

Rapid Recurrent Feedback and the Rise of Consciousness

Recurrent Neural Processing and the Path to Subjectivity

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Abstract

Neural processing in the human brain consists entirely of biological mechanics, yet consciousness presents itself as subjective experience arising from within. How such experience could emerge from purely physical processes is the dilemma historically known as the hard problem of consciousness.

This article proposes that the key to the mystery may lie in a form of recursive neural processing produced by **rapid recurrent feedback systems**. It is argued that, similar to how stereoscopic depth emerges from the combination of slightly different 2D images, subjectivity emerges from a combination of two successive neural states.

The Problem of a View from Within

The human brain is a physical machine. Billions of neurons receive signals, respond to them, and transmit new signals to other cells. However intricate the process becomes, every step appears to consist of ordinary biological events governed by the same physical laws that operate everywhere else in nature.

Yet something remarkable accompanies this machinery. We do not merely process information about the world. We experience it. We see color, hear music, feel pain, recognize familiar faces, and experience the passage of time. Different as these experiences are, each involves a particular point of view: there is someone for whom the color appears, the music sounds, or the pain hurts. This subjective perspective is central to what it means to experience anything at all.

This simple fact, the emergence of a view from within, creates one of the deepest mysteries in science. We can follow sensory signals into the brain and identify neural processes associated with perception, attention, memory and conscious report, but describing what the brain does physically fails to explain why those processes should be accompanied by experience or why that experience should have an internal perspective.

This is the dilemma that lies at the heart of the hard problem. Why should physical processing produce something it is like to be the system doing the processing?

This article suggests the problem might be approached from a direction somewhat different from the usual approach. Instead of asking how neural activity somehow creates subjective experience, we can begin with a more concrete question: **What physical organization would allow a computational system to establish an intrinsic point of view?**

And the answer to that question is argued to lie in an ordinary but remarkable feature of the brain's circuitry known as **rapid recurrent feedback**.

Rapid Recurrent Feedback

When a rapid recurrent network reacts to the world, it sends a burst of information toward multiple downstream targets. Part of that information, however, loops quickly back into the input side of the network from which it originated. If it returns rapidly enough, the result is unexpectedly dramatic.

The returning information joins the process that is generating the next burst of information, and crucially, this returning information appears at the cusp, or boundary between two responses. It is, at the same time, the output of one response and input to the next. Each successive neural moment, then, is attached to not only new incoming information from the outside world but also to information about how the network itself just reacted to the world. This dual role is hypothesized here to provide the physical basis for both the brain's experienced 'now' and its emergent property of subjectivity.

This aggregation of information from two different times, and the brief interval in which it takes place, is termed here the **integrated neural present** which establishes the intrinsic temporal relationship from which subjective experience emerges. Furthermore, this emergence of subjectivity is proposed to be the direct consequence of the organization itself and nothing more.

A Physically Embedded Reference Point

The network's previous response is no longer merely an event that occurred and vanished into the past. Information from that response has circled back and is now included in the formation of the present response.

A portion of the earlier response has become a **physically embedded temporal reference point** for the response now being formed.

This relationship is renewed with each successive cycle of processing. Each response contributes something to the one that follows, establishing an ongoing, internally generated relationship between successive states of the network.

The network's current activity is determined, then, not solely by what is happening to it now, but partly in relation to how the network just reacted in the prior cycle.

This circular dance of information creates a remarkable, physically organized relationship between the two different states. Information from two successive moments—the network's immediately preceding response and its developing present response—becomes causally joined within the same ongoing process. The past is not merely stored or remembered; it actively participates as part of the present.

The proposal made here is that this internally generated relationship supplies something that a purely feed-forward system is incapable of: **a physical reference point derived from the system's prior activity**.

This relationship is argued to be the key to how an intrinsic point of view, and ultimately, subjectivity itself, could emerge from purely physical foundations.

A Point of View Examined More Closely

A point of view requires a relationship between two states: something must occur relative to something else. In ordinary physical descriptions, the reference may be external—a position relative to a coordinate system, for example, or motion relative to another object.

Rapid recurrent processing, however, introduces something fundamentally different: the possibility of an internal reference generated by the system's own immediately prior activity. The network's preceding response becomes part of a relationship within which the last response and its new response can be combined and compared.

Under these circumstances, the system is no longer responding solely to the outside world. In a physically meaningful sense, **it is responding to the world relative to its own immediately preceding response to the world.**

This does not, by itself, demonstrate that the network is conscious, but it implies a physical prerequisite for consciousness: an **intrinsic reference structure** from which an internal point of view can emerge.

The Integrated Neural Present

This continuously renewed relationship between a network's immediately prior state and its present state is herein termed the **integrated neural present**.

