

Communication emerging? On simulating Structural Coupling in Multiple Contingency

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Abstract: The paper presents a Multi-Agent-Model of a population of agents which „learn to communicate” by reciprocally constraining their possibility spaces. Agents are conceived as „closed systems”, meaning that agents are operating solely on the base of their onboard means. They do not have any concept of an „external world”. Therewith, it cannot be said that agents „intend” to communicate or to reach a „consensus” of some sort. However, as they are unspecified in respect to their actions they co-evolutionary aggregate probabilities on how to cope with their environment. In this way, from the structural coupling of multiple unlikely actions (or operations) an „Eigenbehavior” emerges which an observer eventually might interpret as „communication”.

Introductory remark on the empirics of this presentation

As this paper is presented on a conference subtitled „Empirical Studies of Structural Coupling”, it might need an explanatory remark on its methodology. The empirics of this research-work are *self-generated*, meaning that the data from which here theoretical conclusions about the coherence of the conception of Niklas Luhmann are drawn is obtained from a computer-generated Agent-based-Model (ABM, see to this technology a.o.: Axelrod 2002, Epstein 2006). The model has been generated in the course of an ongoing endeavor to reconcile, integrate or just to compare the Luhmannian Theory of Systems to the Anglo-American debates currently lead under titles like Dynamical Systems Theory, Theory of Complex Adaptive Systems, or just Complexity Theory (Füllsack 2010, 2011). The data used in this paper thus is not empirical in a classical sense. But it is not purely theoretical either. What has been said about the methodology of ABM in general (Axelrod 2002), thus can be said about the data and the results of this paper: they are *generative* and therewith implying a „third way” of scientific research.

1. Introduction

The list of attempts to simulate aspects of a Theory of Social Systems as suggested by Niklas Luhmann (a.o.1984) is getting longer (cf: Kron 2002, Fleischmann 2005, Barber/Blanchard/Buchinger/Cessac/Streit 2006, Leydesdorff 2008). Repeatedly, a focus of these attempts has been communication, which Luhmann conceives as a process of three consecutive selections - the selection of information, of message and of understanding. According to Luhmann communication takes place whenever an information can be understood as message. (cf. Luhmann 1984: 498) This conception stands in a more or less striking contrast to some basic assumptions of earlier theories of communication, therewith irritating linguists, social scientists and philosophers alike, and probably also impeding the reception of Luhmann in non-German speaking scientific communities. One of the main targets of Luhmann’s argumentation has been the naturalistic or realistic premises on which classical ontology tried to base its attempts to analytically grasp communication. Especially,

what could be called the „intentional stance“ of philosophers like Jürgen Habermas aroused his contradiction. For Luhmann, attempts to base communication on a *will* to be understood, are fundamentally misconceived. Communication emerges so to speak „unintentionally“ - if it emerges. As there is no „outside world“ needed about which to communicate there is also no *a priori* intention necessary to get communication started. Communication for Luhmann is an emergent property of the aggregation of agents which operate as they operate without aim or *telos*. Only retrospectively, the actions of these agents might seem „intended“ and therewith raise an observer’s expectation about consensus, understanding and harmony.

In the following paper, I will try to illuminate this assumption of the Luhmannian theory. Therefore, at first I will shortly review a well-known mechanism used by social insects to „communicate“ (2.). I will shortly discuss Parsons concept of „double contingency“ and Luhmann’s objection to it (3.). And finally I will introduce the ABM which might help to clarify the concept of structural coupling and therewith the Luhmannian conception of communication (4.a, b, c, d, e).

2. Ant Search

For a clear comprehension of the notion of a „closed system acting solely on the base of its onboard means“, it might help to bring to mind the way how social insects, in particular ants, are said to coordinate foraging. As other insects as well, ants diffuse volatile pheromone secrets for instance when transporting food from a food source to their nest. These chemicals simply increase the probability of other ants, so far randomly roaming, to find and join marked food trails. Since joining ants soon diffuse pheromones as well, the „visibility“ of these paths rapidly increases. The ensuing positive feedback correlates the ants’ actions.

