The published version of this essay is available here:

Schweighauser, Philipp. "The Persistence of Information Theory." *Traditions of Systems Theory: Major Figures and Contemporary Developments*. Ed. Darrell P. Arnold. New York: Routledge, 2014. 21-44.

See https://www.routledge.com/Traditions-of-Systems-Theory-Major-Figures-and-Contemporary-Developments/Arnold/p/book/9780415843898

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Information Theory

When Claude E. Shannon published "A Mathematical Theory of Communication" in 1948, he could not foresee what enormous impact his findings would have on a wide variety of fields, including engineering, physics, genetics, cryptology, computer science, statistics, economics, psychology, linguistics, philosophy, and aesthetics.[1] Indeed, when he learned of the scope of that impact, he was somewhat less than enthusiastic, warning his readers in "The Bandwagon" (1956) that, while "many of the concepts of information theory will prove useful in these other fields, [...] the establishing of such applications is not a trivial matter of translating words to a new domain, but rather the slow tedious process of hypothesis and experimental verification" (Shannon 1956, 3). For the author of this essay as well as my fellow contributors from the humanities and social sciences, Shannon's caveat has special pertinence. This is so because we get our understanding of information theory less from the highly technical "A Mathematical Theory of Communication" than from Warren Weaver's "Recent Contributions to the Mathematical Theory of Communication" (1949), the now canonical popularization of Shannonian information theory, which was published alongside Shannon's original essay (now renamed "The Mathematical Theory of Communication") in *The Mathematical Theory of Communication* (1949).[2]

Why begin this first essay in a volume entitled *Traditions of Systems Theory* on such a cautionary note? For one, because the strictly technical context in which Shannon developed his theorems impacts their translatability to other fields. Most significantly, it is at least questionable whether his transmission model of machine communication is adequate to describe processes of information exchange taking place within biological and social systems. Accordingly, while Shannonian information theory remains an important touchstone for much contemporary media theory and systems-theoretic varieties of sociology (at least in the German-speaking world), subsequent developments in first-order and second-order cybernetics have abandoned many of the premises of Shannon's model of communication. Finally, in stressing that most contributors to this volume know Shannon via Weaver, I do more

than identify a liability. In fact, as I will argue below, Weaver's expository essay opens up new ways of thinking about communication and noise as it reintroduces the semantic considerations Shannon excludes.

Informational Entropy

Shannon's model of communication owes its non-hermeneutic scope, i.e., its insistence that the "semantic aspects of communication are irrelevant to the engineering problem" (Shannon 1963, 29), to the institutional context of its genesis. As an engineer employed by Bell Telephone Laboratories, Shannon had little interest in the dynamics of human sense-making. Instead, he worked at increasing the efficiency of telecommunication when he discovered, to his astonishment, that his definition of information corresponded to Ludwig Boltzmann's definition of entropy. This was indeed surprising since entropy is a measure of disorder in a thermodynamic system. Thus, Shannon's finding suggests that chaotic, disordered, entropic messages have greater information value than ordered, negentropic ones. What seems counterintuitive at first makes perfect sense in the context of Shannon's proposal that the amount of information a given message conveys must be calculated in relation to the set of possible messages from which this specific message has been selected. In Weaver's words, "To be sure, this word information in communication theory relates not so much to what you *do* say, as to what you *could* say" (1963, 8-9). For Shannon, information is a purely quantitative measure. The larger the set of possible messages, the higher the sender's freedom of choice in selecting one specific message, the higher the amount of information communicated. This is true irrespective of *what* is being communicated. At the other end of the communication process, the receiver's uncertainty as to what specific message the receiver has selected correlates directly with the sender's freedom of choice: the higher the sender's freedom, the higher the uncertainty the message removed at the receiver's end, the higher the amount of information conveyed. Given this, it seems clear that a message about whose identity the receiver was already relatively certain prior to its arrival contains less information than one which s/he could not have predicted with a high degree of certitude: "Information is, we must steadily remember, a measure of one's freedom of choice in selecting a message. The greater this freedom of choice, and hence the greater the information, the greater is the uncertainty that the message actually selected is some particular one. Thus greater freedom of choice, greater uncertainty, greater information go hand in hand" (Weaver 1963, 18-19). The more possible messages there are, then, the less probable and predictable each specific message is, and the more information each specific message conveys. Conversely, a fully predictable message is redundant and thus devoid of information:

That information be measured by entropy is, after all, natural when we remember that information, in communication theory, is associated with the amount of freedom of choice we have in constructing messages. Thus for a communication source one can say, just as he would also say it of a thermodynamic ensemble, "This situation is highly organized, it is not characterized by a large degree of randomness or of choice--that is to say, the information (or the entropy) is low." (Weaver 1963, 13)

Let me illustrate Shannon and Weaver's reasoning with an example from the area of human communication. Imagine a situation in which A asks B, "Did you post the letter I gave you?" In an *idealized* speech situation, B's choice of an answer is limited

to either "yes" or "no." Consequently, the amount of information conveyed by B's answer is relatively low, for A could have guessed the correct answer with a 50% chance anyway. Another way of saying this is that the probability that B chooses a specific answer is relatively high and that B's answer therefore removes only little uncertainty on the part of A. If, on the other hand, A asks B, "How did you spend the afternoon?" B may choose her answer from a far greater field of possible messages, and her answer removes far more uncertainty on the part of A as to which message out of a set of possible messages B would choose. No matter what answer B chooses, the amount of information conveyed by it is relatively high.

