COMPLEX MIMETIC SYSTEMS

Hans Weigand,
Tilburg University, The Netherlands

> The goal of science is to make the wonderful and complex understandable and simple – but not less wonderful.
> – *Herb Simon, Sciences of the Artificial*

1. Introduction

Complex Systems stands for an approach in the social as well as natural and computational sciences that studies how interactions between parts give rise to collective behaviors of a system and how the system interacts and forms relationships with its environment. Typical example is the market economy in which the order is emergent: it is the *result of human action, but not the execution of any human design* (Hayek). Complex Systems theory is currently a popular vehicle to understand the complexities of Internet; other examples are as diverse as the stock market, ant colonies, epidemics and the spread of business innovations. The focus in this article is on modeling social systems, rather than physical or biological phenomena.

The mimetic theory developed by René Girard fits well with a system perspective, as it has specific ideas about the drivers of human action (micro level) and cultural processes (macro level). The relationship has been explored earlier in several books and papers (e.g. Dumouchel & Depuy, 1983) - in particular we mention the work of CREA at Paris. The system perspective has received a new stimulus in the 1990s in the form of Complex Adaptive Systems (CAS – Holland, 1995), not the least because of the agent-based computer simulations adopted at that time. The objective of this article is to introduce a special version of CAS, called Complex Mimetic Systems (CMS), that builds on mimetic theory. Its purpose is twofold. On the one hand, the phrasing of mimetic theory in terms of CMS poses an interesting challenge to the theory to formalize its concepts and explicate possible limitations. On the other hand, the CMS might be a useful contribution to the CAS field as it incorporates concepts such as "social influence" that are very basic to but typically not sorted out in current CAS systems, as first-class citizens.

The structure of this paper is as follows. In section 2, we review briefly the CAS literature and introduce the idea of Complex Mimetic Systems. Section 3 describes a strawman agent architecture for CMS, whereas in section 4, we move to the macro level and formalize the Culture Reproduction Cycle. To illustrate the applicability of the CMS framework, we discuss in section 5 the CAS analysis made recently by Ingo Piepers of the European international system in the period 1490-1945, and comment on it from a CMS perspective.

2. Complex Mimetic Systems

Characteristic features of complex systems are:

- *Non-linear effects*. A small perturbation may have a large effect.

- *Feedback loops*: the effects of an elements' behavior are fed back to it in some way. The feedback can be positive (amplification, runaway) or negative (damping).
- *Openness*: a typical complex system interacts with its environment.
- *Memory*: the history of a complex system may be important. Prior states may have an influence on present states.
- *Nesting, hierarchy*: a complex system may itself be an element of a larger complex system. For example, clans in a tribe, nation states in an international system, or divisions in a company.
- *Topology*: the interactions of the elements are enabled and constrained by the network, or grid, of relationships between them.

Complex Adaptive Systems

Complex Adaptive Systems is a modern variant of complex systems theory. The elements of a CAS are called *agents*, as CAS builds on computational research in the field of Multi-Agent Systems (Wooldridge, 2002; Sun, 2006). Although there is not much difference in the overall objectives, the use of agent simulation opens up interesting research opportunities. Let us clarify this by means of an introductory example given by Miller and Page (2006), the Standing Ovation Problem.

Standing ovations, in which waves of audience members stand up express their particular appreciation of a performance, usually arise and evolve spontaneously. Suppose that we want to model this phenomenon. A starting-point could be a simple mathematical model in which we distinguish N people, each receiving a signal $s_i(q)$ that represents the appreciation level of the person given an actual (objective) quality of the performance q. The function may be made stochastic to account for a certain noise in the signal. To close the model, we assume that there is a certain threshold value T, so that each person stands if and only if $s_i(q) > T$.

A model is good as far as it helps to illuminate part of reality. In this case, it could help to predict that when the quality of a certain performance A is higher than that of B, the more people will stand up. However, the model cannot explain waves of subsequent standing. The model can be extended to include the effect that people respond to the behavior of others in such situations. Let us add a parameter α that gives the percentage of people who must stand so that the others ignore their initial signals and decide to stand up nevertheless. This would predict the following behavior: if initially less than α percent of the people is moved, then only this group will stand up. Otherwise, this group will stand up first, followed by a second wave in which everyone will rise. This model is better than the first one, but still leaves much to be desired. It does not explain why there are often more than two waves, how they move to the theater hall in space. The problem is that the model does not take into account that people are more influenced by some than by others, that typically families and friends sit together, and that the hall has a certain design which makes that the people on the first row have the highest potential influence (as they are observed by all) but the least information (it is hard for them to observe the others).

