

These figures merely depict Grossberg's basic idea and omit most of the practical details. Grossberg subsequently produced a great many elaborations building on this basic concept. These elaborations eventually led to the discovery and development of adaptive resonance theory as ART stands today. The question of interest to me in these notes is the following: How well does this basic Grossberg schema conform to the general requirements of mental physics and what are its shortcomings?

The first thing we may note is that the basic avalanche network implements only ritualistic learning and thereafter reduces merely to an automaton. I do not criticize the simplicity of the basic schema because the ritualistic response could be made arbitrarily complex by ~~re~~ judicious use of ART2 networks to implement the various network nodes. Such an extension allows for the incorporation of a wide variety of qualifiers capable of modifying the sequence and admitting a capacity ~~at~~ for manifold fine distinctions among the data of the senses. Grossberg and his staff have, over the years, demonstrated this, e.g. [6].

Even so, the basic avalanche schema continues to underlie Grossberg's networks at the most fundamental level. Thus it is this basic schema we need to critique. In such a critique, the key question is: What is the Objekt given

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6. S. Grossberg, The adaptive self-organization of serial order in behavior, language, and motor control, in *The Adaptive Brain II* (S. Grossberg, ed.) NY: North Holland, pp. 313-400, 1987

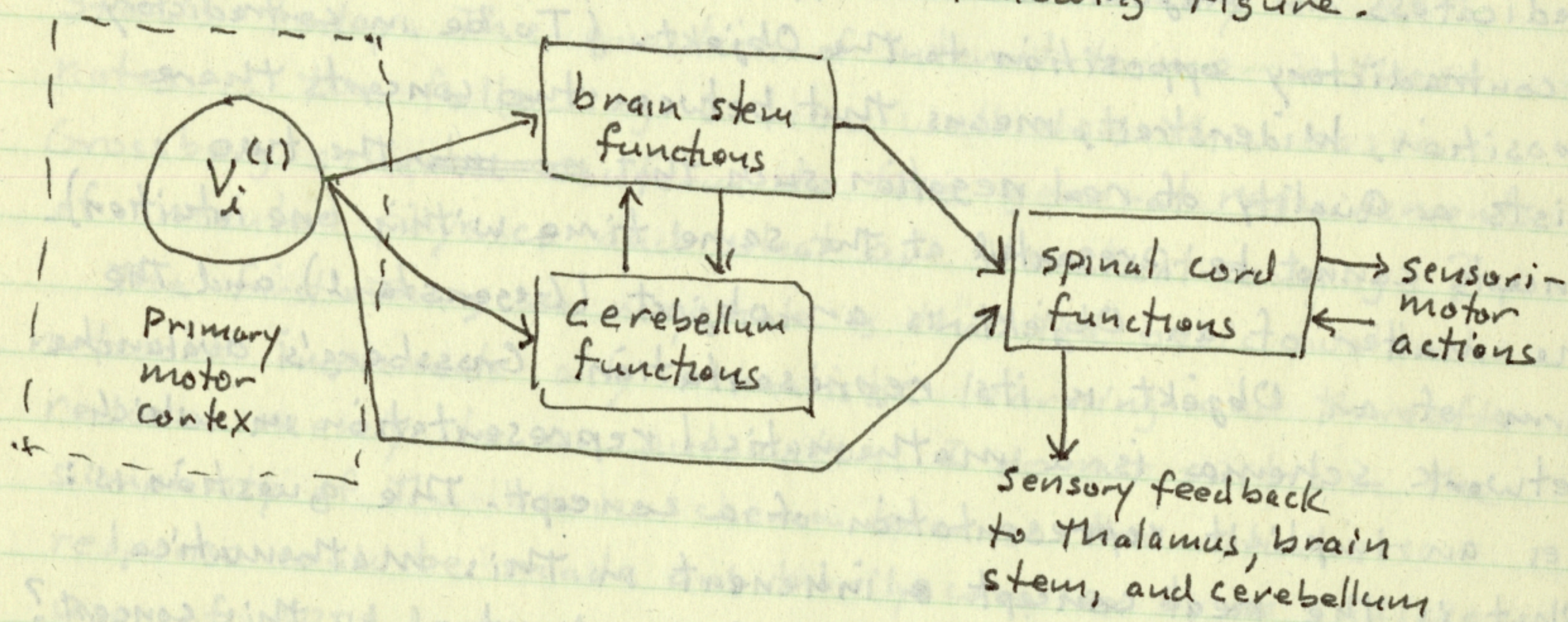
representative structure by an avalanche network?

