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ORIGINAL ARTICLE

The strongness of weak signals: self-reference and paradox in anticipatory systems

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Abstract Social sciences are experiencing an anticipatory turn. A core issue of this turn are the so-called 'weak signals'. In order to speak of this type of signals, we must use the distinction between weak and strong. The question may be raised, who handles this distinction? That is, who is the observer? It seems that only two answers are possible: the observer is either outside or inside, i.e., either he is a world-observer, or he is a extra-world-observer. In the latter case, the problem of weak signals disappears; after the fact, everybody is able to say "I told you!". In the former case, the system has to face the dilemma of warning signals. As social systems cannot observe themselves from the outside, the issue of weak signals should be explained as the outcome of a self-referential dynamics that finally leads to the paradox of knowing the unknown. In fact, the difference between weak and strong refers not to the future as such (to what is signalized), but to the observing system itself. The main hypothesis of this contribution is that a signal is weak for a lack of redundancy that hinders the system to combine a reference to an environmental event with a concomitant reference to a systemic cognitive map. By means of a system theory of sign, it should be possible to see the difference between weak and strong as an unfolding device for temporal paradoxes arising in social systems, and to support the hypothesis that, since in social systems cognitive maps are contingent on time, signals can be only weak, never strong.

Keywords Anticipation · Weak signals · Paradox · System theory · Superignorance · Warning signals

Anticipatory systems in modern society

Social sciences are experiencing an anticipatory turn. The relevance of this topic is indisputable, so it is to be hoped that research may further be developed and intensified. However, it is hard to say whether this turn implies a real change of paradigm. The same attitude toward the idea of anticipation is somehow ambivalent. On the one hand, scholars agree that "anticipations are ubiquitous" both in natural and social systems; consequently, every scientific discipline is dealing with it [1]. On the other hand, scholars complain about the fact that anticipation is a neglected concept, which deserves more attention.[1] However, the anticipatory turn in social sciences can be observed also from the sociology of knowledge standpoint. The sociological concern with the topic 'anticipation' could be grasped as the outcome of fundamental structural changes which gave birth to modern society. I would like to outline only some of the most relevant hallmarks of this change. This short introduction will be used as a socio-theoretical background for further arguments in this article.

As well known, modern society is characterized by a reversal of temporal attitudes. During the transitional period between the 14th and 17th centuries, past gave up its primacy to future. Consequently, future became the principal irritating source for present.[2] In the mid-1970s, Niklas Luhmann [7] already noted that the arising debate on "more anticipatory

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[1] Cf. Glasersfeld's synopsis [2]. Glasersfeld is one of the few scholars who reminded that Hume's theory of causal inference was one of the first modern thematizations of anticipation. The reference work for the revival of this topic is Rosen [3]. See also Poli [4, 5], with large literature.
[2] Cf. Koselleck [6], who refers to life insurance in the 18th century.

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behaviour", on "more future-oriented planning" in decision-making processes (especially in formal organizations) could be regarded as a consequence of the social transition from a closed future to an open future. This temporal change implies the relinquishment of an ontological representation of time. In Stoicism, what-will-be is already what-it-is, although men can neither foresee nor predict the future. Since future cannot be foreseen, it is meaningless to anticipatorily worry about what could be and could be not. Thus, true *certainty* is the absence of cares (*sine cura*, that is, without concern [about the future]), and only men who are not in need of future and do not reckon their time-to-come are truly virtuous.[3]

In the mid-17th century, time-consciousness is radically different. Future does not exist because it has no being at all. Future is simply a "fiction in the mind" ([8] p. 10): the observing system can construct such a fiction all over again because time-to-come never becomes present. 'Open' future means that observers can figure out a set of rival hypotheses, which has space for residual hypotheses [9]. The function of such residual hypotheses is to mark the unpredictability of future events which observers attempt to control through decisions.

One of the main results of this temporal habit is that modern society has an only seemingly contradictory relationship with uncertainty. On the one hand, it regards uncertainty as a fundamental resource for decision-making. On the other hand (and in sight of decisions to be taken), it regards uncertainty as a problem to be solved. However, the awareness lies in the background that without uncertainty it would be impossible to take a decision.

Indeed, in the Middle Ages uncertainty had already been regarded as a resource that could offer some advantages. The main argument was produced by theology, and dealt with the difference between time and eternity. Because of certainty (*securitas*), men are lazy and prove ungrateful to the Lord. By contrast, uncertainty (*sollicitudo*) reminds men that the true peace is in afterlife and that it shall be gained through actions.[4]

In modern society, the concern with uncertainty is mostly secularized. Uncertainty in human life looses its religious connotations, whereas in turn religion is no longer regarded as a serious (and efficient) remedy to addressing the uncertainties of everyday life. For instance, life insurance is a substantially more efficient device; consequently, the family man who places his trust in Providence is irresponsible. In addition, uncertainty becomes a generalized trouble of any social system. Consequently, while it deals with "extrem verunsicherten Zukunftsperspektiven" (extremely uncertain future-perspectives), society is based on an institutionalized culture of providence, and regards itself as a "Versicherungs-Gesellschaft" (insurance-society).[5]

This reappraisal of uncertainty is followed by a reversal of attributions. The primacy of external attribution is replaced with the primacy of internal attribution of events. The final result is what contemporary society calls 'risk society'. This transformation cannot be overestimated because it permeates all social structures, and even concerns the attribution of natural events [12–15]. Obviously, causality is not suspended, nor it is replaced with imputation. As previously, virus causes flu; flood is caused by water. However, the availability of a vaccine changes the danger of falling ill into the decisional risk "Should I vaccinate or not?". In turn, the responsibility for disasters produced by flood can be imputed to the bad maintenance and surveillance of riverbanks. In this very sense, risk is a social construction.