A second factor which determines the entropy of a message is probability. Let us stay with the previous example. When asking the question, "Did you post the letter I gave you?" A will be predisposed to expect one answer from B rather than the other, be it because A possesses knowledge about B's reliability or simply because A has prejudices about her. The two possible answers (yes, no) are therefore not equally probable from A's point of view. Consequently, A's uncertainty concerning B's choice of one of the two messages will not be as high as it would be if the two answers were equally probable, and the amount of information conveyed by the message is correspondingly smaller. A maximally entropic or "informative" message is therefore not only one that has been chosen out of a maximally large set of messages but also one chosen out of a set of messages which are all equally probable:

In the limiting case where one probability is unity (certainty) and all the others zero (impossibility), then *H* [entropy] is zero (no uncertainty at all--no freedom of choice--no information). Thus *H* is largest when the two probabilities are equal (i.e., when one is completely free and unbiased in the choice), and reduces to zero when one's freedom of choice is gone. The situation just described is in fact typical. If there are many, rather than two, choices, then *H* is largest when the probability of the various choices are as nearly equal as circumstances permit--when one has as much freedom as possible in making a choice, being as little as possible driven toward some certain choices which have more than their share of probability. (Weaver 1963, 15)

Human language never reaches a state of maximum entropy and is therefore never maximally "informative" in Shannon's sense. This derives from the fact that the elements human language is composed of (phonemes, morphemes, lexemes, sentences) never occur with equal probability. There are certain rules which govern the production of human language, and these rules constrain the freedom of choice on the part of the sender of a message as well as the uncertainty on the part of the receiver. They increase the probability that certain elements rather than others are chosen by the sender and therefore decrease the information content of any given message. Let us return to the above example once more. Take the fourth word in A's question, "Did you post the letter I gave you?" At the phonetic level, there are phonotactic rules which govern the sequential arrangement of phonemes, and constrain, for instance, the choice of possible sounds following the initial /ð/ in "the." In fact, only vowel sounds could fill this slot. It is such rules which would make a written sequence of letters such as "Dd u post th lettr I gv u?" still perfectly understandable for most speakers of English. Similar rules apply to the sequence of individual words. The probability that "the" is followed by either a noun or an adjective is much higher than it being followed by a verb or an article. At the level of speech acts, it is less probable if not inconceivable that A's question is answered with "12 o'clock" rather than "yes" or "no."

Stochastic processes are processes governed by the laws of probability, and the generation of human language is, mathematically speaking, a Markoff process, i.e. a "special case of a stochastic process in which the probabilities depend on the previous events" (Weaver 1963, 11). The probabilities involved reduce the sender's freedom of choice, reduce the receiver's uncertainty, make messages more predictable and therefore less "informative." So while it is true that "the whole purpose of communication is to send messages which are not fully predictable" (Campbell 1983, 63), i.e., to exchange non-redundant messages, fully *un*predictable messages are not a possibility in human communication.

Noise

Within the framework of Shannonian information theory, fully unpredictable messages are both maximally informative and completely unintelligible. They are *noise*, the direct opposite of redundancy. As indicated, it is, strictly speaking, impossible to communicate noise. However, in machine as well as human communication, any perturbation of signal transmission by noise makes messages less predictable. In point of fact, in Shannon's model, noise not only degrades the message sent in that it effects "that the received signal is not necessarily the same as that sent out by the transmitter" (Shannon 1963, 65). Noise, more specifically white noise, is also the most entropic signal and as such conveys the greatest amount of information: "white noise has the maximum possible entropy" (Shannon 1963, 92).[3] Given the engineering context within which Shannon developed his theorems, such a positive valorization of noise comes unexpected. Shannon's research was, after all, geared at enhancing the performativity of machine communication. In this commercial context, noise is always a force to be reckoned with, but it is by no means a welcome guest. In this scheme, redundancy is necessary precisely because it compensates for the noise that affects all transmissions of information. To return to our example, any distortion of a message like "Dd u post th lettr I gv u?" is more likely to render it unintelligible than a distortion of the message, "Did you post the letter I gave you?" because the former message exhibits less redundancy and is for this reason more vulnerable to noise. This has repercussions on the way messages must be coded prior to transmission: "if the source already has a certain redundancy and no attempt is made to eliminate it in matching to the channel, this redundancy will help combat noise" (Shannon 1963, 75)

With Shannon's military metaphor in mind, it comes as little surprise that he and Weaver stop short of giving noise its full due. For them, noise is indeed the most unpredictable signal and as such exhibits the greatest amount of information; yet they characterize the information it communicates as useless:

Uncertainty which arises by virtue of freedom of choice on the part of the sender is desirable uncertainty. Uncertainty which arises because of errors or because of the influence of noise is undesirable uncertainty. It is thus clear where the joker is in saying that the received signal has more information. Some of this information is spurious and undesirable and has been introduced via the noise. To get the useful information in the received signal we must subtract out this spurious portion. (Weaver 1963, 19)

If one follows Shannon's assertion that "the amount of information received is the degree to which the receiver’s uncertainty concerning that event has been diminished"

(Paulson 1988, 55), then noise is responsible for any remaining uncertainty once the signal has arrived at the receiver's end. From an engineering point of view, "[i]f the information source has any residual uncertainty after the signal is known, then this must be undesirable uncertainty due to noise" (Weaver 1963, 20).[4] Shannon calls this "spurious portion" equivocation and defines it as "the average ambiguity of the received signal" (Shannon 1963, 67).

By characterizing noise as "useless" and describing its effects as "undesirable uncertainty," Shannon and Weaver deftly cast out a player in communication processes that they have just defined as that signal which conveys the greatest amount of information. It is as if these two engineers working for a telephone company were not quite prepared to follow their own insights to their radical, counter-intuitive end. As we will see, a number of contemporary thinkers including Michel Serres, Jacques Attali, and William R. Paulson were much less timid in their creative appropriations of Shannon's reflections on noise. Yet the grounds for their work was already laid in *The Mathematical Theory of Communication*, though at least in one respect less in Shannon's contribution to that volume than in Weaver's essay.

