involving communication and social interaction. It could also lead to positive symptoms, through misattribution of the relationships between one’s own intentions and perceived events.

All of the authors above draw on multiple strands of evidence, which my capsule summaries completely omit. All reward study and deserve further discussion, but for present purposes they illustrate a single point: Each proposal is a variant on the theme of a disrupted recurrent network. They vary in their ideas about the brain regions involved in the circuit, and the proposed mechanism of the pathophysiology. (Andreassen and Frith seem to suggest that schizophrenic symptoms are the immediate effect of a disruption of connectivity among brain areas. Friston proposes that the symptoms are a longer term secondary consequence of disrupted modulation of otherwise normal processes of synaptic change.)

The exemplary theories further develop their proposals to explain several schizophrenic symptoms and deficits. In these theories, localized dysfunction is a secondary manifestation of the illness. No particular component fails in schizophrenia, they claim, but rather all fail together as their interconnections unhinge. It happens that the networks they scrutinize comprise components that are mutually interconnected, and in different ways aberrant feedback is proposed as part of the mechanism of cognition in schizophrenia. But there is a deeper consequence of recurrence which the individual theories omit, but which is prominent in the dynamic architecture of a generic recurrent network. In addition to disrupting inputs and

outputs, dysfunction in a recurrent network both accumulates and spreads. Returning to Figure 1 and the Simple Recurrent Network, a modification in one connection in the recurrent loop can affect one unit, but that unit can affect several others in the next cycle, and those can affect still others as the cycles continue. If the connections are plastic, then the spreading dysfunction embeds itself in many connections between units, and that in turn contributes to further distortion. Like compounded interest reinvested in a savings account, dysfunction accumulates and compounds over time.

In short, the disconnection hypotheses considered above regard schizophrenia as a modification of neural networks that are distributed in space and fail to act in concert. But recurrence provides the functional architecture to accommodate information that is distributed in time. Its failures are deficits in sequence, with the secondary effect of compounded problems. If schizophrenia is a consequence of dysfunction in a recurrent loop, its expression will be quite different from deficits limited to spatial, synchronous patterns.

III. Temporality

“The time is out of joint,” complains Hamlet, and in the previous section I suggested a possible neural network implementation of his predicament: Dysfunction in a recurrent network will distort structures in time. But to understand how this distortion might appear in schizophrenia, we must first understand the normal, undistorted starting point. The basic structures of temporality in cognition are little discussed in cognitive science, cognitive neuroscience, and analytic philosophy. But temporality is foundational in continental phenomenology, and despite variations over the decades, the original phenomenological description of temporal experience is still accepted.

The definitive account of lived time is due to Edmund Husserl, who described it in lectures given in 1905 (although they were only published in 1928). His fundamental observation was that our conscious perceptual experience of a scene before us right now is not exhaustively constituted by the occurrent sensory information available. In addition to sensation, all perception incorporates a non-sensory “apprehension”; Appearances include both sensations and apprehensions. The contents of the apprehension are manifold, but central to all of them is the awareness of the temporal context of the present sensation. The presently experienced context enfolds both future and past. The future “appears” as an anticipation of what will or might happen in the seconds and minutes ahead. Husserl called this anticipation “protention.” At the same time, the past appears as a non-sensory awareness of what has just transpired. Husserl called this form of primary memory “retention.” Between protention and retention, the incoming stream of sensation is the “primal impression.” Our experience of the present, then, is not simply the intake of information before us, but is a triptych of protention, primal impression, and retention. Subjective temporality is “thick” with protentive and retentive layers, in effect adding phenomenal temporal dimensions to the thin line of linear, objective time.

Husserl claimed not only that temporality was apparent, but that it was a necessary condition for anything we would recognize as conscious experience. For example, imagine a watch hanging from a watch chain. Is it moving or stationary? Present sensation of the watch right there is

ambiguous – it could just as easily be a snapshot of an immobile as of a moving object. The perception that the watch is moving can only be achieved by retaining the context of its positions in the immediate past. This is equally true of the perception that the watch is stationary. Husserl's deeper point is that we cannot imagine experience of either change or stasis without temporal information being part of the present consciousness of things.