Against the background of these preliminary assumptions, I will try to explain that the topic of 'weak signals' is a consequence of structural changes in modern society, and that these changes have drawn our attention on complex cognitive systems as a type of anticipatory systems. In § 2, I introduce the hypothesis that we still lack a consistent theory of weak signals because, instead of wondering how it is possible that an environmental event can perform a signalling function, social sciences usually deal with signals as if they were things. I feel that the difficulties of semiotics could be overcome by a system theory of signals. To develop such a theory, a methodological rule should be followed: the observing system is somehow part of its own observations. That is, the moving question should be "How do I observe?", rather than simply "What do I observe?". Moreover, we shall move from the assumption that time can never be observed out of time.

In addition, in § 3, I will try to show that a contradiction hides in the concept 'weak signal': the signal is relevant – that is, strong – simply because the observer who is dealing with it already knows how it came to an end. The question about the information value of weak signals is somehow overlooked because the signal is observed retrospectively. From this standpoint, the distinction between weak and strong may be regarded as an asymmetry that is used both to solve a tautology and to unfold a paradox – the circularity of temporal observations of time.

Subsequently, I study the signalling function from the standpoint of self-referential systems theory. The principle of operational closure and the concept of structural coupling of system and environment support the hypothesis that cognitive systems prompt themselves when they interact with their own environment; in other words, 'irritations' are systemic inner constructions. Consequently, systems cope with structural uncertainties, which can be regarded as a type of 'social

[3] Seneca, *Ep. ad Luc.*, 92, 25: "Quid est in virtute præcipuum? Futuro non indigere nec dies suos computare".

[4] In this respect, the main source is Augustine, *De Civ. Dei*, XIX, 10.

[5] According to the well-known definition given by Ewald [10]. See also Luhmann ([11] p. 130).

signalling system'. In § 4, I try to show that this signalling system is more complicated than signals, which steer the systemic coupling with natural environment because society behaves as a historical machine. Such behaviour implies that both system and environment behave 'anticipatorily'. Thus, anticipation becomes reflexive and second-order anticipations arise from this type of reflexivity. The main hypothesis of mine is that environment is what *is not* anticipated when a system tries to anticipate the environment. In other words, systems behave in an anticipatory manner because the environment cannot be anticipated. Being operatively closed, the system reacts to its own anticipation of the future rather than to the future as such.

On the basis of these rather abstract assumptions, in § 5, I will return on the topic of weak signals moving from an empirical case study: the signals of an economic upturn in Italy. By means of this example, I introduce the idea that in modern society one of the most successful anticipatory systems is statistical probability. This calculus does problematize and de-problematize the future; consequently, it offers a 'substitute for certainty' that can be exploited in decision-making processes. In § 6, finally, I deal with some recent developments of the idea of weak signals in the sociology of organizations. This discipline introduced successful concepts into the scientific debate, for instance, 'vulnerability' and 'resilience'. The provisional result of these sociological surveys is that the true problem actually is that the observer doesn't know that he doesn't know. Social systems try to cope with this second-order ignorance, or 'super-ignorance', when they address weak signals. As a consequence, current society is living in a condition of 'chronic fear'. In fact, I feel that in society every signal should be regarded as a weak signal; unfortunately, this conclusion jeopardizes the usefulness of the distinction between weak and strong.

Toward a system theory of signals

A core issue of the anticipatory turn in social sciences are the so-called 'weak signals'. According to Roberto Poli ([16] p. 32), weak signals are "les fondements de toute société" (the true foundation of the whole society). As well known, the idea of weak signals arose in the mid-1970s in association with other anticipatory ideas such as 'strategic management' or 'strategic surprise'.[6] At the time, the question was why nobody had foreseen the oil crisis. Nowadays, the question is more or less the same; however, oil crisis has been substituted by financial crisis. Consequently, everybody is now looking for (weak) signals of a (weak) upturn in the economy. Moreover, in public opinion there is a surfeit of signals referring to social changes. People feel that there is not a stable reality that everybody can refer to, but only signals of a reality that is everyday different and will never stabilize because in the meanwhile signals are changing, or simply because people will forget to verify if reality eventually became what signals had once signalized.

The debate on weak signals developed during the 1980s. However, only in the 1990s there was a true revival of this topic. In the meantime, literature became very large, while related concepts are still proliferating (sociologists speak of 'wildcards', 'seeds of change', 'emerging issues'). As a consequence, the definition of 'weak signal' is now substantially more ambiguous and unclear than previously [19, 20]. I feel that this ambiguity is the result of the incapability of social sciences to explain what a 'signal' actually is. Therefore, my purpose in this article is to attempt to give an explanation of weak signals, and to clarify some core ideas of the theory of anticipatory systems by means of the interdisciplinary approach of social systems theory.[7]

To speak of weak signals, one has to use the distinction between weak and strong. The question may be raised "Who handles this distinction?". That is, "Who is the observer?". It seems that only two answers are possible: either the observer belongs to the world that he is observing, or he is outside of the world that is observed. Either he is a world-observer, or he is a extra-world-observer. To aptly understand weak signals, we must handle this distinction in a proper manner. In fact, the distinction between inside and outside is more complicated than it appears. According to a constructivist approach, an outer observer cannot exist. If he could exist, he would be nothing for the world because his observations were not visible to world-observers. Also a prophet shall communicate his prophecy if he wants this prophecy to be known. However, when it is communicated, prophecy becomes a social event among many others social events of the same kind. Prophecy may be observed, interpreted, reported. In short, it is linked to the recursive network of similar events reproduced by society. Thus, observers are always inside, although they can observe the world *as if* they were outside. The difference between inner and outer observer is not a difference between two real observers, it is a difference between two reflexive uses of the distinction between inside and outside.

If the observer is outside of the observed world, time-consciousness takes on the form of determinism. Past and future are already present for those who observe the world from the standpoint of eternity. In pre-modern societies, such a performance is a quality of prophets and diviners. Thus, the cockcrow is a signal that confirms a past prefiguration of the future in the present. It has no information value, that it, it is not surprising. By contrast, if the observer is inside the

[6] The reference work is Ansoff [17]. For an updated discussion on early and later specifications of this concept, see Holopainen, Toivonen [18].