In the third and final section of his article ("The Interrelationship of the Three Levels of Communication Problems"), Weaver turns to the semantic questions that neither Shannon nor he ever tired of declaring extraneous to information theory. In Weaver's words, "*information* must not be confused with meaning […]. The semantic aspects of communication are irrelevant to the engineering aspects" (1963, 8). This exclusion of meaning-making is integral to the model of communication Shannon proposes:

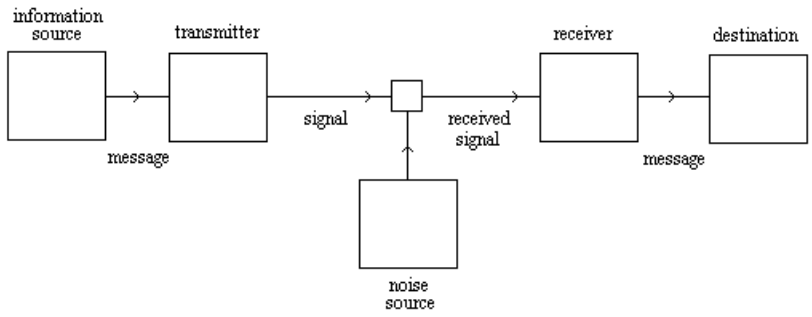

Figure 1 (Shannon's communication model)

In oral communication, the information source is the speaker's brain; the transmitter the physical speech apparatus that transforms the message into a coded signal sent over the air; the receiver is the hearer's ear; the destination his or her brain. Given these correspondences, it seems clear that any kind of interpretive activity would take place in either the information source or the destination. Yet Shannon is singularly uninterested in what goes on within these boxes. For him, "there is no ambiguity about what it means for a message to be 'correct'; it means that if the message before it is *encoded* is compared with the message after it is *decoded*, the two will be identical" (Hayles 1987, 196). In this scheme, there is no room for any interpretive activity; what counts is the successful transmission of self-identical information.

Yet when Weaver does consider semantics in the final section of his article, he opens up a different avenue of thinking about communication, meaning, and noise:

One can imagine, as an addition to the diagram, another box labeled "Semantic Receiver" interposed between the engineering receiver (which changes signals to

messages) and the destination. This semantic receiver subjects the message to a second decoding, the demand on this one being that it must match the statistical *semantic* characteristics of the message to the statistical semantic capacities of the totality of receivers, or of that subset of receivers which constitute the audience one wishes to affect. (1963, 26)

Three years after the publication of "The Intentional Fallacy" (1946), Weaver ever so cautiously (and almost certainly unintentionally) joins William K. Wimsatt and Monroe R. Beardsley in moving away from a communication model that declares the sender the sole source of authority and meaning. Moreover, his contention that the semantic receiver's task is to match the message's semantic properties to the receiver's capacity for processing information qualifies his own earlier assertion that the "*semantic problems*" of communication are solely "concerned with the identity, or satisfactorily close approximation, in the interpretation of meaning by the receiver, as compared with the intended meaning of the sender" (Weaver 1963, 4).

Weaver moves even further away from a linear, one-way model of communication when he speculates about the consequences of supplementing Shannon's diagram with yet another box:

Similarly one can imagine another box in the diagram which, inserted between the information source and the transmitter, would be labeled "semantic noise," the box previously labeled as simply "noise" now being labeled "engineering noise." From this source is imposed into the signal the perturbations or distortions of meaning which are not intended by the source but which inescapably affect the destination. And the problem of semantic decoding must take this semantic noise into account. It is also possible to think of an adjustment of original message so that the sum of message meaning plus semantic noise is equal to the desired total message meaning at the destination. (1963, 26)

Weaver's surprising suggestion that distortions of the sender's intended meaning may have to be considered an integral part of the received message rather than an unwanted nuisance not only breaks with communication models that locate all authority in the sender's intention but also reintroduces the noise expelled by Shannon's categorical distinction between useful and useless information:

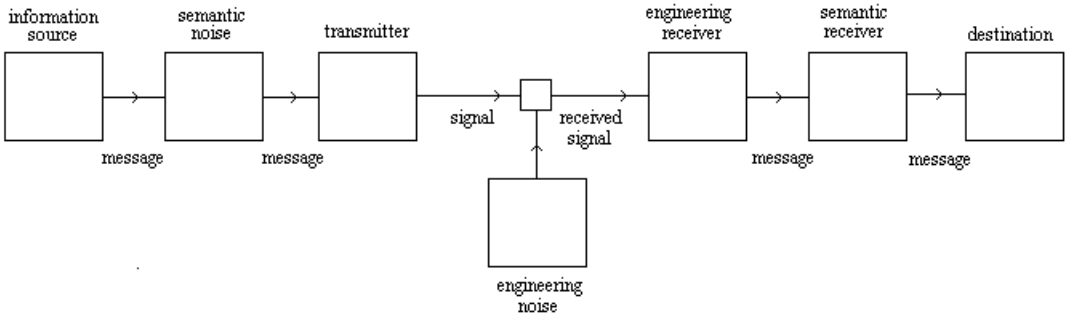

Figure 2 (Shannon's communication model with Weaver's proposed additions)

Clearly, Weaver's reflections are miles apart from contemporary celebrations of noise as a subversive communicative force and bringer of the new. Weaver's model incorporates noise not for its own sake but in order to contain its potentially destructive force. Still, together with Shannon's realization that noise is the signal that

conveys the greatest amount of information, Weaver's suggestion that distortions of the sender's intended meaning by "semantic noise" may actually contribute to rather than impair the meaning received at the other end of the communication process forms the basis for more enthusiastic reappraisals of noise in literary and cultural theory since the 1980s.