In robotics nowadays, this simple technique is successfully applied to robot swarms searching for shortest ways through labyrinths (Russell 1999). At least in regard to this artificial form of Ant search we probably can agree that no whatsoever intention on behalf of the robots is needed to make the mechanism work. Robots - and as I assume ants as well - simply respond to their onboard means. They do not need a conception of any „external world“, nor a notion of other individuals or of being a member of a swarm of individuals. Their coordination and „communication“ therewith, can be seen as an *emergent property* of their aggregated actions as „selfish“ and self-contained machines which have no whatsoever awareness of anything apart from themselves.

As we know, this „unawareness“ of anything „outside“ is a basic assumption in Luhmann’s conception. Systems have onboard means to operate, and whatever (to an observer) might seem „outside“ (the environment), they only perceive with and through these onboard means. An illustrative example in this regard provides the air-conditioning system which is built to distinguish temperatures and to switch on a heater or a cooler in respect to perceived deviations from „normal“ temperature. If the house in which the air-con is working should catch fire the system will perceive this through its onboard means, that is, via its thermostat reporting „too hot“. The air-con will switch on the cooler, even though from the point of view of an external observer - who recurs on a different set of onboard means - this does not seem to be the most reasonable action. The air-con just sees what it can see, and it does not see what it can’t see, as Luhmann famously liked to put it.

What is true for the air-con, should be presupposed for communication - at least in its origins. In order to analytically explain communication, interlocutors should be conceived as self-referentially closed systems with no whatsoever other possibility to perceive anything „outside“ than their onboard means. In details these onboard means might differ from system to system. In order to analytically grasp the „diversity“, Luhmann recurs to the conception of „*double contingency*“ as suggested by Talcott Parsons (1951).

3. Double contingency

The crucial point in Parsons' conception is the fact that the interlocutors Ego and Alter in their interaction initially are not constrained by any kind of limitations or deficits in communicational possibilities. On the opposite: they have *too many* possibilities to start interaction. Or in other words, the crucial problem for the initiation of their interaction, of their communication, is not too little, but *too much* opportunity. The problem consists in the *contingency* of the preconditions on both sides of the potential interaction. Ego and Alter, both face vast possibility-spaces and - at least initially - have no information about which one of their possible options might provide them with a good chance to keep going.

In Parsons' conception the problem is solved by an *a priori* synchronized „shared symbolic system“, a culture for instance, behavioral habits, a language, etc., which constrain the possibility-spaces of the interlocutors to a degree at which at least some action becomes sufficiently likely. In every-day life, these preset constraints confine our possibilities to a degree at which certain actions not only gain sufficient probability to take place, but sometimes even seem to become predictable. It is irritating indeed, if on greeting a colleague at the workplace we are not reciprocated, but answered with a quotation from a mathematical textbook.

In principle Luhmann agrees with Parsons' assumption of pre-synchronized action constraints, but ties his agreement to the still more basic question on how these constraints emerged in the first place (cf. Luhmann 1984: 148f). In his opinion, these constraints as well could not have developed without communication. So in respect to some theoretical past when there was no cultural pre-orientation of social interactions, Luhmann considers it necessary to consider Ego and Alter bare of any assets that could be interpreted as results of communication. Referring to constructivism, he therefore conceives Ego and Alter as self-referentially closed „black boxes“, as systems which are nothing more than an *irritation* to each other and which do not have any other possibilities to cope with this irritation than their own onboard means.

In its most abstract form, these means of operation are differentiations. With George Spencer-Brown (1969) Luhmann conceives the basic operation of systems as the dual act of *differentiation* and *indication*. Systems operate in and on their world by differentiating formerly undifferentiated aspects of it, and by indicating one of them - just like the air-con distinguishes too high and normal temperatures and indicates „too high“ as reason for sending an on-signal to the cooler. Systems in this way generate, so to speak, connectivity to their future. With each act of differentiation and indication they generate a new state which in the next step can be differentiated again in order to indicate one part of it.