We can try to extend our model again with all these features, but the mathematical format quickly tends to become quite cumbersome. It is at this point that agent models step in as

a powerful simulation technique. Agents can be configured, for example, to relate to each other according to a certain topology that takes into account both spatial and social characteristics. Running different simulation rounds, with different input conditions, and validation into real-life, can teach us something about critical parameters. Such knowledge can be applied by theatre owners to position the clique and claque, if they want. Apart from its practical usability, what is interesting from a scientific point of view, is the new horizons that it opens up for inquiry. The mutual influence that elements of a system exercise on each other was known in the past of course, but hard to model, and therefore, for better or worse, left out or approximated by some round-about. Traditional theories of complex systems and economics alike have been focusing on equilibria. In the situations that are considered in CAS, systems are most of the time not in equilibrium – systems "in between equilibrium and chaos" as Miller & Page (2007:222) put it – and most attention is given to the feedback cycles themselves, rather than to possible equilibria.

The example of the standing ovation illustrates another particularity of CAS, which is the attention given to "social influence". What makes the model complicated, and more predictive, is the recognition that the standing behavior is at least partially influenced by the behavior of others. The recognition of "social influence" is found in almost all the cases of CAS that I found in the literature, but is hardly made explicit. John Holland, the "father" of CAS, comes close to it in his definition, when he states that "any coherent behavior in the system has to arise from competition and cooperation among the agents themselves", but he does not try to ground this "competition" and "cooperation" in a specific anthropology. I propose to sharpen the definition of CAS in such a way that the social influence, or mimetic force, is made explicit and to talk about *Complex Mimetic Systems*. A Complex Mimetic System is a dynamic network of mimetic agents. In a Complex Mimetic System, agents compete and cooperate because they are mimetic. In a Complex Mimetic System, coherent behavior, if any, arises because of mimesis, competition and cooperation. Before defining mimetic agents in more detail, we first explore a bit the notions of competition and cooperation and how they are intertwined with each other and with mimetic behavior.

Cooperation and competition

The ubiquitous importance of competition in human societies is widely recognized, not the least in modern capitalist countries. Capitalist ideology is very similar to the ideology of Darwinian biology, and capitalism has frequently used biology a rationalization for unrestrained competitive practices. Darwin proposed competition as the major force in the evolution of life, the main energy driving the relationship between individual and group and one group and another. However, CAS and chaos theory (Briggs & Peat, 2006) shifts perspective and allows us to appreciate the fact that biology is also full of "co-evolution" and "cooperation". From the perspective of chaos theory, it is less important to notice how systems are in competition with each other than it is to notice how systems are nested within each other and inextricably linked. Competition alone is a reductionist and limited idea that doesn't begin to appreciate the deep creativity at work in nature.

According to Briggs and Peat, competition has become a mental cliché often used to describe behavior that isn't really competitive, reinforcing our belief that the central fact of life is competition. For example, competition can be fierce in business, but there is also a lot of collaboration, and in fact the basic drive in business is still to serve customers (and other stakeholders). Competition in business does not exclude imitation; it is well-known that innovations in one company are quickly copied by its competitors, if they get the chance. In CAS, competition and cooperation are not either/or ideas, but seen as the two basic facts of social life.

In mimetic theory, competition is the natural consequence of human desire being mimetic (Girard, 1961). In that respect, it deviates from popular science that typically relates competition to scarce resources. However, scarcity is not a natural order. Moreover, even if it occurs, competition is not the only possible response.

The Evolution of Cooperation is the title of a famous 1981 *Science* article and a related 1984 book by political science professor Robert Axelrod. The article and book explore the conditions under which fundamentally selfish agents will spontaneously cooperate. To perform this study, Axelrod developed a variation of prisoner's dilemma (PD), involving repeated PD interactions between two *players* (i.e., strategies written as computer programs) in a computerised tournament. This *iterated prisoner's dilemma* (IPD) format, he found, tends to offer a long-term incentive for cooperation, even though there is a short-term incentive for defection (the opposite of cooperation). Axelrod invited academic colleagues all over the world to devise strategies to compete in an IPD tournament. Interestingly, the simplest system, *Tit for Tat*, won the tournament. This system simply echoed the action of the opponent (so a cooperative move was met with a cooperative, a defecting move with a defecting move); it started with a cooperative move.