In mental physics an Objekt is that in the concept of which the manifold of a given intuition is united and which stands as the subject of a judgment that can contain different possible predicates. An Objekt has no opposite, i.e. there is nothing in contradictory opposition to the Objekt. (To be in contradictory opposition, Widerstreit, means that between two concepts there exists a Quality of real negation such that ~~no~~ the two concepts cannot be presented at the same time within one intuition). The matter of an Objekt is an object (Gegenstand) and the form of an Objekt is its representation. Grossberg's avalanche network schema is a mathematical representation in which lies an implicit representation of a concept. The question is: What is the real concept inherent in this mathematical form and what objects are to be understood by this concept? What real objects fall under Grossberg's mathematical object? [7]

Grossberg holds that the mathematical form represented by an avalanche network is a mathematical description of brain function. He does not claim to have identified specific biological anatomies corresponding to this structure and usually employs what he calls "mock anatomies" to serve as specific illustrations for the ideas he is trying to convey.

7. The terms I am employing in this discussion are technical terms in the epistemology of the phenomenon of mind. The technical glossary and accompanying text in *The Critical Philosophy and the Phenomenon of Mind* (Wells, 2006) should be consulted here.

His favorite mock anatomies often assign the F_i vertices to motor functions, e.g. the motor cortex, brain stem motor circuits, and cerebellum. He allows the details of his motor actions to remain implicit, but they would have a biological form such as in the following figure.



This class of mock anatomical structure does not preclude the participation of the $V_i^{(1)}$ field in the processes of apprehension and cognition because we now know that high level motor commands emanating from the ~~cerebellum~~ cerebrum do project to the higher order thalamic relay nuclei and, from there, return signals to the neocortex (refer to figure 6 in [8].)

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8. R. Wells, Meanings-based networks: A new learning paradigm for ART network systems models, LCNTR Tech Brief, May, 2007, <http://www.mrc.uidaho.edu/~rwells/techdocs>.

For this class of anatomical correspondences in soma the $V_i^{(1)}$ field representation would be non-cognitive and would seem to fall under the topic of motor-regulatory expression in the mental physics of the psyche. (Refer to figure 17.5.1, pg. 1645, in [9]). Within this context the UCS signals depicted in Grossberg's networks would logically appear to fall within the scope of teleological reflective judgment as meanings implications with the functions of teleological reflective judgment lying "upstream" relative to the F_1 field. The so-called "Plan" vertices on page 11 would presumably fall within the scope of the process of practical judgment and in the simplest cases would correspond to the Quantity of instinct, the Quality of Validation, the Relation of maintenance of purpose, and the Modality of Bonitas pragmatica.

The UCS, the "Plan" vertices and the F_1 field all therefore have ~~identifiable~~ identifiable correlations with the Theory of mind. Matters are considerably more speculative in the case of the F_2 field, which is the heart of the avalanche network model. In terms of final outcomes for the network, the $V_i^{(2)}$ avalanche chain is an idea belonging to the natural schema of judgmentation (the system of schemata in judgmentation governing the ontological outcomes of judgmentation in general; refer to chapter 18 of [9], pp. 1769-~~1778~~¹⁷⁸²). $V_i^{(2)}$ thus lies at the boundary of teleological reflective judgment

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9. R. Wells, The Critical Philosophy and the Phenomenon of Mind, Sept. 6, 2006, Moscow, ID: MRCI E-book, <http://www.mrc.uidaho.edu/~rwells/CriticalPhilosophyandMind>

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and The motoregulatory expression of psyche.

Because Grossberg's idea of the $V_i^{(2)}$ avalanche chain falls within the scope of the natural schema of judgmentation, This idea presents numerous difficulties in identifying its real transcendental object and ~~the~~^{its} objectively valid possibility. This is a pretty serious issue and problem because the idea of the $V_i^{(2)}$ chain is central to almost all of Grossberg's work after 1970.