The reciprocal irritation of Ego and Alter stands for the initiation of such a differentiation process - with irritation being a help term for an act that, when understood stringently, only retrospectively - when interaction *will have*¹ taken off - can be ascribed to an interaction. By itself the system just does something which to an observer might look like irritating another system which in its turn - again to the observer - seems to find a way in its onboard means to cope with this irritation. The system doesn't have to - there is no whatsoever kind of teleology in this conception -, but if it does, it again might induce an irritation to which its vis-à-vis is challenged to find a way of handling it in the next step. In this way, these two black boxes might step by step diminish their possibility-spaces to a degree at which some actions have distinctly more probability than others. Since this reduction of possibility-spaces happens concurrently on both sides of the „double contingency“, Alter and Ego with time seem to coordinate their actions. In Luhmann's terms: their actions are (or become) *structurally coupled*. For the observer (and eventually, if Alter and Ego reach a complexity that enables

¹ Compare this to the „future anterior“ that Jacques Derrida considers adequate to mark respective processes.

self-observation, for themselves as well) these actions begin to look like *reactions*. Alter and Ego seem to *react* to each other.

In this respect, one might say that communication *emerges* as the consequence of self-contained actions which are not based on any conception of a world „outside” of Ego and Alter. Ego and Alter operate (and keep operating) solely on the base of their onboard means. Ego and Alter never are anything else than closed self-referential systems with no immediate connection to any „external world“.² Nevertheless, exactly this enables them to gradually increase the probability of actions by iterating their handling of mutual irritations. Actions therewith might start to *look like* interactions, and eventually might even *be seen as* intended, consensus-oriented communications.

4. The model

In order to comprehend this process of structural coupling in its details and particularities, the following model was generated which, unlike other ABMs, is not so much intended to „proof” a possibility of emergence of macro-phenomena from a well-defined set of micro-actions. The model rather is meant to simply *illustrate* the way the structural coupling of self-contained actors might be conceived in details, following the conception of Luhmannian communication. For reasons of better understandability, I have dissected the model into different scenarios, loosely corresponding to Luhmann’s distinction of information (4.a.), of message (4.b.) and of the understanding of the difference of information and message (4.c.).

4.a. Information

The first scenario of the model is very simple and is meant to explain the basic working principle of the model. However, it might also mediate a first notion of what in this context can be understood as *structural coupling*. In this scenario, a population of p computer generated agents are confronted with n randomly appearing „things” which are assumed to be elements of a “world” or of an environment the agents have to „survive” in by distinguishing things. Technically, these things are enlisted in a <thing-list> in invariant order and, for accessing them, have the form of simple letter constellations like „aaa”, „bbb” „ccc”³ To the agents, however, these „things”⁴ do not appear in the form of these constellations, but in the form of different letter constellations which are interpreted as *signs* or „words” for things. These words are the only way agents perceive things. Words have the form „AA” „BB” „CC” ... and are likewise enlisted in an invariant <word-list> of length n . The position of things in the <thing-list> does not correspond to the position of words in the <word-list>, but is randomly assigned in the model’s setup. Agents have to distinguish things via their representation as words (or signs).

Initially, when starting the model, agents have no whatsoever idea of what words represent what things. They can only „guess”. But for guessing they have a special onboard tool which has the form of a <probability-matrix> with n rows that hold entries for words and n columns which hold entries for things. All entries are set to zero at the start of the simulation.

² However, they are not „solipsistic” either, in the sense of self-contained autonomous entities that do *not* depend on any social circumstances.

³ A variant deploying binaries instead of letter constellations has been presented in Füllsack 2010. This variant was used to show that “communication” - as Luhmann correctly supposed - is *not* promoted by signs that resemble the “things” they designate (i.e. by binaries with a low Hamming-distance to each other). It is *difference*, not resemblance (or “reflectance”) that promotes communication.