[7] In the present paper, social systems are communication systems. Everything that is *not* communication lies in the environment.

observed world, time-consciousness takes on the form of decisionism. Past and future are simply constructions continually reproduced by an observer who is embedded in the current present (in Shackle's terms, in the 'moment-in-being') and deals with provisional memories and expectations. Under these circumstances, any decision depends on the future that one would like to realize, whereas in turn future (intentionally *and* not intentionally) depends on the taken decision.[8] The decision-maker is aware that it is not his attempt to plan the future by means of rational foresights that changes the circumstances; rather it is his attempt to realize the plan, i.e., the taken action, that changes the circumstances under which the (foreseen) future will realize. Consequently, the situation is undecidable.[9]

These different temporal approaches affect the type of orientation one is searching for when he is dealing with an unknown future. In this respect, divination had developed very clever techniques to producing information. The basic assumption was that, whereas gods have certain knowledge of visible and invisible events, men have to search for clues and conjectures. These clues (in modern terms, these weak signals) could be found in nature or intentionally produced by men. In both cases, they required a special art of interpretation. Information production could not be performed at will. Artificial divination provided a "procédure expérimentale méthodiquement organisée". Obviously, the purpose of such procedure was not to set observers' minds at rest by means of a certain knowledge of future. Artificial divination produced sentences and conjectures that should be in turn interpreted. Consequently, that opacity (that 'weakness') that divination should in principle eliminate was introduced into the world again even if with a different shape ([25] p. 36; [26] p. 23). The advantage of this unusual procedure was that observers had a relatively transparent technique for dealing with future opacity.

If the observing system relinquishes an extra-world position, it has to cope with temporal reflexivity. The distinction between past and future re-enters into the time. The observer can observe past and future as such. He can also observe past presents and future presents, too. From the standpoint of these temporal positions, the current situation looks like a past future or future past. The outcome of this temporal reflexivity is a huge increasing of complexity that the observer can employ but must also tame in order to take a decision.[10]

The matter is not simply that after the fact everybody is able to say "I told you!". Decision-makers can anticipate their post-decisional regret, and they are well aware that also avoiding decision-making has consequences which might be retrospectively attributed to a decision-maker. The latter should assume responsibility for his decision not to decide. If it is impossible not to decide, it is impossible to avoid decisional risks, as well. The situation is therefore substantially more complicated than it seems, and I feel that the possibility of explaining the modern dilemma of warning signals depends on the capability to clarify this complexity.

In my opinion, the main obstacle is a – so to speak – ontological rather than phenomenological understanding of the concept of signal. The question should be "How is it possible that in the inner-social environment an event signalize a future change?". This question is evaded because signals are managed as if they were things, thus bracketing the observer. From a constructivist standpoint, we should rather bracket the observed reality and include the observer in what is observed. In this way, we could avoid reifying the concept of signal. Social research should explain how it is possible that something can perform a signalling function. This approach could be the starting point for a systemic (rather than simply semiotic) theory of signals. In this respect, the main hypothesis could be that a whatever reference to an environmental event (or state) becomes a signal when it can affect the self-reference of an observing system. By means of such a constraint, the observing system can selectively reproduce the operative unity of the difference between recall and expectation. To construct such a theory, we first need a theory of anticipation.

The strongness of weak signals

Notwithstanding the relevance of scientific research, I feel that a contradiction hides behind the current debate on weak signals. To worry about weak signals is reasonable only if you already know that they signalize strong changes – for instance, a catastrophe or a disaster that you would rather avoid (if possible). However, only the observer who already knows how it came to an end can be aware of it. This is the reason why the discussion on weak signals usually has a retrospective structure. Why no one did perceive these signals? Why no one held the signalized change for relevant? In short, why nobody understood the strongness of weak signals?

This contradiction (the signal was weak, and yet it was retrospectively strong too with respect to events) is based on the fact that a future which does not exist is unknown. Before starting an enterprise, everybody would like to know to which signals he will have to pay attention in order to seize opportunities and not to run risks. Moreover, a strong signal of a weak change, or a weak signal of a weak change were not a problem for anyone. The difference between weak and strong is used to symbolically bridge the temporal gap between signalized and signal. As a consequence, the problem of lacking information is softened, if not neutralized.

[8] Even in decisionism, future does not fully depend on the taken decision. There might be other influences, too.

[9] The distinction between determinism and decisionism is drawn from Shackle [21, 22]. The transition from prophecy to rational forecasting has been clearly explained, moving from Koselleck [6], by Esposito [23, 24].

[10] On this temporal reflexivity, see Luhmann ([27] p. 129–130).

In modern society, which is obsessed by the need of dealing with an open future, uncertainty is a resource but also a problem for every decision-making process. And every decision-maker must address the circularity of temporal references that turns any present into an undecidable situation. However, this undecidability is the essential condition that makes a decision possible [28]. In other words, if future could be decided, we should simply wait that the decided future eventually occurs. There would be no decision any more that could be taken. Every type of action could no longer affect the future that ineluctably unfolds itself. Social reality would turn into a deterministic machine. On the contrary, if future cannot be decided we are able (and compelled too) to take decisions whose outcome cannot be fully predicted. Every decision-maker is therefore coping with an unpredictable future that depends on predicting decisions. To start a decision-making process, the circular relationship that links future and decision must be first of all turned into some kind of viable circularity.

This transformation is possible if, for instance, an asymmetric distinction is introduced. The latter does not remove the self-referential circularity; it rather enables the observing system to gain at least some information [29]. The distinction between strong and weak is just an example of this type of asymmetries. This distinction refers to the observer rather than to the observed reality, and marks the ignorance which the observer has to cope with when he tries to get some bearings in the opacity of the time-to-come. In other terms, what is weak is the attention paid to the signal rather than the change in the situation that was signalized. As a consequence, the circular self-referentiality of observation does not turn into a tautology.