The most obvious property of the $V_i^{(2)}$ chain is that it implements a time series in objective time. As such its concept is connected in context via the Relation of Causality and Dependency. The nature of its Quantity, Quality, and Modality can be affected by other input signal factors and so these momenta are left unspecified by Grossberg's basic idea, which means there are as many as $3^3 = 27$ possible objective contexts from which the $V_i^{(2)}$ chain can be understood. But its Relation context is fixed and this immediately raises the question: How is it possible for the function of a $V_i^{(2)}$ chain to ~~be~~ assigned a real possibility? Are we to suppose some $V_i^{(2)}$ chains are innate in brain structure? This supposition is possible if and only if such innate chains are necessary for the possibility of experience. But if that is so, would it not mean such $V_i^{(2)}$ innate chains are contained within the idea of the process of pure intuition in space or time or both? That is an objectionable hypothesis because the pure intuitions belong to the synthesis of apprehension and not to the natural schema of judgmentation.

But if the $V_i^{(2)}$ chain does not fall within the scope of the process of pure intuition in sensibility, then it implies the $V_i^{(2)}$ chain is a constructed structure. That raises the issue of what rules or laws govern its construction.

Grossberg neither claims nor argues that the $V_i^{(2)}$ chain is innate. In point of fact he calls such an idea "absurd." He does speculate that $V_i^{(2)}$ chains form adaptively, perhaps from an initially tightly connected network. (See pp. 254-259 and figures 12-14 of [S]). However, he presents no quantitative theory for this and the question is one of those he never returned to address so far as I know.

Grossberg is correct to say the $V_i^{(2)}$ chain is not a preformed innate structure. Primitive innate reflexes in the human infant require no such structure because the combination of brain stem motor centers, spinal cord, and the generalized afferent reflex pathways within the spinal cord suffice for these first behaviors, ~~and~~ belong cleanly with the scope of motoregulatory expression, and are known to be stereotyped response structures. If we accept the hypothesis that $V_i^{(2)}$ chains are constructed, it places their somatic context cleanly within the higher brain centers. Furthermore, their context and place within the framework of mental physics at once becomes clear. The $V_i^{(2)}$ chain falls within the scope of the idea of a practical concept.

A practical concept is an obscure representation of a practical rule or tenet for the production of actions. It serves as a rule for the synthesis of appetites. An appetite (Begehrde) regarded from the practical standpoint in mental

physics is the self-determination of the power of the Subject through the representation of something in the future as an effect of this determination. But this is precisely the practical consequence of an avalanche network.

An appetite regarded from the judicial standpoint of the Critical Philosophy is ~~the~~^a representation ~~of a~~ having Desire as its matter. Desire is the unity in affective perception by which it is possible for subjective affects to be made into the representation of an appetite. ~~The~~ The idea of Desire is represented in the theory of mental physics as having desire (Begehren) as its ~~form~~ matter and desiration (Begehrung) as its form. The representation of a desire falls within the scope of affective reflective judgment (as a combination of affective perceptions). The representation of desiration belongs to teleological reflective judgment and is the determinable in motoregulatory expression. Functionally, therefore, the CS input to $V_i^{(2)}$ represents a construct subordinate to the idea of desire while the overall avalanche network structure represents a construct subordinate to the general idea of desiration.

From the theoretical standpoint of the Critical Philosophy, an appetite is the assimilation of perceptions and, therefore, is the representation of a determined practical purpose. A practical purpose is the object of a practical concept. Purpose is the Idea of a relationship between teleological reflective judgment and acting on Desire.

Because of this overall congruence between the function of the $V_i^{(2)}$ chain and all three standpoints of

Critical Philosophy, we may therefore conclude that the $V_i^{(2)}$ chain and its various connections does indeed fall within the scope of a practical concept.

Grossberg did appear to have something like this in mind in proposing the avalanche network, although he lacks the education in Critical Epistemology to fully understand his own idea. We may now draw the following conclusions.