⁴ Which thus might be interpreted as a Kantian „Ding an sich” (the *essence*) which is represented by signs (*occurrences*).

		things		
		aaa	bbb	ccc
words	AA	0	0	0
	BB	0	0	0
	CC	0	0	0

		things		
		aaa	bbb	ccc
words	AA	23	100	63
	BB	100	47	5
	CC	18	12	100

Image 1. Schematized probability-matrices with $n = 3$, left initially with all entries zero, right at the end of a run.

This matrix serves as a kind of „memory” for the agents. Whenever one of them is „irritated” by the representation of a thing, that is, by a word, the agent checks the row of her probability-matrix corresponding to this word. Of course, initially there is no difference in this matrix. All entries are set to zero. So the agent will pick one random position in this row and interpret the heard word as indicating the thing corresponding to this position. The agent „guesses”. In many cases the guess will be wrong, but if it coincidentally is correct (with “correct” meaning a correspondence that benefits survival) the agent memorizes this „success” by increasing the corresponding matrix position by one point. From then on, whenever the agent again is „irritated” by a word, she will find a differentiated probability-matrix from which she chooses the highest entry and - with a certain probability - interprets the corresponding thing as the one represented by the word.

For technically not determining agent’s interpretations already in the first step, agents compare each entry to a random number between 0 and 100. The corresponding thing is assigned only if this random number is smaller than the entry. Agents thus have to increment entries up to 100 to be finally sure of word-thing-correlations. Nevertheless, with this simple procedure agents rapidly „learn” to correctly discriminate things via words.⁵ We might say, they discriminate information using nothing else than their onboard means (that is, their probability-matrices). This information, however, is just information *to them*. It is a difference that makes a difference *to the agents*.

Note, however, that 1.) what here is called „learning” of course is an anthropomorphic interpretation of an observer who observes a process of *structural coupling*, that is, of an autonomously acting mechanism that has no other perception of its world than an aggregated „experience” about those of its acts which have proven „successful”. Additionally, 2.) what here is called „memory” has no real access to any „past” of some sort. Agents always check only the highest, that is the last entry in their matrices, and determine their interpretations from this. The process thus follows a simple Markov-chain and agents can be seen as finite-state machines.

Nevertheless, we might say that agents get *structurally coupled* to their environment by „learning” how to cope with irritations. Remember Maturana and Varela’s submarine driver (1987: 137) who, on being congratulated for avoiding reefs, is confused because all he did was read certain dials and maintain correlations between indicators within the limits of his equipment. Like this submarine driver, our agents have no concept of any reefs or other world particularities. They act solely on the grounds of their own onboard means.

4.b. Message

In the second, slightly more complex variant of the model, things are not presented in the form of words to the agents, but agents themselves react to an „irritation” by a thing with the utterance of a word. Things, words, thing-list and word-list are all the same as above and this means that correspondences are initially undetermined. Agents have no idea about which word to choose for indicating a thing. An utterance of a word is interpreted as a mechanical

⁵ As I have shown in other occasions, employing slightly more complex Genetic Algorithms (2010, 2011), this simple procedure works with changing environments analogously as long as the agents learning capability on average has more flexibility (that is, faster adaptability) than the environment.

(re)action just like an ant emitting pheromone when finding food. And as in the case of ants, other agents in the population can „hear” the uttered word. However, in this case the other agents have no whatsoever idea in reaction to which thing the word was uttered. And, as we will see, they also do not have any „understanding” of the word as being uttered by an agent. For them, it might as well have been coincidental noise.

As in the case of pheromone, a correct attribution of the heard word to the thing in reaction to which it was uttered, (and also, as we will see in variant 3 of the model, a correct attribution of the word to another agent as „sender” of a message), would benefit the listener, presumably in respect to some kind of collaboration in foraging or something similar. Initially, however, there is no whatsoever collaboration possible, for there is no „connection” between the agents. Agents have no idea of other agents in their world. They are conceived as self-referentially closed operating systems, black boxes, which construct their world solely with their onboard means. Among these onboard means, however, there again is a memory in the form of a matrix with n rows and n columns with all entries initially set to zero.