The idea can be illustrated by the example of stereoscopic vision. Our eyes view the world from slightly different positions. Neither image alone contains stereoscopic depth, but when the brain integrates the two views, their positional relationship provides something neither view possesses independently: the emergent perception of depth in space.

Something analogous to this is argued here to occur between successive neural states linked by sufficiently rapid recurrence, only it happens in the dimension of time instead of space.

In a rapid recurrent network, newly arriving information is processed together with information generated by the network's immediately preceding response. The result is described here as a kind of **temporal depth** where the network's **present** activity is physically organized in relation to its own immediate **past** activity.

The analogy is both structural and logical. In each case, **the relationship provides something that neither of its elements possesses independently.**

In stereoscopic vision, two different views establish a relationship from which spatial depth emerges.

In the integrated neural present, two temporally separated neural states establish an intrinsic internal point of view from which subjectivity emerges.

From Perspective to Experience

A single neural response, however complex, simply occurs. But when information from that response remains causally active in producing the next response, the new response is formed with a built-in physical relationship to the one immediately before it.

The integrated neural present is therefore not simply a brief interval containing successive events. It is a particular causal organization in which **the system's immediately preceding activity is physically included in determining its current activity.**

This organization is proposed as the minimum physical structure required to support an internal point of view by establishing the two component views required for the relationship and for it being embedded in the network's own internal machinery. It is not merely a relationship imposed by an outside observer describing the system; it exists within the system's own causal organization. The hypothesis is that this organization provides the crucial step from merely processing information to directly experiencing that information.

Subjective experience need not require the brain to create a separate internal observer that somehow watches its neural activity. The point of view may instead reside in the organization of the activity itself—specifically in the continuing relationship between what the system is doing now and what it just did.

Consider the sensory experience of seeing red.

Light of an appropriate wavelength produces a characteristic response in the visual system. In a rapid recurrent network, some information generated by that response returns quickly and is included in forming the network's next response. The sensory response is therefore no longer merely an event passing through the system. It has become part of an internally referenced, cyclic process by which each subsequent activity is, in turn, compared to its previous activity.

The qualities of an experience—the redness of red, the sound of a violin, the sting of pain—do not require an additional observer to inspect neural activity. The proposal is that these felt qualities arise from sensory responses simply because those responses occur within a causal organization that presents them from an intrinsic, internal point of view.

The **integrated neural present** is thus suggested to provide the physical foundation for *experiencing* rather than merely *processing*. Sensory activity supplies the content of the experience, while recurrent organization supplies the internally generated perspective from which those contents are promoted to the level of subjectivity.

The claim is not simply that recurrent processing contributes to consciousness, but that sufficiently rapid recurrence allows a physical system to establish its own immediately preceding activity as an internal reference for its present activity, thereby allowing the two moments to be combined and compared—setting the stage for the rise of an emergent property.

Putting the Idea to the Test

Any proposal about consciousness ultimately has to do more than offer a logical explanation for subjectivity, no matter how appealing. Most importantly, the hypothesis must be capable of being wrong and it must lead to questions that can be investigated.

Testing this proposal requires research methods that can distinguish rapid recurrent activity from incoming sensory processing and determine whether disrupting that recurrence changes conscious perception.

If conscious experience can be shown to occur while the system's immediately preceding response is prevented from participating, the integrated neural present theory cannot be a necessary foundation for consciousness.

The integrated neural present theory makes, then, a specific proposal. What matters is not recurrence simply because activity travels back around a feedback loop. What matters is whether information from the network's immediately preceding response returns rapidly enough to participate causally in forming its next response.

Looking From the Inside

The mystery of consciousness may turn out to appear unnecessarily difficult because we usually begin with two radically different things—physical neural activity and subjective experience—and then ask how the first could possibly produce the second.

But perhaps that is not the most productive way to approach the problem.

Rapid recurrent feedback creates a physical system in which the past does not simply vanish. Information derived from the network's previous response returns to the network rapidly enough to become part of its present response. Moment by moment, the system repeatedly carries forward an internal reference to its own immediately preceding activity.

The result is the step-wise progression generated within the **integrated neural present**: a continuing process in which what is happening now occurs with a built-in physical relationship to what the system itself just did.

The network thereby possesses something that purely feed-forward processing lacks—an *internally* generated reference supplied by its own prior activity.

The proposal made here is that this organization provides the basic physical foundation for an intrinsic point of view and, ultimately, for subjective experience. Consciousness need not depend upon some mysterious additional ingredient being added to neural activity. It may emerge automatically when neural activity becomes organized so that the system's own past continually provides an internal reference for its unfolding present.

This suggests a physical bridge between mechanistic processing and experience that can be stated surprisingly simply:

Subjective experience may emerge automatically when a system's present state is formed with a continuing internal, physical relationship to its own immediately preceding state.

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