In this respect, Ansoff himself had distinguished future uncertainty into an uncertainty which preserves a certain continuity compared with the past and therefore enables observers to estimate historical regularities, and an uncertainty which, on the contrary, is characterized by discontinuities and can become a threat or an opportunity. Ansoff's firm belief was that these discontinuities could be "anticipated by available forecasting techniques" ([17] p. 22) – which is to say, if the firm were able to forecast temporal discontinuities between past and future it would let itself not be surprised by such discontinuities, whereas, indeed, the only thing that can be foreseen is the continuity of discontinuities.

To understand how it is possible that an event may perform a signalling function, one has first of all to take into consideration the principle of operational closure. Communication systems have no operational contact with the external environment because they cannot link themselves with the outside world by means of their own operations [30–32]. Society can communicate *on* the environment but not *with* the environment. From the standpoint of a system, the environment is simply the filling of systemic external references, which are continually combined with concomitant systemic self-references. If the environment is conceived in temporal terms as time-to-come, it is clear that nobody can hurry up into the future to see what is going on and then come back to tell what he found.

In turn, the environment cannot communicate *with* a system. The former can behave either in a disruptive way (skiers are swept away by an avalanche, nobody can communicate anymore), or as irritation (a skier warns the other ones of the avalanche danger). Consequently, a system that is irritated by the environment changes its state, and yet every change of state is a systemic operation. In fact, closure does not mean closeness ([33] p. 147). A system does not exist without a respective environment; in turn the environment does not exist without a reference to a respective system. However, only systems can recursively reproduce their own operations by means of the outcome of previous operations. In turn, the environment can neither beget nor specify the nature of systemic operations, although the environment is an essential condition for the system being able to reproduce its own operations. In other words, environmental perturbations are never *instructive* for a system; on the other hand, without perturbations a system cannot instruct itself about what shall be done. This complicated situation is possible through the structural coupling of system and environment.

The concept of structural coupling refers to any environmental condition, which allows systemic self-irritation, i.e., which enables the system to irritate itself ([34] p. 80, p. 93–95; [35] p. 61). The environment cannot produce systemic operations (wood is not speaking), nor trigger systemic irritations (a burning wood gives no alarm). Every irritation is produced by the system through its own operations and arises against the background of those structures of expectation which coincide with the system's current state. In this very sense, irritations are "purely internal constructs" and arise every time as perturbations, deviations or surprises ([36] p. 1432). This empirical assumption also implies that the information value of an environmental event does not depend on the event as such, rather it is contingent on system's structures. Consequently, irritation is the intra-systemic side of the structural coupling of system and environment, that is, it marks one side of a form whose opposite side is indifference.

Telling examples of social irritation are ecological threats. In this respect, as well known, the search for warning signals is feverish and often becomes a reason for social tensions. However, if we remember the principle of operational closure of communication systems, it is clear that only society can threaten itself ([37] Ch. 6). In order to irritate and alarm itself, society can also employ very simple structures, for instance, distinctions. I would like to give an example.

The water of a river does what it does: it flows. We may draw a distinction, for instance 8 metres. This distinction is a technical device that works as a kind of threshold value. The distinction let the observer oscillate between over and under insofar as river rises or not, so that the observer can have some

information. From this standpoint, signal is a difference for information processing. Without a difference, indeed, nothing can look like a selection and be thus information. Moreover, the information value of an event depends on the selectivity of selection. Such selectivity, in turn, depends on the number of possibilities, that is, the variety that a system can deal with. For instance, to guess the name of a person is much more informative than to guess his or her sex. Hence, not only observers depend on information, but also information depends on observers. In other terms, information is never transmitted by the environment, rather it is "generated by observers" ([38] p. 658).

This condition also goes for signals. A red light is informative for the one who just got the driving license in a different sense compared to the one who is working in an industrial plant. In everyday life, this is almost a truism and can be learnt very quickly. What instead is often neglected is the highly *selective* nature of signals that process information. Structural coupling itself cannot take into account everything is occurring in the environment, otherwise system should address an information overload. Rather, systems balance high irritability with high indifference. Signals focus system's attention on environmental events which could have a surprising effect for the system; simultaneously, they distract system's attention from other events which are not taken into account and could become a second-order surprise.[11]

Technology and the use of computer hugely increase the irritability of social systems, so they help (if not even substitute) perception in many fields. Nowadays, no one would take the control of the danger of volcanic eruption seriously by looking at rising smoke. Technology provides society with a highly complicated and opaque system of technically controlled indicators. As always in the case of structural coupling, these indicators increase the structural uncertainties which the operationally closed communication system has to cope with. These structural uncertainties do represent what might be called *social signalling system*: its outcome is not simply an increase of security, but also a concurrent increase of uncertainty which society is able to address. This is the reason why, while actually living in a safer society, we feel that we live in a society that is substantially more vulnerable than before.[12]

While structuring the systemic irritability towards environmental perturbations, signalling bounds the systemic capability to process information. To be coherent, we should say that it is not a signal that informs the system, rather it is the system that informs itself through a signal.[13] This reasoning also explains why the same whistle that for players is the signal of the beginning (or the end) of the match, for my dog is the signal of running back to me.

On a temporal dimension, signalling combines the simultaneousness of system and environment with the problem of their synchronization. System and environment behave simultaneously because time flows for both with the same speed. Neither can the system stay behind in the past while the environment is moving forward into the future, nor can the environment be anticipated by a system that is running more speedily toward the future. Therefore, anticipation is possible just because environment cannot be anticipated.[14]

If a system is complex enough, it can combine the temporality of its operations with the temporality of environmental events, and look for some synchronization. Formal organizations know this problem very well and they deal with it especially when they are coping with warning signals. This point deserves further investigation.

Both time and attention are scarce resources. Scarcity increases when time and attention interact with each other. When only little time is available to solve a problem, one has to focus his attention on this problem; however, when one is focusing his attention on a problem, he must relinquish something else that could be taken into consideration only if more time were available. Signals that trigger irritation catalyze attention. Through sign systems, cognitive systems simultaneously save attention and produce attention. From this standpoint, pain might be regarded as an evolutionary advance.