Two further points deserve emphasis in this account. First, this tripartite structure of time is all packed into the present moment. Protention and retention are both here now. Second, this fundamental temporal structure is distinct from our explicit attention to the future, through conscious prediction or planning, or to the past, through recollection. These distinct processes receive their own analysis (of their own distinctive tripartite structure).

Once we have clearly in mind a present that includes a nonsensory anticipation of the future and a nonsensory trace of the past, we are ready to follow Husserl and launch the present, which *is* time, in motion *through* time. What appears as time passes is a continuous slippage of the present into retention (along with a continuous resolution of protention into primal impression). What slides into retention is not merely the present primal impression, the momentary sensory inputs, but rather the entire tripartite structure, moment by moment in a continuous temporal flow. At 10:10, present consciousness includes the sensory content at 10:10, along with an occurrent retention of (formerly) present consciousness at 10:09. But that lapsed present consciousness at 10:09 included its primal impression (sensory information at 10:09) *and* retentional consciousness at 10:09, itself enfolding retentional consciousness from 10:08, and so on into the past, as if into a bottomless well. But all this recursive nesting is experienced, all at once, at 10:10. Similar recursion opens into protention. We anticipate not just the next primal impression, at 10:11, but a next moment that will include a retention of the present package at 10:10 (and a further protention toward 10:12 and beyond).