The Persistence of Shannonian Information Theory

That Shannonian information theory should continue to enjoy such currency in a number of contemporary theoretical debates is, however, by no means self-evident. While *The Mathematical Theory of Communication* remains an important reference point for major literary, cultural, and media theorists including Serres, Attali, Paulson, Friedrich A. Kittler, and N. Katherine Hayles, most communication theorists agree that Shannon's transmission model of communication is too restricted to its technical context to serve as a general theory of communication. A glance at the historical context in which Shannon's seminal article was published shows that the grounds for the latter opinion were already prepared in the middle of the twentieth century.

"A Mathematical Theory of Communication" was published in issue 27 of the *Bell System Technical Journal* (July/October 1948). Disseminated primarily via *The Mathematical Theory of Communication*, Shannon's bold refunctioning of Boltzmann's definition of thermodynamic entropy, his definition of information as "a measure of one's freedom of choice when one selects a message" (Weaver 1963, 9), and his decision to divorce the study of data communication from that of sense-making processes had a major impact on a great variety of fields. One legacy of that impact is that Shannon's definition of "information" has even found its way into the *Oxford English Dictionary*: "As a mathematically defined quantity divorced from any concept of news or meaning […]; spec. one which represents the degree of choice exercised in the selection or formation of one particular symbol, message, etc., out of a number of possible ones, and which is defined logarithmically in terms of the statistical probabilities of occurrence of the symbol or the elements of the message" (sense 2.c). While few laypersons will have heard of Shannon's definition of information, his conceptualization of it as the result of a process of selection provides an important basis for further developments in first- and second-order cybernetics, most prominently Niklas Luhmann's reconceptualization of information as the result of not one, but three processes of selection:

[C]ommunication must be viewed [...] as a three-part selection process. [...] The standard concept of information elaborated since Claude E. Shannon and Warren Weaver makes it easy to formulate this. According to today's standard interpretation, information is a selection from a (known or unknown) repertoire of possibilities. Without this selectivity of information, no communication process would emerge [...]. Furthermore, someone must choose a behavior [i.e., a specific medium] that expresses this communication. That can occur intentionally or unintentionally. What is decisive is the fact that the third selection can base itself on a distinction, namely, the distinction between information and its utterance. (1995, 140)

Yet as much as Shannon's pioneering work remains an important reference point for some contemporary sociologists and many media theorists in the German-speaking world, the grounds for a significant shift away from Shannonian information theory were already laid in the year that "A Mathematical Theory of Communication" was

published. In 1948, Norbert Wiener's *Cybernetics or Control and Communication in the Animal and the Machine* was also issued, and even though Wiener near the beginning of the second edition of *The Human Use of Human Beings: Cybernetics and Society* (1954) writes that cybernetics grew "from a few ideas shared by Drs. Claude Shannon, Warren Weaver, and myself, into an established region of research" (1954, 16), it was Wiener's cybernetics rather than Shannon's information theory that became the major rallying point halfway through the interdisciplinary Macy conferences (1946-1953). This was decisive, since it was these ten conferences that changed the way we think about communication. While Shannon was a guest at three of the four final meetings and gave talks at two of them, Wiener belonged to its core group for the first seven.[5] Wiener's cybernetics and Shannon's information theory are compatible in several ways, most significantly in their conceptualization of information as the outcome of a process of selection and their disregard for questions of meaning. Indeed, Wiener already in *Cybernetics* explicitly references Shannon's mathematical theory of communication, and Shannon acknowledges that "[c]ommunication theory is heavily indebted to Wiener" (1963, 85n. 4). But apart from Wiener's equation of information with negentropy rather than entropy (which he inherits from Boltzmann, who observes that more ordered and regular messages are actually less probable than disordered, "noisy" ones), there is an even more decisive difference between the two models.[6] Wiener and his fellow cyberneticians were moving away from Shannon's transmission model of communication to study processes of information exchange, feedback, and self-organization taking place on several distinct levels within complex systems such as computers, the brain, and human communities. As Wiener makes clear, this move away from the engineering context was crucial to the cybernetic program:

Besides the electrical engineering theory of the transmission of messages, there is a larger field which includes not only the study of language but the study of messages as a means of controlling machinery and society, the development of computing machines and other such automata, certain reflections upon psychology and the nervous system, and a tentative new theory of scientific method. This larger theory of messages is a probabilistic theory […]. Until recently, there was no existing word for this complex of ideas, and in order to embrace the whole field by a single term, I felt constrained to invent one. Hence "Cybernetics," which I derived from the Greek word *kubernētēs*, or "steersman," the same Greek word from which we eventually derive our word "governor." (1954, 15)

True, both Wiener's science of communication and control and Gregory Bateson's famous definition of "information" as "a difference which makes a difference" (1972, 453) are inconceivable without Shannon's conceptualization of communication in binary terms (which he inherits from Ralph V. L. Hartley's earlier work) as well as Shannon's insight that completely predictable messages are redundant and therefore devoid of information. But Wiener's focus on feedback processes, self-regulation, and learning and Bateson's holistic exploration of open, homeostatic systems are already drifting rapidly away from Shannon's linear, technical model. With the shift of focus to questions of autopoiesis and emergence in second-order cybernetics, the move away from sender-receiver models of communication became ever more decisive.