Pain compels consciousness to become aware that something in body is wrong – which otherwise went unnoticed because consciousness and body are not operatively linked with each other, although consciousness depends on the autopoietic closure of a living organism. Therefore, a sign system is a type of 'attention equipment';[15] in social systems, it is used to distract people's attention from everyday life and to focus their attention on a still uncertain situation that eventually requires a structural change (when fire alarm is belling, teachers cannot go on teaching as if nothing had happened). Although these structural changes usually are provisional, alarmism is an almost permanent hallmark of modern society.

Here again we address a temporal issue. A warning signal should be given neither too late nor too early. In the former case, there would not be time enough to react to the signalized threat. In the latter case, the warning signal could spread unnecessary panic, or change danger circumstances so that, eventually, signalling itself proves inefficient [39, 43, 44].

The difference between alarm and alarmism does not solve the problem; it simply defines it. If we investigate the criteria that control the difference between alarm and alarmism in the

[11] The distinction between surprise and second-order surprise is drawn from Turner, Pidgeon [39].

[12] On this paradox, see Cevolini [40]. See also below, § 6.

[13] Luhmann ([41] p. 32) speaks of "Umformung von irritierenden Signalen in Informationen" (transformation of irritating signals into information). The matter is to explain what does it mean 'transformation'.

[14] On this point, see § 4.

[15] This concept (Aufmerksamkeitsapparat) is drawn from Waldenfels ([42] p. 14).

moment-in-being, we address the undecidability of decisional situations again. The true question rather is on what is based the credibility of a warning signal. As any structural coupling, also warning signals imply the simultaneity of system and environment. The paradoxical effect is that the efficiency of signals depends on the impossibility of verifying their efficiency, as Lars Clausen and Wolf Dombrowsky clearly proved. Also, we should remind that warning against risks implies the risk of warning. As the lacking of warning signals makes it impossible to react to threats by means of prompt remedies, so the excess of alarm can produce a tailing-off of attention (as those who live on the volcano slopes know very well), or the loss of credibility of the signal itself (the 'crying wolf' mechanism). In addition, there is the well-known danger of self-fulfilling prophecies: warning triggers the catastrophe which one would avoid simply because it has been communicated ([45] Ch. 13).

Anticipatory systems in anticipatory environments

The question could be raised "How is it possible that an event is understood by social systems as a signal of an impending change?". The systemic coupling with natural environment is relatively less complicated compared with the systemic coupling with social environment because nature usually behaves as a trivial machine. Otherwise, there would be no pharmaceutical industry. In the social world, the interpretation of signals is more complicated because society usually behaves as a historical machine. To disentangle this complexity, we shall return to the idea of anticipation.

The principle of operational closure does not admit that the system can anticipate its environment, and this is also true when the environment is conceived as future threat. Such misunderstanding is the result of a thick description made by a third party who describes the interplay of system and environment. However, if the environment is operationally unreachable, how is it possible an anticipatory system? For cybernetics, the matter is how it is possible for a cognitive system (for instance, brain) to construct internal representations of the outside world so that the system can recognize a shape without having every time to start all over again ([46] p. 25 ff.). The problem of anticipation cannot be decoupled from the problem of memory. The capability to perceive, the capability to recall, and the capability to infer depend on each other, as Heinz von Foerster [47] explained, because without perception no cognitive system can produce inner representations of outer regularities, and without recollection of these regularities a system cannot anticipate future events.

In very abstract terms, we may state that the system is complex enough to combine these three performances – perception, recollection, and inference – if it is able to represent the unity of the difference between system and environment inside the system. Such *re-entry* of the distinction in what has been distinguished[16] enables the system to compensate for the lack of operational contact with the external environment by means of internal performances. Thus, instead of controlling the environment, the system can control its lack of control over the environment. The very fact that this control is efficient does not depend on the isomorphic relationship between inner representation and anticipated environment. Isomorphism is just what an operationally closed system can never verify. Realism of representations is simply a description (performed by an external observer) of a systemic reaction suited to the conservation of adaptation to the respective environment.

The re-entry of the distinction in what has been distinguished allows the system to handle the distinction between self- and hetero-reference. This distinction is managed both *in* the system and *by* the system; also the external reference is thus internal with respect to the system that is referring to its own environment. Self-referential systems of this type can usually fulfil two fundamental performances: selection and generalization. On one side, the matter is to factor out what repeats when the system is dealing with a certain type of objects. On the other side, the matter is to generalize what has been selected and to preserve it as a type of redundancy[17] (shape, enduring constants, representation) [46]. In this way, the cognitive system can take its distance from the respective environment (it can gain autonomy) – e.g., the *idea* of duration has no duration.

According to cognitive psychology, this assumption implies that the system can construct a field (or cognitive) map of its environment [49]. The construction of this map is an internal performance that does not depend on information produced by the external environment. According to constructivism, the environment is what it is; it can neither inform nor instruct the system. If we think seriously upon the principle of operational closure, the question is not so much whether the inner map is consistent with the outer space, but how can the system react to the external environment in a suitable manner by referring to itself and to its own representations of the reality. If it is not the maze that informs the mouse, we shall admit that it is the mouse that informs himself when he is walking through the maze. Otherwise, cognitive systems could not be provided with autonomy. A prerequisite and a consequence of such autonomy are anticipatory performances.

The result of systemic decoupling from environment is the arising of a systemic temporality. This temporality implies the development of some type of language. On the biological

[16] The concept of 're-entry' is drawn from the laws of form developed by Spencer Brown [48].

[17] I use the term 'redundancy' according to the well-known mathematical theory of communication developed by Shannon. Redundancy is what repeats and is therefore predictable.

level, we know that some hormones trigger enzymes that behave for organisms as 'predictors' of future developments, so the organism can get ready to anticipatorily react to these changes. Those who take part in conversation act 'tactfully' if they anticipate the reaction of communication partners to their utterance, for instance, by avoiding embarrassing questions [50].