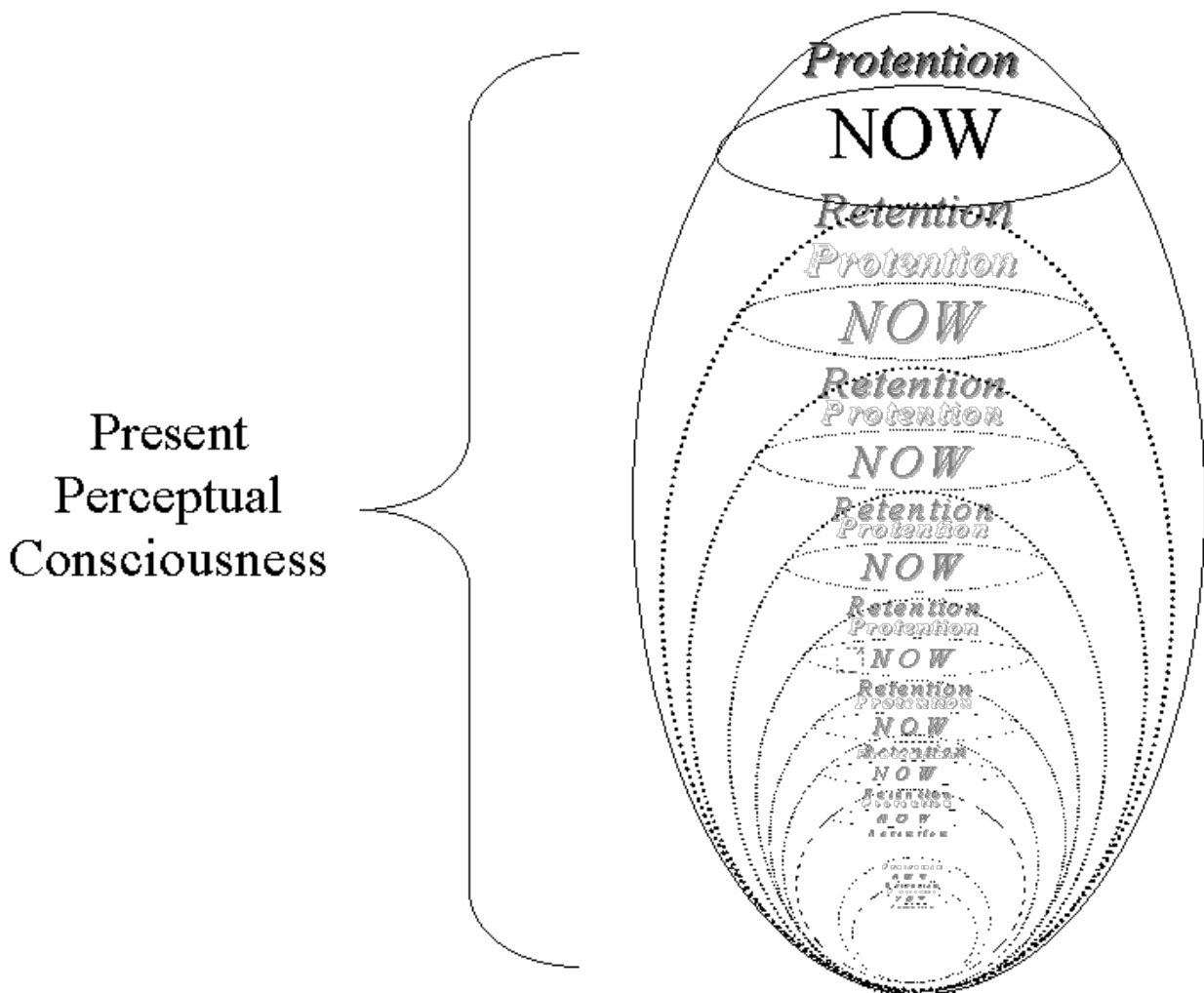


Figure 3. Phenomenology of the present, according to Husserl.

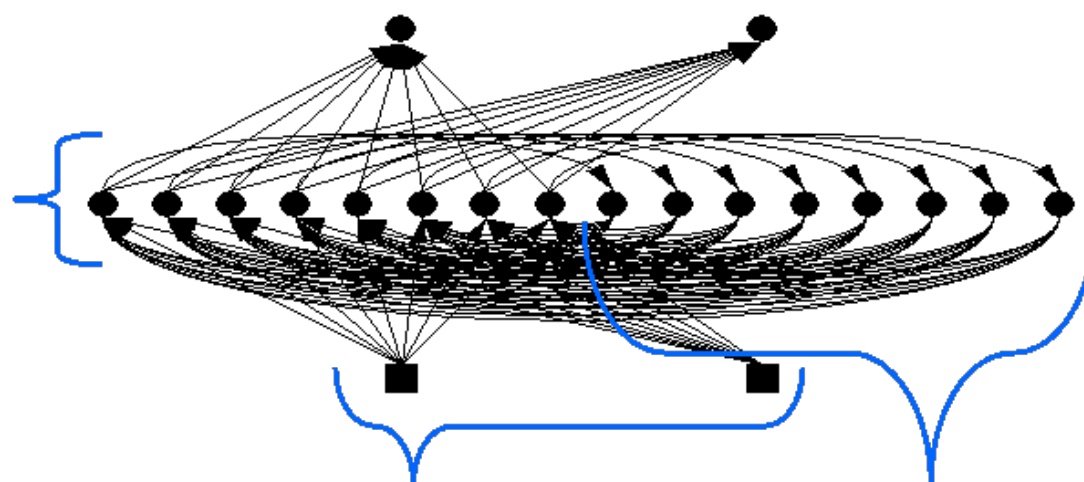
Figure 3 presents a schematic outline of the present moment of consciousness, as understood (in outline) by Husserl. Both the example just above and the diagram suggest discrete time steps and sharp boundaries between phases of temporal experience, but this is just for clarity. Husserl imagined a continuous slippage or flow of time. In addition, the nesting depicted reaches into retention only, omitting equally complicated structures of protention.

What then is time? For humans, at least, it is more than meets the eye, and more than the clock reports. That “more” goes beyond locating one’s experience in a framework of subjective history. Rather, temporality is the basis for the subjective sense of reality itself. Since both stability and change are essentially temporal experiences, every element of the experienced world is inflected by temporality. Objects get (or lose) their objectivity by their trajectory through a complex counterpoint of protention and retention, and by exactly the same calculus we siphon off the subjective component of consciousness. Subjective and objective are both aspects of experienced time.

Temporality adds a significant complication to any model of cognition, in the form of a new dimension in perception. It entails, for example, that no two sensations are the same, no matter how similar the physical stimuli are. By the same token, nothing endures. Even the serene contemplation of a good size boulder yields an evanescent flow of experience. At a minimum, duration itself is a changing variable as the boulder evolves from first glance to steadfastness. In addition, anything else straying into perception might remain in the temporal field even after it has disappeared from sensation.