- (1) The idea of the avalanche network structure is objectively valid.
- (2) All signaling representations within this network are non-cognitive. This means that no part of the network depicted in the previous figures falls within the scope of the synthesis in sensibility, although the affective perception outcomes of sensibility are upstream factors in the CS, UCS, and "Plan" afferents coming into the network.
- (3) The network as a whole does not lie entirely within any one subdivision of the organized Being model. It belongs in part to the division of psyche (motorregulatory expression) and in part to the division of nous (reflective judgment).
- (4) These findings are entirely consistent with Piaget's findings concerning the fundamentally practical nature of the development of early sensorimotor intelligence in human infants and with ~~the~~ his findings concerning the origins of meanings and the primitive logic of actions.

II. Grossberg's Avalanche Timing Method

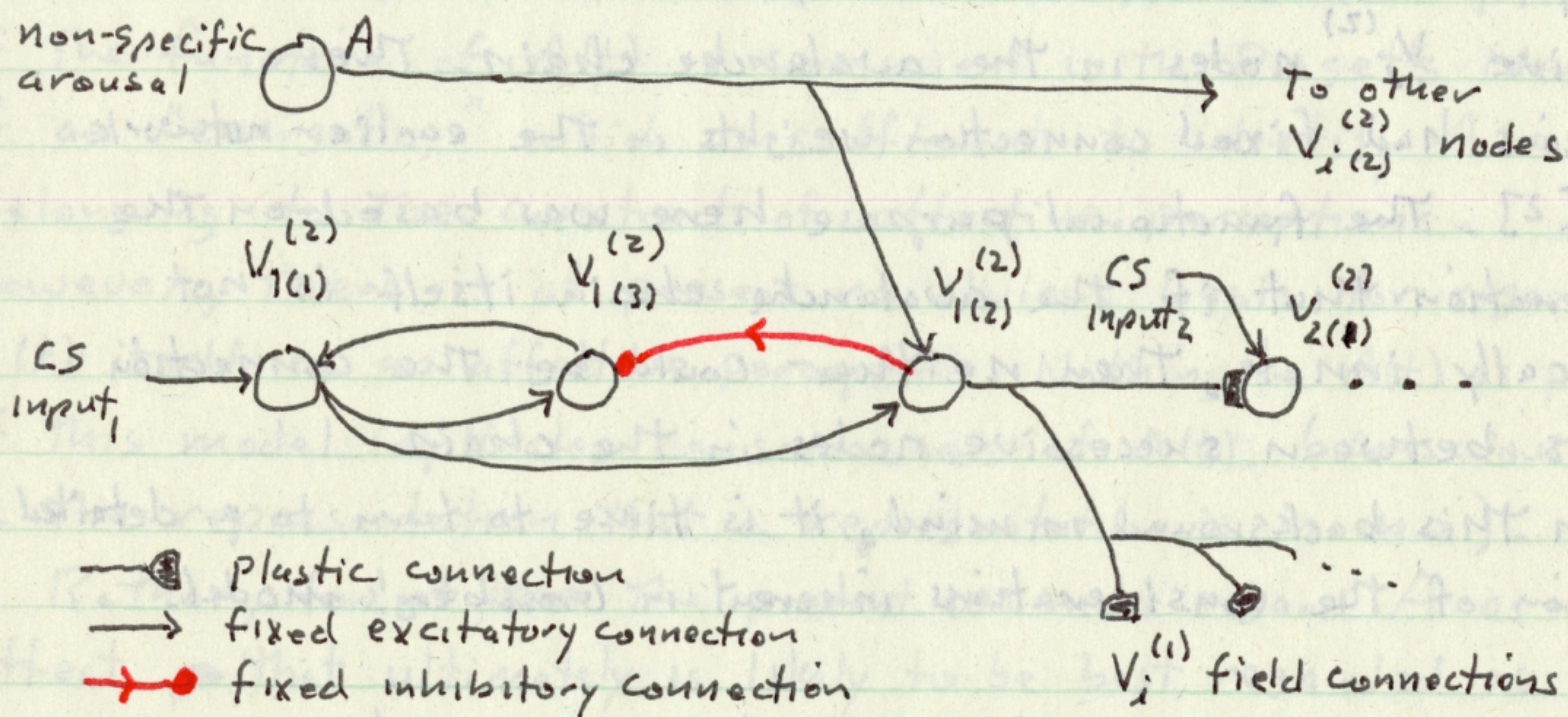
In [1] Grossberg discusses the issues involved in space-time timing of avalanche network cascades. "Time" in this context is "objective time" and is unrelated to an organized Being's intuition of subjective time. Because the $V_i^{(2)}$ field represents a constructed practical concept, the ordering of successive activations in the avalanche and the speed with which steps in the avalanche are performed represent two different psychological dimensions in the development of sensorimotor intelligence. (See pp 519-531 of [1]).