Indeed, it is not only from the vantage point of an empirically oriented communication studies but also from semiotic and cybernetic perspectives that Shannon's model--which (despite Weaver's modifications to it) considers the

transmission of self-identical messages as the touchstone of successful communication--does not seem complex enough to describe communication outside of the model's narrow technical context. Daniel Chandler usefully summarizes objections raised against transmission models: they are based on a transport metaphor that informs commonly used phrases such as "did you get my message?" and "sending information using Bluetooth" but misleadingly conceives of information as "packages" sent from A to B; they accord the receiver an entirely passive role; they mistakenly conceptualize communication as one-way and linear; they wrongly equate content and meaning; they account only for goal-oriented/instrumental communication; they ignore all social and cultural contexts; they cannot account for acts of communication between more than two entities; they deny the temporal dimensions of communicative acts; and they ignore the specific properties and functions of different media. In several senses, then, Shannonian information theory is an imperfect precursor to more sophisticated models of communication.

And yet, Shannon's model continues to generate a considerable amount of serious discussion among more theoretically inclined students of media and culture. Why is that so? Chandler suggests that, despite all its deficiencies, Shannon's model has three important advantages: it is simple, generalizable, and quantifiable. Granted, but I believe that it is a fourth feature of Shannon's information theory, one that relates to its generality but is not identical with it, that makes Shannon amenable to more recent media theories. In fact, that feature which made Shannon's model such a continuing success story is precisely one that may be considered its main weakness: its exclusion of semantic considerations (which Weaver only partly qualifies). If, at least in the German-speaking world, the most exciting and influential work in media theory since the 1980s has been produced by scholars intent on developing a technology-centered, post-anthropocentric theory of culture, Shannon's technical definition of information comes in handy. Thus, for a theoretical project such as Kittler's, which stages--to translate the title of an early essay collection edited by him--an "exorcism of *Geist* [spirit, mind] from the humanities"--Shannon is--pardon the pun--a kindred spirit.[7] Likewise, for Hans Ulrich Gumbrecht and Karl Ludwig Pfeiffer, who stage their various challenges to the hermeneutic tradition's focus on interpretation and meaning under evolving labels such as "materialities of communication," "the nonhermeneutic," and (in Gumbrecht's recent phrasing) "the production of presence" (as opposed to the production of meaning), Shannon's exclusion of questions of meaning is an asset, not a liability.[8] This preference for a technical (some say technicist) understanding of information goes a long way toward explaining why another contender for the title of "founder of information theory" has nowhere near Shannon's currency in current theory debates

At the eighth Macy conference on March 15-16, 1951, Shannon met Donald M. MacKay, whose contribution to that meeting may have reminded Shannon that the title of his own 1948 article is a misnomer. Since Shannon explicitly excludes all semantic considerations, his "mathematical theory of communication" would more accurately be labeled a "*mathematical theory of data communication*" (Floridi 2004, 52). In the paper MacKay gave at the eighth Macy conference, "In Search of Basic Symbols" (1951), and more elaborately in his *Information, Mechanism and Meaning* (1969), he insists that meaning could and should have a place in Shannon's theory but that it was exorcised from it by way of a sleight of hand that neither Shannon nor his followers or critics noticed. Shannon's conviction that the purpose of communication is to transmit messages so that the message received is identical to the message sent is based on the assumption that, apart from distortions introduced by noise, these two

messages are basically the same. This assumption, MacKay notes, does not hold ground since the receiver needs to reconstruct the message received against the background of a set of possible messages that may well be different from the set of possible messages from which the sender selected her message. This entails that there is no basic identity between message sent and message received. For the receiver, both the sender's message *and* the set of messages from which s/he chose it are indeterminate, and this double indeterminacy can be reduced only in a negotiation that takes place in social space. MacKay names this negotiation "communication" and adds that meaning comes into play precisely in those moments when we turn our attention to the set of possible messages against which a specific message must be read.[9] In making this argument, MacKay directs our focus on the role of observation in the construction of meaning, thus aligning himself much more closely with classic cybernetic perspectives than Shannon ever does. And yet, though Shannon's transmission model of communication has not stood the test of time, MacKay's contributions have been all but forgotten by today's media theorists. This represents a lacuna in current scholarship that this essay cannot fill. Suffice it to point out that the history of ideas on communication since the mid twentieth century would have taken a very different turn if it had started from MacKay's observations rather than Shannon's.

No Order from Noise

So why should humanities scholars continue to engage with Shannonian information theory if its model of communication is flawed and its exclusion of sense-making processes jars with fundamental assumptions most of us have inherited from the hermeneutic tradition? For many of us, it is first and foremost Shannon and Weaver's reflections on noise that have continuing relevance.

In *Noise: The Political Economy of Music* (1977), Jacques Attali, a French cultural theorist, economist, and long-time economic advisor to François Mitterrand, takes direct recourse to Shannon's work to suggest that, in addition to Shannon's conceptualization of noise, a more archaic notion of the term must also be taken into account:

Information theory uses the concept of noise (or rather, metonymy) in a more general way: noise is the term for a signal that interfered with the reception of a message by a receiver, even if the interfering signal itself has a meaning for that receiver. Long before it was given this theoretical expression, noise had always been experienced as destruction, disorder, dirt, pollution, an aggression against the code-structuring messages. (1985, 27)

Attali stresses both this originary, disruptive and violent force of noise and its generative potential: "Our science has always desired to monitor, measure, abstract, and castrate meaning, forgetting that life is full of noise and that death alone is silent. […] Nothing essential happens in the absence of noise" (1985, 4). Starting from these premises, Attali develops a history of music in which music emerges as "a channelization of noise, and therefore a simulacrum of the sacrifice. It is thus a sublimation, an exacerbation of the imaginary, at the same time as the creation of social order and political integration" (1985, 26). What he ultimately calls for is a form of improvisational musical and sounding practices that no longer contain the noise. He calls these practises "composition" and champions their "conquest of the

right to make noise, in other words, to create one's own code and work, without advertising its goal in advance" (1985, 132). For Attali, composition is prophetic and decidedly political in nature: it "heralds the emergence of a formidable subversion, one leading to a radically new organization never yet theorized" (1985, 6).