Now we might interpret the ensuing process in terms of the Parsons/Luhmann „double contingency” concept. The procedure is as above. Whenever an agent hears a word she checks the row in her probability-matrix corresponding to the word-list-position of this word. Initially all entries are zero, so the agent has an „open” possibility space. She faces *too many* options to correlate the word to a thing. The only thing she can do is to „guess”. Guessing again means to randomly choose one of n things as the one „indicated” by the heard word. If just by chance this guess is correct the entries in the probability-matrices of speaker and receiver corresponding to the „meant” thing and the uttered word are increased by one point – up to a maximum of 100 points. Agents, so to speak, benefit from (initially completely coincidental) correlation and this benefit manifests in the form of an increased entry in their probability-matrices.

Hence, in each step of the simulation, agents are confronted with randomly appearing things. When „irritated”, they check the column of their probability-matrix which corresponds to the thing irritating them. If entries differ, they check for the highest, compare it to a random number between 0 and 100, and if this number is smaller than the entry, utter the corresponding word from the word-list. Likewise the hearer of a word analogically compares this word to all positions in the rows of *her* probability-matrix that correspond to the positions the word has in the word-list. Again the highest entry is compared against a random number between 0 and 100 and if higher is assumed to indicate the thing which corresponds to the column the entry was taken from. If the assumption is right the corresponding positions in the probability-matrices of the agents are raised by one point. An entry of 100 eventually implies certainty (100%-probability) about a word designating a thing. If all agents have 100%-entries for all things in their world their onboard means for communication are considered determined. No further changes are possible.

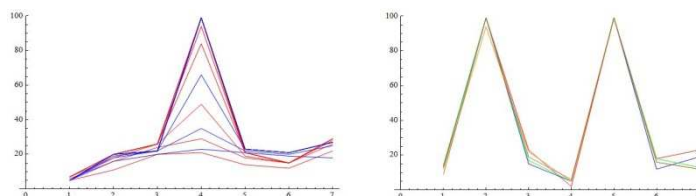


Image 2. Left: development of a probability-matrix column of two agents, red for Ego and blue for Alter, from step 500 to step 1350 in steps of 50, the peak growing up in time. Right: the final probability distribution in a column of the probability-matrix of five agents, in this case convening on two different words.

In this way, in terms of Luhmann’s conception, agents simply *concurrently* reduce their initially „open” (i.e. in all positions equally likely) possibility-spaces. In doing this, they are

not „connected” in any sense, but they are *structurally coupled*. Their probabilities for uttering certain words in reaction to certain things *co-evolve*.

Hardly surprising, after some iterations, agents „convene” on certain words for certain things. In my trials, with $p \leq 10$ and $n \leq 5$, agents practically always converge on one language, meaning that all agents are using the same words to indicate things. Agents thereby are not allowed to use words homonymously, that is, to indicate different things with one word. For this, in order to prevent their probability-matrices from running up in a dead end, the possibility had to be implemented to decrease probabilities again when two words reach high entries in the probability-matrix simultaneously. For this reason, simulation runs with $p > 10$ and $n > 5$ at times can become exceedingly long. However, even with $p = 25$ and $n = 10$ typical results consist of a population with around 50% of the agent speaking one language and the rest differing in not more than 50% of their words. With David Lewis (1969) one might say that agent convene on a sort of „babbling equilibrium”.

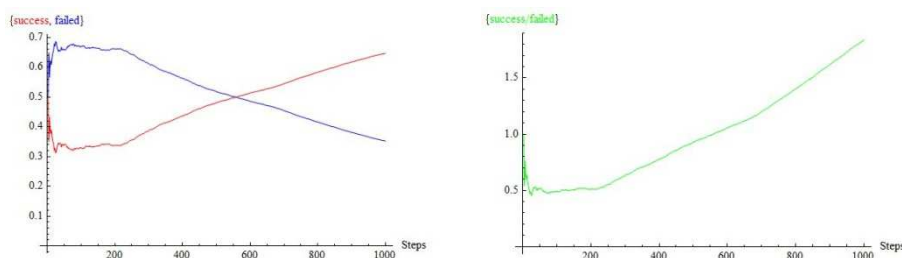


Image 3. „Successful” versus „failed” interactions (i.e. interpretations). Right: as ratio of „successes” and „failures”. The plots show a typical correlation development in a population of 10 agents confronted with 3 things.