IV: Braiding time and recurrent networks

Husserl never considered how temporal consciousness might be implemented in any physical system. Nowadays things have changed a bit. However, the new complexities of time do not lend themselves to a classical box-and-arrow functional decomposition. Instead, we turn again to dynamic systems in general, and to the simple recurrent network. The recurrent architecture offers information processing to support retention in very much the way Husserl imagined. The “context layer” reproduces the entire state of the hidden layer from one cycle past and makes it available along with the current inputs. Thus, the basis of each cycle of processing includes two streams of information: an analogue of the primal impression, i.e. the current input, and an analogue of the retentive contents retained from the immediate past, i.e., the context layer, preserving the information encoded from the previous cycle. Figure 4 presents the analogy diagrammatically.



Primal Impression + Temporal Context

Figure 4. Speculative mapping of temporal information processing in a recurrent neural network, expressed in the language of phenomenology

The case for this intertwining of temporality and its network implementation appears elsewhere (Lloyd 2003). Briefly, I simulated a recurrent network faced with a simple predictive task and developed methods for analyzing the model to demonstrate the presence of information required by Husserlian temporality. Then I used the same analytical techniques to confirm that temporal

information processing is a conspicuous global feature of brain activity, as detected by functional neuroimaging (See also Lloyd, 2002).

At this point, several pieces of a larger puzzle are before us: To begin, our conscious experience of the world continually presents its own context. Although temporal context is not sensed, it is woven into every experience, and is essential to the constitution of consciousness. From an information processing standpoint, any record of the past can influence the present only by some mechanism where information is gathered, stored, and re-presented in ongoing processing. The simple recurrent network offers a functional architecture to support this contextual information processing, and it has just the right components to implement the flow of experience Husserl posited, and to produce an integrated temporal structure of conscious experience. Computer models of recurrent networks demonstrates that all this is feasible for a material system.

Phenomenology makes temporality conspicuous and emphasizes its importance. Phenomenology and network models together remind us that perceptual time is not a physical fact, but rather an ongoing construction of cognitive processes that are distinct from basic sensation. In ordinary, healthy cognition, temporal cognition is so exquisitely attuned to the causal patterns of the real world that we forget that it is a construct. What, then, is the consequence when temporality fails?

It's difficult to articulate a normal, functional sense of temporal reality, but even harder to imagine its disruption. Consider again the example of the watch on its fob, this time as it might be misperceived. The ordinary case of misperception is a momentary failure of sensation. Perhaps the watch suddenly flashes red. The perplexed misperceiver inquires into the cause of the unexpected flash, which may be external or internal. This inquiry is entirely framed by normal temporality, in which the red flash and events before and after it are fixed, offering stable objects for reflective scrutiny and further exploration. The goal is to save the appearances, which at the most fundamental level entails saving reality itself. That is, the best explanation is always measured against an edifice of one's understanding of the way the world works and the circumstances of the anomaly, all expressed within the infrastructure of time. At the outcome of the investigation one might conclude that the sensation had no physical cause, and was therefore an internally generated hallucination. But this is nonetheless an account that preserves reality as such. Sensation may be in doubt (no small matter), but the world sticks.

All the clues of schizophrenia surveyed here draw attention to another sort of breakdown, however. In schizophrenia, perhaps, sensory channels are preserved and operate normally, while recurrent circuits fail. In perceptual experience, how might this sort of anomaly appear, and what remedies would it require? Disruptions in recurrence will appear as anomalies in retention. Since a recurrent net stores both spatial and temporal information in distributed representations, its dysfunction could affect either the "what" of the immediate past or its "when." The unstable network might insert or delete content with the perplexing property of seeming to have occurred. Or the distortion may be temporal, dilating or shrinking the felt duration of processes. (For a similar proposal regarding the relationship of stored material, sensory input, and cognition in schizophrenia, see Hemsley, 1996.)