Anticipatory systems of this type are regarded as intelligent systems. In turn, intelligence may be regarded as an anticipatory performance based on systemic behaviour. Indeed, it is possible to ask the question "Whose anticipation?".[18] But also "What is actually anticipated?". If we take into account what has been said so far, it is clear that the only answer consistent with a constructivist approach is that systems can anticipate their environment since the environment let itself never be anticipated. Or in simple terms: when it is performed, anticipation is always a future-referred present operation.

If future could be anticipated, there would be nothing more to anticipate; eventually, nothing more to do. Systems do not react to the future as such; they rather react to their own anticipations of the future. Every policyholder is well aware of it. When he seizes the opportunity of taking out an insurance, he anticipates the possibility that the premium can be paid in vain if the claim that he was afraid of or had calculated in advance does not occur. In social systems, the situation is very complicated because social systems usually behave as a historical machine. Every field map, like a financial model or rational forecast, changes the field (i.e., the reality as such) that is mapped for the simple reason that it is communicated, thus making the same map somehow unreliable [52]. Moreover, every map, just like every distinction, has no real correspondence in the external environment. This basic condition (in usual terms, the map is not the territory) does not exclude that a map may be very fitting and successful, for instance as a field map of an organization. However, the transitory success is not due to the map as such, it is rather due to a transitory adaptation of social system and environment through the map. Moving from these assumptions, we can understand what is the most relevant drawback of Robert Rosen's anticipatory theory.

In Rosen's theory, anticipatory behaviour is distinguished from reactive behaviour because in the former case time plays a crucial role. A system is an anticipatory system if it contains "a predictive model of itself and/or of its environment, which allows it to change state at an instant in accord with the model's predictions pertaining to a later instant" ([3] p. 339). However, an inner-social environment is very different compared with a spatial environment. First, because when we move in the space, space does not move, and this is the reason why a field map is efficient. The relationship between input and output, in others words, remains invariant. Society behaves in different manner. As any historical machine, society changes recursively when a new event arises and is compared with the available systemic redundancy. In this case, the relationship between input and output is variable and depends on past.

Furthermore, social systems arise from double contingency. Usually, space does not react to the observers' movements unless it has been intentionally constructed for this purpose.[19] In social systems, the observer who is aware that he is object of an anticipatory behaviour by his communication partner will for sure anticipate such anticipation. Consequently, a more or less unpredictable situation arises (e.g., when partners play chess). In other words, both system and environment are performing an anticipatory behaviour. For instance, politics is simultaneously system and environment: it is an autonomous social system and an (anticipatory) environment for other social systems as economy. When politics tries to anticipate economic reactions by means of political decisions, economy reacts anticipatorily. The financial crisis has clearly demonstrated that an unpredictable situation thus arises. As a consequence, to speak of anticipatory systems is not enough; we should also speak of anticipatory environments and ask the question "How is it possible for a system to behave anticipatorily when it interacts with an anticipatory environment?".[20] Anticipation turns into a reflexive performance, and second-order anticipations arise from such reflexivity.

When we deal with social systems, we must remember that internal representations of external environment are 'clusters of expectations'. In this respect, Sommerhoff introduced the "principle of expectancy", namely, the systemic capability to build up a "what-leads-to-what" expectancy [46]. By means of expectancy, the cognitive system can fulfil predictions and inferential performances. For instance, it can prevent the clash with a moving object, or it can hit a moving target. Moreover, it can learn to the extent that it can replace (that is, forget) disappointed expectations with expectations that more likely will be fulfilled.

However, the crucial question is "What does *trigger* these expectations?". The systemic reaction to environment goes through the systemic reaction to systemic expectations toward

[18] As Riegler ([51] p. 11–12) does.

[19] For instance, I think of a maze where an open door is closed when the mouse goes through it a second time – and it is closed just because once the mouse went through it. I do not know whether psychological experiments of this kind have been realized.

[20] Rosen ([3] p. 403) already focused on the same problem with respect to the game theory, which he regarded as insufficient. According to Rosen, the theory of interacting anticipatory systems did represent "another direction for future research". Today, cognitive sciences speak of "adaptive learning systems" [53]. However, results are rather disappointing. Riegler [1] suggests to make a distinction between weak and strong anticipation: the former type of anticipation is based on 'predictive models' of the environment; by contrast, the latter type of anticipation is based on systemic self-organization – thus, systems can relinquish inner models of their outer environment.

the environment.[21] The reaction is efficient if triggering is highly selective. The hypothesis of self-referential systems theory is that this selectivity is conditioned by external references. In other words, when the reference to an environmental event can trigger the systemic self-reference again, the system can selectively combine the recollection of past experience and the expectation of future events. In this very case, we can say that the event performs a signalling function for the system. The purpose of the well-known research developed by Pavlov on conditioned reflexes was, in fact, to understand how it is possible that a whatever environmental event can perform a signalling function and trigger an anticipatory behaviour in a cognitive system. System's performance (its 'intelligence') can be explained by means of the distinction between event and structure.

Whereas events mark irreversibility, structures mark temporal reversibility ([54] p. 73 ff., p. 389 f.). The system can quickly react to an event that appears and disappears, and quickly forget what happened. In this case, the systemic behaviour is very similar to the model (environmental) stimulus/(systemic) reaction. Or, the event can make tracks in the system, which thus reacts more slowly [55]. An association of ideas arises which coincides with a peculiar systemic expectation. Indeed, expectation has no duration, whereas the perception of duration is the outcome of an expectation. The expected event is (and remains) uncertain, whereas the expectation of such an event provides the system with a relative certainty, which is used to get some bearings in an environment that remains unforeseeable. An event is a *structuring* event if it can change systemic past, thus binding the way the system get ready to react to the future. In other terms, if it can shape the way the system recursively combines self- and external reference.