As might have been noticed, there is a certain analogy of this model to the Chinese Room scenario with which John Searle (1980) argued against the notion of thinking machines. Obviously agents act similarly „automatically” without any intention to generate interaction. One might say that interaction (or at least some kind of correlation between agents) emerges, so to speak, „behind the back” of the agents. The difference to Searle’s fiction of a non-Chinese speaking translator who just blindly follows the rules of a book which instructs him how to correlate English and Chinese words is that the agents in this model do not have such a book beforehand. The book (in the form of a differentiated probability-matrix) *emerges* in the course of action (which might therewith start to look like *interaction*). Obviously, this resembles the difference between Parsons’ and Luhmann’s version of double contingency. What eventually allows to overcome contingency and thus enables interaction is not given *a priori*, but emerges in the course of structurally coupled self-referential actions.

4.c. Understanding information as message

In the third variant of the model, I endowed agents again with slightly more possibilities to couple. Additionally to the probability-matrix for aggregating „knowledge” about thing-word-correlations, they now are supposed to discriminate between a word being uttered by another agent and a word as coincidental background-noise.

However, the principle is the same as above. Agents react to randomly generated things by uttering words which are chosen in respect to entries in probability-matrices. In order to visualize these reactions (for the observer of the model, not for the agents themselves), agents when uttering a word are made to take on a certain, initially randomly assigned color which technically is provided in an invariant list of possible colors with length n .

Simultaneously with the agent’s word, the model generates one or more random words which other agents perceive as well. As indication for „hearing” and interpreting a certain thing, the

listening agents also take on a color from the color-list. Taking on the same color as the speaking agent AND interpreting the correct thing from the heard word (that is, the one in reaction to which the speaker has uttered the word) again is considered a success. Agents are seen as „understanding” a word (an information) as coming from another agent in the form of a „message” and not in the form of noise from the background. Hence, they are „rewarded” with an increase in the respective positions of now two matrices, which is one for the probability of a word representing a certain thing and another one for choosing a color corresponding to the one of a „speaking” agent.

The ensuing process might be seen as a sort of *second order* structural coupling. Agents couple in respect to interpreting things via probability-matrices for word-thing-correlations. And additionally their probability-matrices for word-thing-correlations couple with lists for color-correlations as well. Agents so to speak couple to their „material” environment from which the thing-irritation arises. And at the same time they couple to other agents which „irritate” them with words uttered in response to *their* own „material” structurally coupling. As a result, agents seem able to discriminate between „correct” words coming from other agents and coincidentally generated background noises which technically indeed are words as well but are not assigned to other agents as speakers. We could interpret this as agents „understanding” the difference between „information” and „message” by way of *multiple* structural coupling. Note however, that agents in this scenario can discriminate between background generated and agent generated words, but they cannot distinguish other agents as such. In other words, agents do not have an *identity* to each other.

4.d. Some results

In the variants of the model mentioned so far, all agents have equal chances to utter and to hear and interpret words. Their coupling depends very much on coincidental initial „irritations” to which their probability-matrices *lock in* (Arthur 1989). From these path dependencies, after a couple of iterations networks of coupling possibilities form. If an agent for example in its first steps repeatedly couples to a „red” agent in „agreement” about the word „AA” meaning the thing „ddd” and additionally couples to another „red” agent in agreement on the word „BB” meaning the thing „ccc” his probability for guessing red as the color that indicates „agent-message” (and not noise) can rapidly grow to a level at which the coupling to other agents who in their interaction-history experienced, say, „blue” or „green” as indicating „messages” becomes impossible. The population therewith differentiates. The parts get „incommunicable” to each other. True, for not running up in dead ends, the model foresees a possibility to decrease color-probabilities in the same way as word-probabilities. However, probabilities can be reinforced beyond fast decreasing by members of the same-color-network. Therewith decreasing can take a pretty long time. As a consequence, in my experiments agent population often polarized into at least two groups of roughly same size which to each other remained „incommunicable” over long periods of time.