Tit-for-tat had a number of important features as a strategy - it was "nice" (it didn't defect first), and it was "provocable" (it fought back if it were attacked). Tit-for-tat never did better than its immediate opponent, but was able to cooperate very well with it self and with other "nice" strategies - thereby harvesting the substantial benefits of mutual cooperation. Ironically, more fierce strategies tended to "cannibalize" each other leading to fewer gains. They also could not take excessive advantage of Tit-for-Tat other than in their initial surprise defection - because Tit-for-Tat retaliated. When Tit-for-tat represented a large enough proportion of the population, other "nice" strategies could also effectively co-habitate. The success of Tit-for-Tat is interesting, as it shows exactly the kind of behavior expected from a mimetic agent (see next section).

Cooperation and imitation

There are real-world examples of IPD-type situations in which there is provision of information about the behavior of others, often with the intent of inducing cooperation by others (Parks, Sanna and Berel, 2001). A good example involves fund-raising by public television stations in the US. A public television station is an example of what is called a public good. Group members must decide whether to contribute to the provision of some entity that will be available to the group at large. The dilemma lies in the fact that the entity can be used by all group members, even those who did not contribute to its

provision. Hence, it is individually rational not to make a contribution because one will then have both the intended contribution and the collective good available for selfish use. However, if all members act in this way, there will be no contributions at all, the good will not be provided, and all will be worse off than if all had made some contribution. Because public television in the US exists largely due to viewer contributions and programming is available to non-contributors as well, it fits the definition of a public good.

Many of the fund-raising tactics used by public television stations assume that, if given the chance, viewers will engage in social comparison with those who have already contributed. For example, many stations take part in the national "viewers like you" campaign. Programs are prefaced with an auditory and visual acknowledgement of the financial contributions of "viewers like you and many stations use testimonials given by individuals who have already contributed money to the station, with the person describing his or her background and what he or she likes about the station. The goal of these campaigns is to convince viewers that they are quite similar to the typical contributor. The assumption seems to be that the viewers will then engage in social comparison and conclude that they too should give money to the station.

Research on connections between social comparison and decision-making processes provide further support for this hypothesis. Individuals often look to similar others for information about an appropriate course of action in a decision-making situation, especially when the situation is a novel one for which no objective standard of behavior exists. For example, a model can influence the choices of a person who is confronted with potential entrapment, a situation in which a person continually invests resources but realizes no positive pay-off from that enterprise (e.g., continual investment of money into a social program that has produced no benefit to society). It was found that participants patterned their choices after a model. If the model chose to continually commit resources to the failing enterprise, so did the participant. If the model ceased to invest, and avoided entrapment, so did the participant.

Cooperation and envy

Whereas cooperative behavior can be diffused by imitation, it can be played down by envy (Parks, Rumble & Posey, 2002). Emotion researchers argue that envy is a very specific emotion that arises when one compares their own outcomes against superior ones received by others and is characterized by feelings of resentment and inferiority, wanting of the better outcomes, pleasure when the envied person suffers a setback, and a sense of injustice over being in a disadvantaged position, even when the disadvantage is purely subjective. A person who exerts the same amount of effort as a comparison individual, yet receives a lesser outcome than that comparison other, will often react negatively, even if that lesser outcome is still objectively quite desirable. Furthermore, negative reactions typically manifest themselves as a reduction of effort, or as an increase in performance of negative behaviors. In discussing the problem of envy, Axelrod suggested that envy arises as the result of an inappropriate standard of comparison being used to evaluate outcomes. He hypothesized that people evaluate their outcomes against those of the opponent because it is the most immediately available and obvious standard to use; but

the appropriate standard should be another person playing against the same opponent but using a different choice strategy. Put another way, Axelrod suggested that one ask the question, "Given the strategy of the other player, could someone else in my situation, using a different choice strategy, be doing better than I am?" (Axelrod, 1984:111-112). Whether this rational advice is useful, will depend on how rational the subject is.