Since they are based on expectations, system's orientations may also fail. Expectations can be not only confirmed but also disappointed. Pavlov's dogs can be easily defused if no food is served when the experimenter rings the bell. This prerequisite is often forgotten in social systems, so the model of reality is eventually confused with the reality represented by the model. From this standpoint, we could say that reality is everything that is not anticipated when one tries to anticipate reality, as the financial crisis dramatically proved.[22] However, an occasional disappointment is not enough to relinquish expectations. The commuting worker who has no train to come back home because of a rail strike does not relinquish his expectation that the day after trains will travel again. When disappointments trigger long-term structural changes, on the contrary, social sciences speak of learning or evolution. But this is subject for another research.

Warning signals in social systems

The reasoning developed so far is very abstract. I would like to return to the main topic of this article, namely, weak signals, moving from an empirical example. In a newspaper article published in 2015, Luca Ricolfi [58] commented some news spread by the Italian Government on a supposed economic recovery. On the basis of data concerning employment in the first 2 months of 2015, the Italian Government spoke of clear signals of an upturn in economy. An evidence was that in the first 2 months of 2014, the amount of permanent employments had been 112,000 unities per month, whereas in the first 2 months of the next year it was 152,000 unities per month, which implies a 35 % increase. Thus, the Italian Government spoke of an "extraordinary acceleration" ("formidabile accelerazione") of employment at the beginning of the new year. Ricolfi noted that, if compared with further data, these figures could have a different meaning. In the first 3 months of 2014, the amount of permanent employments had been 147,000 unities per month. Compared with this average, the already mentioned average of 152,000 unities per month in the subsequent year (with exclusion of data referring to March; at that time they were not yet available) clearly was substantially less 'extraordinary' than it appeared. Moreover, Ricolfi pointed out that the amount 152,000 was nearly the same average of two 'horrible' years, 2011 and 2012. Last but not least, the Italian sociologist regretted that along with data concerning employment, the Italian Government did not communicate data concerning 'cancellations', that is, ceased employment relationships during the same period, thus making a calculus of employment balance impossible.

Ricolfi's empirical observations are telling for many reasons, which I can here only briefly list. Ricolfi is obviously right when he reveals the slyness of public communication that manipulates seemingly objective statistical data to spread optimism among public opinion. However, the distinction between 'true signals' and 'smoke signals' does not grasp the complexity of future-referred signals. Warning signs have the same logical drawbacks of future contingencies. The only certainty is the distinction between two contradictory events. The current observer cannot formulate any absolutely true or false proposition about the event that will actually occur. In addition, Ricolfi's article shows another fundamental attitude of modern society: the use of statistical probability in order to have some (anticipatory) orientation in view of the future.

Statistical probability is perhaps the most relevant anticipatory system of modern society, and represents the functional substitute for the ancient virtue of prudence. A striking consequence is that, thanks to statistics, past is both highly

[21] Cf. Sommerhoff ([46] p. 31): "Our *reactions* to the *external world* are formed physiologically as *reactions* to the *activated models*" (italics added).

[22] Cf. Esposito [56]. See also Derman ([57] p. 5 ff.) who speaks of "foolish consistency of financial models".

informative and poorly instructive for present in view of an unknown future. In a sense, we could say that past is of no importance – if social systems produce discriminations, they do that by means of self-referential criteria as, for instance, examination in educational system or general election in political system, for sure not because of familiar membership or gender distinctions[23] – and this is the reason why past is so obsessively calculated. From numerical clusters, and – as Ricolfi's article clearly demonstrates – from comparisons between numerical clusters one can mine information that can be used to cope with complexity rather than to forecast a future which in spite of everything remains unpredictable [59].

Statistics has another advantage: it offers a type of 'secondary normality' that explains the deviation in everyday life as a normal event ([15] p. 1). Thanks to statistics and statistical probability, the oddity becomes credible that also contingency has its own order, that is to say, that there is some regularity in random distributions and that such regularity can even be calculated. Those who go beyond the limit of disbelief can use the regularities of chance as rules for decision-making. Obviously, this does not imply that one has the certainty of taking the right decision, as gamblers know very well. What can be achieved rather is a sort of 'substitute for certainty' by means of which one can plan actions, figure out short- or long-term strategies, and make profit, as the existence of insurance companies actually demonstrates.[24]

However, reckoning does not eliminate dangers in everyday life, and does not give any information on the single case. The average of car accidents does not inform the policyholder whether or not he will be involved (whether or not insurance is profitable). Nonetheless, it can justify a risky decision that remains right also when it eventually proves to be wrong. Consequently, the calculus of probability problematizes and de-problematizes the future that the calculus itself pretends to anticipate. It problematizes future because it calculates what indeed cannot be calculated – which is better than fatalism, in any case. It de-problematizes future because it offers a reason (in a sense, an alibi) for taking a decision despite the uncertainty of the situation. In short, what is calculated is the ignorance of the decision-maker, and the oddity is that this calculus of ignorance is based on a highly sophisticated mathematical calculus ([62] p. 50).

This mathematics of ignorance – essentially, an oxymoron – replaces the problem of anticipation with a problem of quantification. Both past and future are reduced to percentages. However, as the future that becomes present is never exactly the same that had been predicted (it would be a highly improbable outcome if future were exactly the same that had been calculated), so the present past that the decision-maker shall address in order to conjecture upon the future is somehow different. Despite the fact that, by definition, past cannot be changed, past continually changes with respect to the meaning of statistical data. One of the most relevant consequences of this type of combination of past and future in every moment-in-being is that past must be continually updated.

In the mid-18th century, social scientists had already noted that statistics is characterized by a 'chronic obsolescence', and that for the same reason every decision-making process must address the irregularity of statistical regularities [61, 63]. Consequently, statistical calculations simply offer a provisional orientation. Nobody would legitimate decisions taken on the basis of old statistical reports. Thus, society remembers substantially more than before. However, it also forgets more quickly than before. As a consequence, the anticipation of a contingent future is in turn a contingent performance – which finally clarifies the consistency of reversible (if not even contradictory) decisions.