In the case of the swinging watch, these effects would give rise to unusual hallucinations. The otherwise normal watch may appear to have been changed (a content shift) or to have accelerated oddly (a temporal shift) or both – even though its present sensory presentation is normal. Mystifying alterations like these naturally attract attention and demand explanation. If this happened once in a while and seemed to affect only some types of experience, it might be possible to wall off the anomaly, leaving it unexplained, while preserving a normal outlook on ordinary reality. *Déjà vu* may be an example of this phenomenology. *Déjà vu* experiences are not sensory hallucinations, but illusions of temporal context that charge the present sensory experience with the feeling of having been experienced before. They are typically perceptual and (as the name implies) often visual. We don't ordinarily experience *déjà vu* with respect to internally generated experiences like thoughts or mental imagery.

But even *déjà vu* inspires some people to leap to mystical or occult explanations. In the case of the temporally distorted swinging watch, an almost inevitable inference might posit unusual causes, forces operating in addition to the normal mechanics of the situation. Hypothesizing occult causes restores temporal experience to normalcy, at the expense of physics. To the subject, perception would be operating correctly in a world where watches are shoved around and transformed by mysterious forces. The anomaly remains, but the new explanatory context preserves the non-sensory appearances. Perhaps schizophrenic experience is like this, but amplified: the conjectured schizophrenic breakdown of recurrent processing is not a sporadic occurrence, nor is it limited to external sensory modalities. In dysfunctional recurrent networks, both externally and internally generated processes are candidates for derailment over time. In schizophrenia, anomaly is the rule. This paradoxical assault on one's efforts to make sense of the world will intensify a desperate struggle to explain an endless slippage suffusing the objective world. But the process of explanation itself suffers the compounded effects of dysfunction. Things misbehave, and so do ideas. But an individual in this horrifying predicament cannot easily give up a claim on reality. He or she cannot doubt the temporality of experience. Acknowledging the pervasiveness of dysfunction would be to surrender the very possibility of perception.

A dynamic systems hypothesis of schizophrenia will find ultimate grounding in the brain. Many regions seem affected in the illness, but not all, and a full story will need to balance spared function against the cataclysm described above. Nonetheless, the hypothesis illuminates the primary datum of schizophrenia, namely, its elusive resistance to explanation. The symptomatology, phenomenology, and general characterization of schizophrenic thought processes are elusive because every aspect of information in the affected brain areas is potentially subject to disruption. That is, no concept, distinction, or pattern of thought, expression, or feeling is immune from potential distortion. Accordingly, it is unlikely that there is a single "essential confusion" that defines the conceptual content of the illness. The idiosyncrasy of schizophrenic symptoms is rooted in the particularity of the experiences, habits, concerns, and personality of each patient. Although no particular ideation accompanies the disorder, the effort to preserve phenomenal reality in the face of random disruption may frequently elicit certain strategies, including posits of occult causes, hyperelaboration of systematic explanations, and, when all else fails, a catatonic withdrawal from the tumult. Each of these strategies is an attempt to preserve perception, and to the extent that they succeed,

patients in the grip of psychosis will believe that their reality is Reality, and thus are likely to assume their reality is shared. They will neglect to communicate their world effectively.

These comments outline an “epistemology of schizophrenia,” a characterization of information processing in a dysfunctional recurrent network. In humans, the pathophysiology of the disease seems dependent on dysfunctional neuromodulatory pathways. In us, then, the epistemology of schizophrenia is a dopaminergic epistemology. But through the unique lens of schizophrenia, we see some aspects of healthy cognition that are not usually conspicuous. Healthy cognition depends on the edifice of temporality. The phenomenal experience of reality, and the experience of perception as perception, i.e., as our subjective access to reality, is the product of a carefully tuned internal recurrent mechanism that may implicate many regions of the brain. The explanatory struggle of a mind with schizophrenia conforms to the smaller scale reactions to anomaly that those of us who are lucky in health experience routinely: cognition pounces on anomaly and labors to embed it in the warp and woof of reality. Schizophrenic symptomatology and phenomenology suggest that phenomenal reality is robust. But, although the feel of the real is not easily overcome, the actual correspondence to the physical world is a fragile one, dependent on the smooth functioning of a recurrent net with billions of nodes. In the dialectic of phenomenal, felt reality versus one’s antecedent knowledge of the objective world, phenomenal reality wins easily. Delusions and other positive symptoms of schizophrenia indicate a striking willingness to give up bedrock ideas of agency and causality. But this, I suggest, is the price of maintaining an even more basic hold on perception. Any reality, no matter how bizarre, is better than no reality. As King Lear says:

O, let me not be mad, not mad, sweet heaven, Keep me in temper: I would not be mad. (I,v)

V. Civil schizophrenia

So far this paper has circulated through several aspects of a single idea, variously expressed through phenomenological temporality, dynamic systems recurrence, and neurophysiological modulated circuits and systems. In all three incarnations, I’ve considered schizophrenic cognition and its healthy counterpart in terms of internal information processing. The loop of recurrence on which reality hangs is a loop inside the head. But this book and a good deal of contemporary discussion have explored the outsourcing of cognition. “Distributed cognition” has come to mean more than parallel distributed processing implemented inside networks and nervous systems; distribution now reaches into the world, and worldly processes are considered as proper parts of cognition itself. Accordingly, in this penultimate section I’ll revisit the ideas above in the framework of distributed cognition in this broader sense.

At the core of this paper is the theme of recurrence, a functionally loopy notion of information produced by a system and then re-introduced to the same system. Elman’s Simple Recurrent Network showed the cognitive power of the architecture, phenomenology already had a niche for the lived experience of the loop, and neuroscience showed that the brain is broadly organized accordingly. If anything, this loop is even more apparent outside the box. In its tightest form, action changes the world and perception detects the change. The action-perception loop is crucial to self-monitoring. Action, of course, is more than mere

bodily movement. In the physical and social world, our actions ramify in their effects, and these ripples return to our perception, where they shape further action, and so forth.

Schizophrenia invited us to consider a disruption in the loop, and highlighted some perplexing implications of recurrence run amok. First, I labored above to conceive of a non-sensory dislocation of context, especially temporal context, and to conceive of the wobbly self-corrections of a recurrent net and the experienced struggle to fit context slippage into a real world, however weird. Second, arrayed against the hope of self-correction is the re-entrant magnification of dysfunction. In general, recurrence allows a local dysfunction to spread as it recycles through the system. Finally, these two discussions underscored the fragility of our home in time. However comforted we may be by the immutable laws of nature, we seem to live in a house of cognitive cards. A dopaminergic tweak can bring it all down.

Now consider these same observations, applied to the manifold concentric and overlapping loops of the inhabited world. As a metaphorical handle, I propose to consider the “Gaslight Effect,” after the movie *Gaslight*, in which greedy Charles Boyer attempts to convince his spouse, wealthy Ingrid Bergman, that she is going mad. The intriguing proposal of the film is that the husband’s project is not hard to pursue. A few misplaced items and earnest lies push the heroine into a state of high anxiety. That is, small external events ramify in her mind toward a terrifying global hypothesis about her own psyche. The Gaslight Effect, accordingly, will name this potential for destabilization, in which some sort of disruption in the information flow in the environment spreads to the epicycles of the brain. Another name for it might be “social schizogenesis.”

In *Gaslight*, the nefarious plot unravels as Ingrid Bergman seizes on another small clue, a flickering gaslight, to successfully deduce the conspiracy against her. Like the patients considered in the sections above, she labors to preserve her hold on reality, and succeeds. In the movie, the plotting of an evil husband dislocates the reflective stability of the heroine. One hopes that no one is a victim of deliberate manipulation toward schizogenic ends. In any case, we can’t begin with a literal interpretation of the effect, nor assume that there is a villainous agency at work in society. Casting our net into the great sea of culture, how might we detect a Gaslight Effect in the wild?

Of course, our cultural milieu, like any cultural milieu, breeds misinformation along with knowledge. In this respect, culture is not unlike cognition, muddling through. Schizophrenia, in contrast, is a specific kind of disruption in the cognitive flow. The sections above have emphasized alterations in recurrent information processing due to alterations in modulation. In addition, I’ve discussed some characteristic responses to the massive threat to perceptual reality posed by the illness. The Gaslight analogy lends itself to various loose interpretations and many applications; here I’ll comment on a few instances. Consider, for example, mass media in its contribution to one’s perception and understanding of the world. There are many reasons to question the accuracy of mediated “perceptions,” but here the issue is a different sort of distortion. We should consider not how information is presented in the first instance but rather how it is re-presented through recurrent processes. In this respect, it seems to me that text-based media and photographic media diverge, especially in the era of television and easy video recording. Modern video affords rapid and exact repetition of scenes. Where other information