The dynamics of cooperation

For mimetic theory, it is interesting to explore how cooperation can arise and grow, as traditionally its focus has mainly been on competition and rivalry. Reciprocity is a basic social principle (Gouldner, 1960; Anspach, 2002) that has a reinforcing effect ("the appreciation of the value of reciprocity becomes self-reinforcing. Once it gets going, it gets stronger and stronger" – Axelrod, 1984:189). Both imitation and rational calculation play a role here. Axelrod suggests that such a reinforcing process could be triggered by a small "cluster of individuals who rely on reciprocity" (ibid:69). In other words, a small cooperative minority can ultimately have a large impact.

Still, the question is how benevolent cooperation could be sparked off. Although this question in fact deserves a paper of its own, it is possible give a suggestion on the basis of mimetic theory. According to the thesis of Girard, culture is founded on sacrificial violence (see section 4 for more details). In this context, it can be argued that the peace that is created between the group members after the sacrificial violence is perceived as a *gift* resulting of the victim giving his life. Let us call this "an experience of grace" that may set in motion an economy of grace, to use a wording of Dunnill (1995). Given the mimetic nature of the group members, the perceived gift will push them to give as well, to "pass" the gift, where the gift may not only be a material thing but also a service. In this way, social action (acts aimed at a beneficiary) could arise, as a prerequisite for cooperation. Once we realize the potential effect of this experience of grace in the sacrificial scenario, it is easy to see that it need not be confined to this particular case. For example, life received at birth may also be perceived as an experience of grace. Perhaps the only prerequisite for such experience is to live in an "open system".

To build up cooperation is one thing, to sustain it, especially in large groups, is another. There is always the risk of free-riding and defection (perhaps because of envy), and in larger groups, this behavior can easily get away unnoticed or as too costly for the other agents to correct. Therefore, according to Bowles and Gingis (2004), there must be an incentive (or a special institution) to punish defectors, even if the costs exceed short-term benefit. The sacrificial order on which culture is built and by which sanction is legitimized, according to mimetic theory, may provide a solution to this dilemma that seems not solvable in purely economic terms.

3. Mimetic Agents

A Complex Mimetic System is a dynamic network of mimetic agents. How does such an agent look like? As a starting point, we use the following structure of a mimetic agent (Fig.1). The agent collects observations that are stored in Memory as tuples <Actor,

Condition, Action, Recipient>. The Action part not only describes the action itself, but also the objects or participants involved. The level of detail can vary from one observation to the other. The condition describes the context in which the action was done, or that provoked the action. The Actor is the agent instigating the Action, and the Recipient is the agent to which the action is oriented (the one who receives an object, or a blow, kiss or whatever). The set of tuples is called M (memory). For the moment, we do not care about where the observations come from, and they may also stem from other agents by communication.

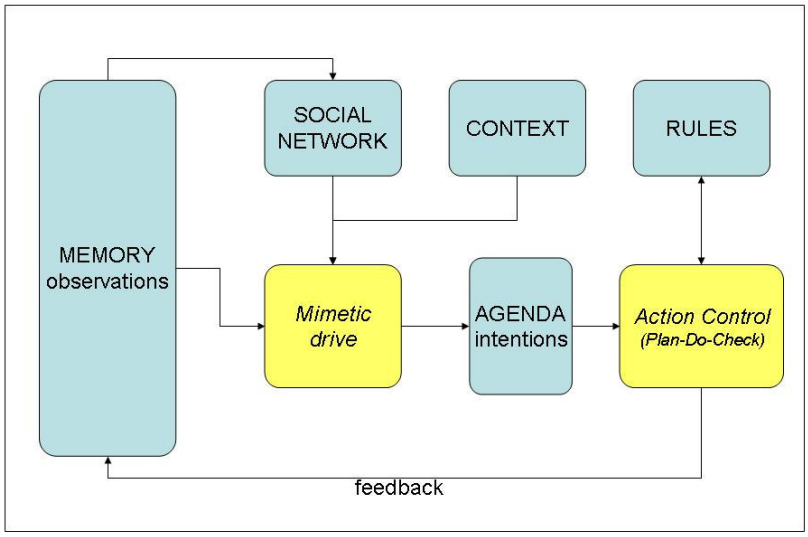

Fig. 1 Architecture of the mimetic agent

Furthermore, the agent has a view on the current situation (Context), and he maintains an overview of the social network. This network consists of tuples <Agent, Proximity, Status,Valuation>. The proximity attribute distinguishes between agents that are considered close (neighbour) and remote (stranger). The status is a derived attribute that summarizes the status of the agent in the network (in the perception of the agent), and Valuation characterizes the attitude of the agent towards the other agent (positive, negative, neutral).