The culture of alertness

The problem of weak signals has been mostly investigated by the sociology of formal organizations, especially of those that make use of high technology, for instance airports or nuclear facilities [64, 65]. The control of the lack of control is represented here by the semantics of 'vulnerability'. Scholars do not state that vulnerability is a fault to be removed, rather they hold the opinion that it is an inherent property of any social system, so everybody has to copy with it in order to be surprised by an unforeseeable future as little as possible [66, 67]. A disaster materializes system's vulnerability. It usually occurs in the form of interruption of organizational routines. The functional advantage of the latter is that they save attention. However, for the same reason they may become a great obstacle to the ability of paying attention to the first weak signals that precede the occurring of unexpected events. The matter is not simply the lack of information, but the overload of information which people have to cope with when time for processing is scarce.

By means of technology, as already seen, the problem becomes even worse. Indeed, technology implies an extension and complication of that social signalling through which society can gain information in a self-referential way. A further 'adverse effect' is that, because of operational closure, technology can only be technologically controlled. The paradoxical outcome is that, while the technical control of a danger is a risk, the spreading of the risk of dangers controlling technologies (and of technologies controlling technologies) in turn becomes an incontrollable danger. Since technologies gives experts the impression of keeping everything under control

[23] If distinctions like good and bad students were based on gender or familiar membership, the educational system would be regarded as a discriminating system.

[24] Cf. Esposito ([60] p. 72–73, p. 100–103). See also D'Amador ([61] p. 32), according to whom "la probabilité n'est en quelque sorte que le substitut de la certitude".

and being able to face unexpected events, they let them ill-equipped when an unpredictable event occurs; for instance, when technology or technology controlling technology suddenly doesn't function.

If the experience accrued by social studies on disasters is generalized, the real problem seems to be that the concerned system (for instance, a formal organization) *doesn't know that it doesn't know*. The ignorance which social systems are addressing is not simply a first-order ignorance, that is, I known that I do not know. In other terms, the matter is not simply that information is still lacking. The situation is even worse because nobody really knows which lacking information will be more relevant in the future. The observing system is addressing a second-order ignorance, or 'superignorance' ([68] p. 5 ff.; [69] p. 93): it doesn't know that it doesn't know. So, if the debate on weak signals always contains the latent question "Why did you not know that you didn't know that you didn't know?", the only answer one can give is "Just for this reason". In this very sense, the idea of weak signals attempts to symbolically hide the paradox of (lacking) information on the lack of information.

The second-order ignorance is a consequence of the fact that the blind spot, which is embedded in every observation, cannot be eliminated, even when the observing system performs reflexivity. The problem of uncertainty becomes autological. The matter is not simply that future is uncertain. The observer also addresses the uncertainty of the uncertainty that he is addressing by means of anticipatory performances. After a disaster, the meaning of anticipation can be retrospectively re-constructed. Right now, the observer understands that he did not know that he did not know. In other words, he understands that in his expectations there was a void.

Facing a so complicated situation, scholars look like resigned. On one side, formal organizations legitimate their decisions by acknowledging in advance that they do not know which outcome these decisions will have [70]. On the other side, the anticipatory paradigm is substituted by a cognitive and practical habit called resilience.[25] Instead of getting ready to react to unexpected events, social systems get ready to react to unpredictability by preparing in advance the capability of facing the counter-expected event after it occurred. At the same time, the sociology of organizations recommends to compensate for the blindness of management routines by "routinely suspecting" that organizational expectations are incomplete. The organization is thus encouraged to live in condition of "chronic fear", to act mindfully, so that it can give "strong responses to weak signals" [72]. However, this "mindfulness" (just like the difference between alarm and alarmism)[26] does not solve the problem, it simply defines it. The "struggle for alertness", moreover, is very expensive for the organization both in temporal and attentional (or, economic) terms. If one waits too long to be sure that he has every information he needs in order to take the right decision, he eventually misses the best opportunities.

To be coherent with the principle of operational closure, we should admit that the problem of weak signals can be solved only through signals, just as scientific problems can be solved only through scientific research, not for instance through moral issues. Here, the matter is not so much to think out signals that can signalize the occurring of weak signals. The matter rather is to think up signals that make social systems' irritability increase. We may guess that technology has a key role again in this respect. In principle, there is no limit to the invention of technological devices which can increase social systems' sensibility for unpredictable environmental events. Every time a device of this type is designed, the invention is regarded as an outcome of progress, or civilization. However, in this way systems run the risk that increasing information begets more confusion rather than more orientation. Social sciences should ask the question "To what extent is society able to bear the information overload that society itself continually reproduces?".

When the respective environment is the same society, social systems address a *chronic lack of redundancy*. An event is perceived. However, as it is the first time that it occurs, nobody knows to which experience it should be referred, consequently nobody knows what kind of future development one has to wait for. The map is incomplete because, instead of being a field map, it is a map of the relationships between social and temporal contingency. Under such conditions, in the available present it is harder to select those indicators that with more certainty correlate with possible future changes, and to do it just in view of systemic anticipatory reactions. The outcome is that in social systems any signal is actually weak, never strong, and this very fact somehow jeopardizes the validity of the difference between weak and strong.[27]

Finally, social sciences usually move from the assumption that the problem (of anticipation) has a solution, so the question is simply how can we get such solution. On the contrary, social system theory moves from the assumption that the problem has no solution at all (future can be anticipated because it cannot be anticipated). The true question is therefore "Why are we addressing the problem (of anticipation), despite the fact that future is and remains unforeseeable?". Why is society dealing with such a paradox? What is the usefulness of a problem that cannot be solved? This is, in my opinion, the

[25] Cf. Wildavsky ([69] p. 77 ff., p. 122). Ansoff ([17] p. 22) already spoke of "strategic surprises". Behind the term 'strategic', as Luhmann ([71] p. 1087) pointed out, lies the paradox of the inclusion of excluded possibilities.

[26] See above, § 3.

[27] The same conclusion arises also in recent debates on weak signals. According to Mendonça et al. ([73] p. 221), "there are *no* strategically relevant signals *per se*".

real challenge of the anticipatory issue in future studies – and for future studies.[28]

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