is sparse, particular images recur as placeholders, despite the low information value of their nth presentation. With repetition, certain images acquire iconic significance and heightened availability to recall and reflection. In this way they amplify one path through an ongoing recurrent loop. Commentators have noted that this repetition leads either to numbness or to overreaction ('hysteria'), which could be cultural analogues of the negative and positive symptoms of hysteria. Whether these responses correspond exactly to schizophrenic symptoms is not as important as the recognition that the process of repetition in the external environment may have psychological effects that distort cognitively appropriate responses to the original event. (Providing examples from recent events will be an exercise left to the reader.)

Looking more closely at mass media news-gathering, we can see many instances of modulation of information flow, and speculate about their cognitive effects as well. For example, the *New York Times* reported in March 2005 that several government agencies were producing television news stories for inclusion in local news broadcasts. Providing information to citizens is of course an essential function of government, but these segments took the liberty of disguising their governmental origins. Instead, they were presented as independent reporting, complete with a fictitious on-air reporter. The Potemkin correspondents offered laudatory descriptions of U.S. military prison guard training, successful business women in Afghanistan, and airport security.

Setting aside bias in the content of these reports, consider their deceptive framing as objective reporting. This is an example of aberrant modulation of the information. Like repetition, the framing exaggerates the information value of the depicted content, making it more available to recall and reflection (as "fact" rather than propaganda). In this case, ideas have been moved from one category to another. Nowadays we refer to this as "spin," a term of art that entered American English only a little more than a decade ago. One arena of ongoing spin is the appropriation of terms across categories, a practice that especially affects evaluative terms. Language itself is a recurrent medium, and the long-term effects of spin on thought may be subtler than those of outright deception. Consider this description of an earlier instance of out-of-control spin doctoring: Revolution thus ran its course from city to city, and the places which it arrived at last, from having heard what had been done before, carried to a still greater excess the refinement of their inventions, as manifested in the cunning of their enterprises and the atrocity of their reprisals. Words had to change their ordinary meaning and to take that which was now given them. Reckless audacity came to be considered the courage of a loyal ally; prudent hesitation, specious cowardice; moderation was held to be a cloak for unmanliness; ability to see all sides of a question, inaptness to act on any. Frantic violence became the attribute of manliness; cautious plotting, a justifiable means of self-defense. The advocate of extreme measures was always trustworthy; his opponent a man to be suspected. (*History of the Peloponnesian War*, 10.33-34, Richard Crawley, trans.)

This is Thucydides' description of the erosion of discourse in the later stages of the Peloponnesian wars. I think his diagnosis of the cumulative effect of spin is correct: words change their meaning. In this respect, civil discourse gradually unhinges in a similar manner to the breakdown of language in schizophrenia.

Nothing in this section should come as a surprise to any witness to recent cultural and political developments in the United States. But I invite their reconsideration under the rubric of the Gaslight Effect: External events and processes that disrupt healthy cognition, with the potential for intractable runaway feedback. The prognosis for the mental disorder of schizophrenia remains poor. For now, there is no cure for this illness. Civil schizophrenia is another matter, however. The Gaslight Effect is an epistemic dysfunction, and its cure follows a sustained course of treatment with the therapeutic practice of rational inquiry. Searching for evidence for one's claims, especially disconfirming evidence, weighing alternatives, careful communication, and plain old honesty are the modulators needed to restrain civil schizophrenia. In an era where "values" are themselves subject to spin, perhaps we would do well to keep these epistemic values before us. They are essential in the struggle to achieve every other value. To abandon these fundamental epistemic values is to abandon civil discourse. If there is a Gaslight Effect, then civil society always faces a dual threat. Dysregulated discourse and misinformation undermine a society's collective grasp of consensual truth, while at the same time dislocating cognition itself. As civil schizophrenia spirals inward, it infects our capacity for rational reflection. Through the inner and outer dynamics discussed in this paper, these processes of disintegration can ramify and compound. As we lose our communities of discourse, we may also lose our minds.

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