To accomplish this outcome, Grossberg ~~elaborates~~ makes an elaboration on the avalanche schema in [2] by introducing the following enhancements:

- (1) Introduction of a non-specific arousal signal that enables the $V_i^{(2)}$ field to produce suprathreshold signals $\chi_i^{(2)}(t) > \Gamma$;
- (2) Introduction of a reverberating short term memory (STM) signal within each $V_i^{(2)}$ netlet;
- (3) Introduction of negative feedback within each $V_i^{(2)}$ netlet that terminates STM after the $V_i^{(2)}$ node has had adequate time to sample the activity of the $V_i^{(1)}$ field for establishing the learning of long term memory (LTM) by the synaptic connections $Z(t)$.

2. R. Wells, Grossberg's Parallel Associative Learning Theory, these notes, pp 1-19.
1. S. Grossberg, A Theory of Human Memory (1970), in Studies of Mind and Brain (S. Grossberg, ed.), Boston, MA: D. Reidel Publishing Co., 1982, pp. 498-639

The new network schema for the $V_i^{(2)}$ field is illustrated in the following figure.



The triplet of nodes $\{V_{i(1)}^{(2)}, V_{i(2)}^{(2)}, V_{i(3)}^{(2)}\}$ replaces the $V_i^{(2)}$ node in the ~~earlier~~ $V_i^{(2)}$ field. $V_{i(2)}^{(2)}$ provides the netlet ~~output~~ output. Furthermore, new CS input stimuli are now allowed to be present in the downstream $V_i^{(2)}$ netlets in the avalanche chain.

Grossberg provided only a verbal description of the operation of this avalanche schema and did not provide a mathematical description in [1]. It seems fairly obvious that he intended that the final elaboration of this schema to be accomplished using an avalanche chain of ART fields (see fig. 36, pg 584 in [1]). Nonetheless, he never did clearly elaborate the specifics of this in his later works and, so far as I have been able to tell, the later network algorithms published by Grossberg and his associates merely built the necessary avalanche timing into the algorithms without returning to the details of how more primitive network models would accomplish this. The task

of accomplishing this is thus left up to us to carry out.

A fourth enhancement present in the extended mock anatomy was the introduction of plastic connection between successive $V_i^{(2)}$ nodes in the avalanche chain. These connections had fixed connection weights in the earlier network in [2]. The functional purpose here was based on the consideration that if the avalanche chain itself is not genetically innate, then neither could be the connection weights between successive nodes in the chain.

With this background in mind, it is time to turn to a detailed discussion of the considerations inherent in Grossberg's model.

II. A. The Mental Physics of Grossberg's enhancements.

The expansion of $V_i^{(2)}$ into $V_i^{(2)} = \{ V_{i(1)}^{(2)}, V_{i(2)}^{(2)}, V_{i(3)}^{(2)} \}$ presents no special metaphysical problem in Grossberg's model. The new structure merely adds distinctness to our concept of $V_i^{(2)}$. The enhanced idea of $V_i^{(2)}$ merely replaces the Quantity of unity with the Quantity of totality in our notion of $V_i^{(2)}$.

~~It expands the~~ The excitation variables $x_{i(1)}^{(2)}$, $x_{i(2)}^{(2)}$, and $x_{i(3)}^{(2)}$ still represent degrees of intensive magnitude which by themselves are without context but which acquire context within the idea of ~~the~~ the $V_i^{(2)}$ field as a practical concept. The Critical Category of Quality for the mathematical dynamics of a $V_i^{(2)}$ node is that of limitation. This is because both excitatory actions (affirmation) and inhibitory action (negation) simultaneously depict the neuro-dynamics of $V_i^{(2)}$ insofar as the logical momenta of Quality in its model are concerned.