French philosopher Michel Serres shares Attali's emphasis on the originary and generative force of noise and in his books *Parasite* (1980) and *Genesis* (1982) proposes especially influential creative re-readings of Shannonian information theory and its cybernetic and systems-theoretic successors. In noise, static, and interference--*bruit parasite* in technical French--Serres finds allies in his sustained philosophical challenge to the exclusionary logic of binary systems of thought. Serres's allegiance to noise is both a positive and a negative one. He rejoices in things being born out of chaos and noise: one of his figures is Aphrodite, this "beautiful goddess," whom he imagines "invisible, standing up, […] born of the chaotic sea, this nautical chaos, the *noise*" (1997, 25). Simultaneously, he denounces the violence that inheres in the logic of the excluded third: "Hell is the separation of paradise and Hell, the Devil is the bifurcation between God and the Devil, evil is the crossroads of good and evil, and error is the dualism that only opposes twins" (1982, 20). Serres shares Henry Adams's insight that "Chaos was the law of nature, Order was the dream of man" (Adams 1995, 427) but, unlike Adams, he is no longer prepared to pay the price to realize dreams of unity and order:[10]

> This couple [noise-message] and their relation are set apart by an observer seated within the system. In a way he overvalues the message and undervalues the noise if he belongs to the functioning of the system. He represses the parasites in order to send or receive communications better and to make them circulate in a distinct and workable fashion. This repression is also religious excommunication, political imprisonment, the isolation of the sick, garbage collection, public health, the pasteurization of milk, and so forth, as much as it is repression in the psychoanalytical sense. But it also has to do with a history, the history of science in particular: whoever belongs to the system perceives noises less and represses them more, the more he is a functioning part of the system. He never stops being in the good, the just, the true, the natural, the normal. All dogmatism lives on this division, be it blind or decided. (Serres 1982, 68)

In Serres' "noisy philosophy" (1997, 20), the logic of the parasite informs all systems, and its exclusion always only announces the emergence of another, more powerful parasite. As it does in information theory, noise always remains part of the equation.

With *The Noise of Culture: Literary Texts in a World of Information* (1988), William R. Paulson has written what is still the most sustained reflection on the cultural functions of noise in my own discipline of literary studies. A specialist in eighteenth- and nineteenth-century French literature and culture, Paulson in this monograph considers the changing functions of literature in a "world of information." What value and function do literary texts still have under late capitalism, when readily processible information has become an increasingly desirable commodity? Literature appears to meet none of the requirements of an age that asks for clear, unambiguous, and machine-readable information; it is "a residue of a no longer dominant mode of cultural organization" (Paulson 1988, 181). So what functions can it still perform today? Paulson refuses to give humanistic answers that would stress literature's educational value, its contributions to cultural memory, or its opening up of fictional worlds that allow for vicarious kinds of experience. Instead, he draws on Serres' work, Humberto R. Maturana and Francisco J. Varela's theoretical biology, information

theory, systems theory, and Belgian and French formalisms to argue that literature is indeed "the noise of culture":

Literature is not and will not ever again be at the center of culture, if indeed it ever was. There is no use in either proclaiming or debunking its central position. Literature is the noise of culture, the rich and indeterminate margin into which messages are sent off, never to return the same, in which signals are received not quite like anything emitted. (1988, 180)

For Paulson, "noise" designates both formal properties of literary works and their communicative function. Literary noise is internal in the sense that the language of literary texts differs from ordinary, everyday language uses in its aporias, indeterminacies, ambiguities, and the complex structural relations between its parts: "Rather than attempting to reduce noise to a minimum, literary communication *assumes* its noise as a constitutive factor of itself" (1988, 83). Literary noise is also external in the sense that, due to their linguistic alterity, literary texts cannot be fully assimilated to the communicative and discursive networks that are already in place. It is, then, the literariness of literary works, their internal noise, that enables them to function as a form of cultural perturbation that prompts "new moves in the linguistic and symbolic games that constitute knowledge and society" (1988, 180).

In *The Noises of American Literature, 1890-1985: Toward a History of Literary Acoustics* (2006), I embark on an exploration of American literary soundscapes from naturalism to postmodernism. Understanding "noise" both in its everyday sense as the discordant or unwanted sound that literary texts represent and as an information-theoretic notion that helps me conceptualize the communicative and social functions of literature, I develop a history of "literary acoustics" that explores convergences between the representation of noise (noise as an object of literary representation) and its cultural production (literature as a "noisy" form of communication that perturbs the communicative networks that are already in place). As much as the latter line of my argument is inspired by Paulson's work, I do not subscribe to his conclusion that the function of literature today must be understood in the context of "a cognitive community" that "constitutes a kind of self-regulating system, one that continues in its activity by producing differences and then integrating into its organization those differences that it finds acceptable" (1988, 157). Here and elsewhere, Paulson draws on systems-theoretic notions of "order from noise" and "self-organization from noise" to argue that the cultural perturbation literature effects is valuable not in itself but because it triggers processes of systemic reorganization that result in new forms of order. In this view of things, literature continues to play an important social role because it facilitates systemic evolution. Literature keeps the system going. This may sound like a harsh indictment of the ultimate political valence of Paulson's theoretical project (which I admire a lot), but it is entirely in line with systems theory's exclusive interest in those forms of environmental disorder and noise that can be reintegrated as systemic order via the "order from noise" principle:

External influences appear to self-referential systems only as determination for self-determination and thus as information, which changes the internal context of self-determination without eliminating the structural principle that the system must come to terms on its own with everything that ensures that self-determination. (Luhmann 1995, 68)

Systems theory is a theory of evolutions rather than revolutions, which is why it has repeatedly been charged with a conservative political bias (Lyotard 1984, Kneer and Nassehi 1993, 186-192). While I refuse to subscribe to such dismissals of systems theory on ideological grounds, I continue to find Shannon and Weaver's description of noise as both a maximally informative and radically unintelligible signal ultimately more helpful than systems-theoretic approaches to describe the communicative and social functions of certain types of literary works.