The following tables show clippings from probability-matrices, with agents listed from the top down. In the left column the color-probability-matrix of ten agents after 750 steps is shown. At this point, 6 Agents „convened” on „understanding” blue as indicating a „message”, 4 „convened” on red. The middle column shows the corresponding word-probabilities of the ten agents at the same time. Although the „choices” of agents 8 and 9 for example seem to differ not too dramatically and therewith indicate a possible coupling in respect to word-thing-correlation, they are „incommunicable” in respect to color-probabilities (here red and blue). Hence, in order to enable an overall „agreement” agents have to „reconsider” their color-choices. The right column shows the same word-probability-matrices after 12000 steps. At this point „agreement” on one color is accomplished, but not all agents convene on words. While a majority (red underlined) seems clearly inclined to agree on words as defined by the

first, second and third position in the respective rows, agent 9 for example still seems in the process of changing her „choice” (e.g. a probability of 88 (which has to decrease) against 76 (which has to increase) in the third row) and agent 3 „disagrees” on the words as defined by the first and second row of her matrix.

[24 100 12]	[[34 17 14] [15 24 19] [42 22 27]]	[[95 56 44] [50 88 50] [88 62 87]]
[32 100 20]	[[40 15 13] [16 45 15] [26 32 53]]	[[90 67 61] [51 92 60] [59 79 86]]
[100 46 24]	[[14 24 14] [22 18 15] [19 14 31]]	[[86 89 55] [89 86 68] [74 76 89]]
[37 100 20]	[[29 19 32] [23 22 10] [27 17 19]]	[[95 54 87] [58 89 44] [68 70 94]]
[100 43 18]	[[26 21 16] [14 17 19] [29 19 17]]	[[90 88 38] [85 62 88] [87 85 87]]
[100 39 13]	[[30 13 17] [18 11 11] [15 16 26]]	[[86 82 62] [87 77 78] [68 89 92]]
[35 100 17]	[[45 17 25] [13 40 18] [18 11 32]]	[[92 47 58] [45 88 46] [46 34 95]]
[37 100 18]	[[41 17 24] [20 20 18] [26 28 18]]	[[87 74 88] [62 90 60] [71 86 86]]
[100 25 23]	[[32 11 14] [20 20 26] [16 40 9]]	[[88 56 44] [72 89 88] [68 88 76]]
[27 100 14]	[[36 19 21] [26 41 16] [20 25 32]]	[[90 52 64] [59 95 53] [60 70 95]]

Image 4. Probability-lists and -matrices of 10 agents in various states: left: color-probabilities after 750 steps, middle: word-probabilities after 750 steps, right: word-probabilities after 12000 steps. Colored dots indicate color-choices. Underlined entries indicate promising probabilities for correlation (red) or conflict (black).

As said before, if coupling proceeds very contradictory, (that is, influenced from agents who themselves are influenced from different sources), the emergence of a complete set of words can take a long time. Agents then are forced to „reconsider” their „choices”, that is to decrease the entries in their matrices in order to be able to converge on an allowed (that is, not homonymous) set of words. In the above example, agents „agreed” upon using the same word-set, that is, one language (for designating just 3 things) after 19467 steps.