Arousal signal A is the fundamentally new constituent in the enhanced model. Grossberg refers to this signal as a "command signal" ([1], pp. 519-520). His description of the function of $A(t)$ is congruent with Piaget's idea of an "energetic," which is sufficient to identify A as belonging to the construct of affective perceptions. However, there is at present no obvious basis for regarding $A(t)$ itself as an affective perception. Nothing in $A(t)$ as part of this model implicates consciousness of $A(t)$ (consciousness is the representation that a representation is in me).

Rather, for at least the present we must regard A as an effect that ultimately is likely to be best regarded as belonging to psyche under the idea of *lust per se* [3] but originating from some as yet undiscovered combination of aesthetical reflective judgment, transcendental Meaning, and the motivational dynamic of judgmentation in general. The Quantity in aesthetical judgment that best describes a relationship to $A(t)$ is the sense of continuity (particular satisfaction). The Quality could be either the feeling of pleasure/displeasure or the feeling of sublimity. Relation would be the sense of transient interest (sense of *Unsache*-desire). It seems at this time that Modality could be any of the three momenta of Modality in aesthetical reflective judgment.

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3. R. Wells, The Critical Philosophy and the Phenomenon of Mind, Sept. 6, 2006, Moscow, ID: MRCI E-Book, <http://www.mrci.idaho.edu/~rwells/CriticalPhilosophyandMind>.

In its relationship to transcendental Meaning, $A(t)$ at this level of modeling is congruent with reflexion (the function of identification in the synthesis of Meaning) as the Quantity for $A(t)$. Quality in this relationship is likely to be belief (the affirmative function in the synthesis of Meaning) in at least the earliest stages of the development of sensorimotor intelligence. The momentum of Relation congruent with the model of $A(t)$ in early sensorimotor development is the nexus of purpose (the disjunctive or transitive function in the synthesis of Meaning). Modality in this relationship is the meaning implication (determination of a meaning).

The momenta of ~~Quantity~~ Quantity in the motivational dynamic are called "wants" and bear the explicit names expression of interest, differentiation of ~~the~~ Desires, and organization of equilibration. At present we have no basis for supposing $A(t)$ is linked to any one of these more so than the others. The momenta of Quality ^{one} named "drive" and bear the explicit names affirmation of reevaluation, negation of Desires, and conditioning of motivation. Again, we currently have no basis for supposing $A(t)$ is more favored by any one of these compared to the others. Relation in the motivational dynamic is called "drive state" and the specific momenta are enforcement of law, conditioning of Desires, and organization of motivation. All three are applicable to $A(t)$. Finally, Modality in the motivational dynamic is called "type-of-motive" and the momenta are groping for equilibration, determination of elater animi, and

regulation of motivation. Once more, we have no basis at this time for thinking any one of these is preferential for $A(t)$. The implication of all this is that $A(t)$ is a mechanism within judgementation for determining the motivational dynamic but is not itself a motivational dynamic function. Rather, we might regard it as being analogous to a metabolic factor in mental physiology, and this is consistent with seeing $A(t)$ in the role of an energetic.

I have had to be very brief in this summary because the theory of aesthetical reflective judgment, Meaning, and the motivational dynamic does not permit a brief background encapsulation here. Rather, [3] must be consulted for a fuller explanation of these technical elements of mental physics. While it is premature at this time to speculate on the biological substratum for $A(t)$, the overall research context is the same as that which is the basis for [4]. This reference may be used to gain a more concrete picture of the general psychophysical issue and the relationship to the problem of the neural code. The mental physics considerations discussed here are nothing less than the earliest exploration of an objectively valid theory of motivation.

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4. R. Wells, Meanings-based networks: A new learning paradigm for ART network systems models, LCNTR Tech Brief, May, 2007, <http://www.mrc.uidaho.edu/~rwells/techdocs>