If Theodor W. Adorno is right in arguing that the social function of highly experimental modernist texts such as Marcel Proust's *À la recherche du temps perdu* (1913-27), Franz Kafka's "In der Strafkolonie" (1919), Paul Celan's poetry, Samuel Beckett's *Endgame* (1957), and Eugène Ionesco's *Rhinoceros* (1960) depends on their very refusal to conform to the debased and reifying languages of modernity that are the order of the day, then systems-theoretic conceptualizations of "order from noise" and "self-organization from noise" fail to account for the radically unintegrable difference of such texts. I am taking my cue here from Shannon's original essay, where he adduces a classic example of a noisy text with minimal redundancy: "James Joyce's book *Finnegans Wake*," which "enlarges the vocabulary and is alleged to achieve a compression of semantic content" (Shannon 1963, 56). Indeed, Joyce's novel (if that's the word) reinvents the English language to achieve maximum distance from the ways of speaking and writing that we are used to. Witness the beginning of the book's third paragraph:

the fall
(bababadalgharaghtakamminarronnkonnbronntonnerronntuonnthunntrovarrhounawns kawntoohoohoordenenthurnuk!) of a once wallstrait oldparr is retaled early in bed and later on life down through all christian minstrelsy. The great fall of the offwall entailed at such short notice the pftjschute of Finnegan, erse solid man, that the humptyhillhead of humself prumptly sends an unquiring one well to the west in quest of his tumptytumtoes: and the upturnpikepointandplace is at the knock out in the park where oranges have been laid to rust upon the green since devlinsfirst loved livvy" (Joyce 1960, 3)

Joyce scholars have worked exceptionally hard at unraveling the riddles of this supremely difficult book's prose. They have taught us that the seemingly random, hundred-letter sequence of consonants and vowels after "the fall" reproduces the fracas of Adam and Eve's Fall through a rendition of the words "thunder," "noise," and "defecation" in several languages; that "humptyhillhead" and "tumptytumtoes" refer to the somewhat less spectacular fall of Humpty Dumpty; and that "pftjschute" is an ideophonic word that reproduces drunk Tim Finnegan's deadly fall from a ladder (Tindall 1969, 31-32, McHugh 1980, 3, Campbell and Robinson 1980, 15-16). And this scratches only the surface of the multiple historical and linguistic references that Joyce scholars have excavated from this short passage. Yet despite all hermeneutic efforts, *Finnegans Wake* retains its strangeness. In this book, a surplus of noise remains that cannot be reduced to order.

More recent examples of such highly experimental, "noisy" texts are Diane Williams's collection of microstories *This Is About the Body, the Mind, the Soul, the World, Time, and Fate* (1990), David Foster Wallace's encyclopedic opus magnum *Infinite Jest* (1996) as well as his posthumous unfinished novel *The Pale King* (2011), Mary Caponegro's short stories in collections such as *All Fall Down* (2009), and Ben Marcus's ensemble of short experimental prose pieces in *The Age of Wire and String*

(1995) as well as his novel *The Flame Alphabet* (2012). The last of these creates a fictional world in which children's speech has become lethal to adults who hear it. Unlike Joyce, Marcus does not invent new words. Instead, he creates a communicative perturbation by rearranging the words we already know in surprising new ways. Take the following paragraph from the novel's second chapter as an example chosen almost at random:

When the Esther toxicity was in high flower, when it was no longer viable to endure proximity to our daughter, given the retching, the speech fever, the yellow tide beneath my wife's skin, to say nothing of the bruising around my mouth, that day should have been darker, altogether blackened by fi re. (Marcus 2012, 8)

Unlike his fictional children's speech, Marcus's prose does not kill adults; but it leaves us sufficiently unsettled to glimpse something of the existential chasm of the novel's premise, which reverberates down into the hiatus of "fi re." In their different ways, texts such as *The Flame Alphabet*, *The Age of Wire and String*, *All Fall Down*, *The Pale King*, *Infinite Jest*, and *This Is About the Body, the Mind, the Soul, the World, Time, and Fate* do not trigger processes of systemic rejuvenation; instead, they stage an act of communicative refusal. In that, they tap into and rework for our own times a modernist aesthetics of what Adorno calls "negativity":

Art […] is social not only because of its mode of production, in which the dialectic of the forces and relations of production is concentrated, nor simply because of the social derivation of its thematic material. Much more importantly, art becomes social by its opposition to society, and it occupies this position only as autonomous art. By crystallizing in itself as something unique to itself, rather than complying with existing social norms and qualifying as "socially useful," it criticizes society by merely existing, for which puritans of all stripes condemn it. (Adorno 1997, 225-226)

In information-theoretic terms, what Adorno calls for is an aesthetics of noise that follows the maxim "only what does not fit into this world is true" (1997, 59). From this perspective, formally experimental and difficult texts can be described as noisy forms of communication whose very hermeticism allows them to retain a critical distance from society. Paradoxically, then, these texts are social in their very asociality and autonomy. Yet this radical and irreducible linguistic alterity falls outside the scope of the systems-theoretic "order from noise" paradigm. And this is precisely why von Foerster, Luhmann, and Paulson are ultimately less important reference points for my own thinking about modernist, postmodernist, and contemporary literature than Shannon and Weaver and their "wilder" successors Attali and Serres.

