

On this fine factory day I find myself in the linguistic mode of a state of puzzlement. In answer to the question Why is there language? Iberall seems to have pointed to the Second Law of Thermodynamics. As scientist, qua linguist, I am impressed. My soft complex systems seem to get softer as a wave of amphiboly rolls over me. Language? Languages? English?

Iberall's (2) characterization of the term, as linkage or guide between soft components of soft systems, as catalyst and coupler of sensory and motor elements, is new, but as complex coding accomplished with a finite symbol set, a syntax, and semantics I recognize a grammar. How then are grammars related to physics?

As I understand Iberall's story, to be (to maintain the matter fluctuations over the energy fluctuations) and to become (to maintain the energy fluctuations over the matter changes), it is necessary to shield our stomachs and protect our motor equipment. Such shielding necessarily means introducing a time delay between the responses of particular internal states to external energy conditions. In all organisms the delay is purchased by a chemical symbol set (e.g., ATP; see also Ref. 1), which faithfully stands in relation to external conditions (for some systems) and whose fluctuating concentrations catalyze the responses of the relevant complex systems. In humans the delay is also accomplished by the presence of a cortical layer in the brain. The cortical layer can be seen to emerge evolutionarily as a solution to the internal degrees-of-freedom problem for a particularly large number of motor-sensory modes that the organism may have. Language is the characterization of the linkages among the soft system elements available to the cortical-limbic mosaic. Languages must symbolize effectively for the organism all such linkages, catalysts, states, modes, etc. Grammars are just the sort of devices that permit the finite symbol set and finite rule set to be advantageous in the presence of a cortex, because it is in the presence of cortex that such unique linkages are required. Such

REFERENCES

1. BELLMAN, K. L., AND L. J. GOLDBERG. Common origin of linguistic and movement abilities. *Am. J. Physiol.* 246 (*Regulatory Integrative Comp. Physiol.* 15): R915-R921, 1984.

linkages make possible the neural-time energy fluctuations (external to the organism) that we call speech and sign and thereby assure responsivity to the organism on a particular time scale. Through the organism's encounter with such fluctuations come the social linkages, and through these, the linkages we designate as social values.

Now, why do grammars have the properties that linguists have found for them? Can it be that just this set of properties suffices to link the soft elements at the appropriate cost to the organism in terms of the energy-matter equations of state? We may then see the change in natural languages, such as English or Swahili, as a change in the grammars without requiring a concomitant change in the physiological hardware. All such changes will be satisfying the same thermodynamic requirements (at some yet-to-be described level). We may see the language-learning problem as the forging of the soft linkages in response to the course of development and in response to intercepted environmental energy fluctuations in speech and sign. We may see linguistic pathologies as failures of the soft linkages to assure appropriate responses, as breakdowns in the shielding, time-delayed, internal changes. We can see that the absence of cortex entails for the organism that the grammar (and therefore the language) will be different from that of a cortically structured individual.

Will thermodynamics of soft systems really answer the what, how, and why questions that linguists ask about grammars, speech, and language? Will the linguists' answers about the relevant structures interest the physicists? I do not know; I will be busy trying to explain these special reductionisms to myself and my colleagues. Iberall has given a thermodynamic twist to the imperatives: keep your head, and let yourself go. How do I get out of this mode?

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2. IBERALL, A. S. On the genesis of "is" and "ought." *Am. J. Physiol.* 246 (*Regulatory Integrative Comp. Physiol.* 15): R937-R942, 1984.

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