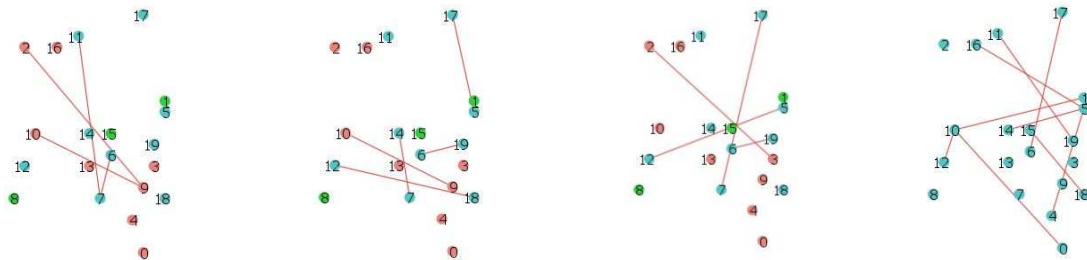


Image 5. Clippings of coupling possibilities. The left, second-left, and second-right image show the population’s differentiation after about 1000 steps, the right image after 15000 steps. Same colors indicate an agreement on „agent-messages”. Red links indicate successful interactions. (Numbers indicate the internal numbers of the agents.)

4.e. Identity

In a still slightly more complex variant of the model, agents are supposed to develop identity. Their actions now are considered successful, if they not only correctly interpret things from uttered words and discriminate between agent-generated („messages”) and background-generated words („information”), but also successfully discriminate between other agents as sources of words. In other words, agents actions are considered „successful” if a „speaking” agent is „recognized” as the carrier of a particular identity and therewith distinguished from other agents as carriers of different identities. What might be sociologically interesting in this

variant of the model, is the fact that agents start out with no whatsoever self-identity. They gain their self-identity in the process of mutually ascribing identities.

In order to enable this process, agents are endowed with yet another probability-matrix for memorizing identity-probabilities. An agent, when confronted with a thing, now in addition to checking her matrix for thing-word-correlation and the list for color-correlation, also has to check the matrix for identity-correlation. If there is no entry higher than zero at first, she just „guesses” who she might be and decides randomly for an ID in the form of a name. This name then is „heard” by another agent and checked for its probability designating a particular agent. If all probabilities are zero, she as well „guesses”. And as before, if this guess is correct it is „rewarded” with a corresponding entry in the matrices of both „interlocutors”. Also as before, agents are not allowed to use names twice. Thus, if a name once is assigned to an agent, others who have high probabilities for using the same name have to „reconsider”. In this way, slowly but steadily identities form, word-thing-correlations establish and an „understanding” of „information” as „message” emerges. The relatively simple coupling of three probability-arrays generates a correlated system which to an observer might seem the result of the well orchestrated and may be even *intended* interaction of autonomous actors. Wouldn't it obviously be just computer generated agents, who knows, we would ascribe them the *will* to communicate and to be understood.⁶



Image 6. Names and probability-arrays of 5 agents „convening” on (in this case) the same 5 words. Left to right: identities, words, word-probabilities, identity-probabilities and color-probabilities. Internally agents are ordered from top to bottom which corresponds to the order of columns in the identity-probability-matrix.

5. Summary

In the light of contemporary ALife- and AI-research, the model as introduced in this paper is of course rather simple and far from using the possibilities modern IC-technology provides. However, the model has not been generated to test and expand these possibilities, but to illustrate aspects on what Niklas Luhmann might have had in mind when conceiving his theory of communication. The model tries to show that the aggregated actions of autonomously operating „black boxes” which have no conception of an external world (let alone of a society they are members off) suffice to generate - via *structural coupling* - a form of correlation which might well be interpreted as the result of intended (willful) attempts to cooperate and to be understood. If the model and the assumptions it is build on hold water, this might give reason to consider Luhmann's conception of communication scientifically more reasonable than competing theories which recur to an irreducible quality of consensual communication.

⁶ As some ALife researches seems willing to condition the possibility to reproduce to the emergence of identity (cf. Varela 1992), it might be interesting to give agents, once endowed with IDs, the chance to reproduce in respect to the number of their „successes” in „communicating” with others. Predictably, from the ensuing evolutionary selection the „babbling equilibrium” of partially different languages should vanish. This and related experiments will be investigated in subsequent work.

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