Shannonian information theory and its progenies have proven more congenial to my own work for yet another reason. To my mind, one fundamental difference between information-theoretic and cybernetic models of communication that I only hinted at above has major consequences for their respective contributions to the study of literature and the arts. Consider Wiener's brief comment on poetry in the second edition of *The Human Use of Human Beings: Cybernetics and Society*:

Messages are themselves a form of pattern and organization. Indeed, it is possible to treat sets of messages as having an entropy like sets of states of the external world. Just as entropy is a measure of disorganization, the information carried by a set of

messages is a measure of organization. In fact, it is possible to interpret the information carried by a message as essentially the negative of its entropy, and the negative logarithm of its probability. That is, the more probable the message, the less information it gives. Clichés, for example, are less illuminating than great poems. (1954, 21)

For both Wiener and Shannon, poems (and works of art more generally) are less probable and for that reason more "illuminating" than clichés, but for very different reasons. For Wiener, communication is an activity that enables human beings to set something against the entropic decline of the universe predicted by the second law of thermodynamics: "In control and communication we are always fighting nature's tendency to degrade the organized and to destroy the meaningful; the tendency, as Gibbs has shown us, for entropy to decrease" (1954, 17). And artistic creation is, in Wiener's view, the negentropic activity *par excellence* precisely because it is a highly ordered and regular form of human communication. This conception of art is fundamentally different from that favored by critics starting from Shannon's insights. While both views share the premise that art is a special form of human communication, the main difference between them hinges on the question of whether the specificity of art is to be found in an unusually high degree of structural regularity and order or in its opposite, i.e., in the disruption and fragmentation of regular patterns.

In literary-theoretical terms, the difference between a Wienerian and a Shannonian conception of art is that between the New Critics' "organic unity" doctrine and Adorno's reflections on the necessary negativity of art. If we follow Wiener's model, we are, in other words, likely to read modernist literature as T. S. Eliot did in his famous 1923 review of Joyce's *Ulysses*: as "a way of controlling, of ordering, of giving a shape and a significance to the immense panorama of futility and anarchy which is contemporary history" (1923, 482). If we follow Shannon's model, we are likely to accede to Adorno's demands for art: "in order to resist the all-powerful system of communication [artworks] must rid themselves of any communicative means that would perhaps make them accessible to the public" (1997, 243). Ultimately, then, if we abandon information theory as an imperfect precursor and follow systems theory and its theorization of "order from noise" and "self-organization from noise" instead, we are in danger of losing some of the radicality of the lessons Shannon and Weaver taught us.

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Notes

[1] This essay builds and expands on research done for my 2006 monograph *The Noises of American Literature, 1890-1985: Toward a History of Literary Acoustics*. My exposition of the fundamentals of the Shannonian model of communication draws on my entry for "Information Theory" in the *Routledge Companion to Literature and Science*. I would like to thank Ridvan Askin and Andreas Hägler for their useful input on an earlier version of the present essay.

[2] In what follows, I am quoting from those versions of Weaver's and Shannon's articles that were published in *The Mathematical Theory of Communication*.

[3] In physics, white noise refers to a sound with a very wide frequency range and equal energy (or volume) at every unit of the frequency spectrum. It is called white noise in analogy to white light, which is made up of all the colors of the color spectrum, just as white noise is made up of all the frequencies of the frequency spectrum.

[4] In Shannon's own words, "*If the signal and noise are independent and the received signal is the sum of the transmitted signal and the noise then the rate of transmission is [...] the entropy of the received signal less the entropy of the noise*" (Shannon 1963, 99).

[5] It was at Heinz von Foerster's suggestion that the Macy conferences were titled "Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems" from the seventh conference in March 1950 onward. Wiener was deeply moved that his peers accepted von Foerster's proposal (Foerster 2003, 300-301). Ironically, though, the seventh conference was also the last one he attended.

[6] In Wiener's own words, "Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other" (1961, 11). This view is shared by general systems theorists. As Ludwig von Bertalanffy put it in 1968, "entropy, as we have already heard, is a measure of disorder; hence negative entropy or information is a measure of order or of organization since the latter, compared to distribution at random, is an improbable state" (1968, 42).

[7] The full title of Kittler's essay collection is *Austreibung des Geistes aus dem Geisteswissenschaften: Programme des Poststrukturalismus*. The publication of this volume in 1980 marks a crucial event in German-language literary, cultural, and media studies not only because it was instrumental in introducing (French) post-structuralist thought into Germany but also because it initiated a shift of attention from questions of meaning and interpretation to the materiality of communication.

[8] See Gumbrecht's "Materialities / The Nonhermeneutic / Presence: An Anecdotal Account of Epistemological Shifts" for a concise account of the evolution of his (and Pfeiffer's) challenges to the (hermeneutic) culture of sense.

[9] My reading of MacKay is informed by Dirk Baecker's account in "Kommunikation als Selektion."

[10] In the field of literature and science, Henry Adams is best known for the thermodynamic theory of history he developed in *The Education of Henry Adams* (1907/1918) and "A Letter to American Teachers of History" (1910). For a more sustained discussion of Adams and Serres, see my "The Desire for Unity and Its Failure: Re-Reading Henry Adams Through Michel Serres."