The information choices described so far are used in the motivation component of the agent. For the mimetic agent, the choice of the action is mimetically determined, in the sense that the agent tries to achieve the *best imitation* of the observed actions. In some cases, the choice is easy, for example, if all the observations show people standing up, then the best imitation is to stand up. However, usually there are conflicting drives. If some people stand up and others sit down, then what is the best imitation depends on the numbers of the two groups as well as the status of the respective agents. If observations from the past similar to the current situation point towards a “rise”, whereas the current

observations point towards a "sit down" (nobody rises yet), again the choice depends on the relative weight of these observations. A standard Memory-Based Learning algorithm like originally proposed by Stanfill & Waltz (1986) could do this job very well. The best imitation may necessitate a translation from the reference context to the current context before it can be executed. For example, if in the reference context the model agent gave a tip of $0.25, then imitation in the current situation requires that the subject agent checks his pocket to see what he can give. Translation means that a homomorphism is defined between the reference context and the current context; this is not purely deterministic.

The execution of the action usually requires some practical deliberation (how to say it, what instrument to use etc). To account for that, we assume that the mimetic drive creates an intention only, to be put on the agents' agenda ("what should be done"). The agenda is input for the Action-Control Component that follows an action cycle (PLAN/DO/ CHECK) to realize the intention. Whereas the agenda tells the ACC what he should do, how and when he should do it is supposedly determined by rules. We assume that the rules are learned according to a standard reinforcement learning algorithm (Kaelbling, Littman and Moore, 1996). At this point, the CMS architecture can be similar to e.g. the CLARION cognitive architecture (Sun, 2006). The main difference is made by the mimetic drive, although both architectures agree again on the sub-symbolic character of the motivational subsystem.

When we would use such mimetic agents to model the Standing Ovation problem, the "social influence" is located in the Mimetic Drive and the "threshold rule" in the Action-Control component. The social influence is represented in the memory by the observations of the agent in the current situation that urge him to imitate. Both the nature of the drive (nobody finds out the standing ovation himself; it is always based on having seen others doing it) and its force are determined mimetically by the observations. The threshold is a rule that can evolve over time based on learning.

The network view N keeps track of the social environment of the agent. In simple terms, it is an address book with all the agents that the subject knows about. The attributes are computed by functions to be worked out. Roughly said, the proximity is based on the number of interactions and the status is based on the attention that this agent has received and/or the number of times he has been imitated by others.

Valuation is a measure of rivalry. As noted earlier, competition is something that can grow naturally between mimetic agents. If mimetic agent A does something (take object X let's say) and mimetic agent B observes this, he will be inclined to take X as well. Ipso facto A and B have become competitors. In line with Girard (1961:23) we do not equate the notion of competitor with the notion of rival. Only when the effort of B to take X will be frustrated, because of the resistance of A, this will have a (negative) effect on B's valuation of A: A will be considered a *rival* or *enemy*. The more this happens, the more negative the valuation will become. A fatal process of self-reinforcement starts when both the status of A (the more B imitates him) and the negative valuation of B grow. However, this negative scenario has also a positive counterpart. If mimetic agent does something (give X to B, let's say), and B observes this, he will be inclined to give X to A

as well. The interaction will have a positive effect on B's valuation of A. A will be considered a *partner*. In this way, a positive self-reinforcing process may start.

4. The Culture Reproduction Cycle

If mimetic action is what determines the micro level of Complex Mimetic Systems, what can we say about the macro level? Let us make a strong statement. We submit as basic hypothesis that all the feedback loops that we find in complex systems of social life, ultimately draw on mimetic reinforcement. That does not mean that all these phenomena should be *reduced* to mimetic action. We do not say that feedback cycles between abstract variables, such as network connectivity, level of conflict or social welfare are worthless. Rather, our hypothesis states that the explanation for such processes should be sought in the mimetic actions. Below, we will illustrate this by means of an example.

Although there can be many feedback cycles in a complex system, we further posit on the basis of mimetic theory that there is at least one basic cycle, which we call here the *Culture Reproduction Cycle*. This is the cycle that has been described extensively in the anthropological work of René Girard and that is supposed to underlie all human culture. It is a cycle in which competition leads to increasing rivalry, culminating in a crisis in which the survival of the culture is at stake. However, at that point reconciliation can occur once collective violence has expulsed a single scapegoat. The scapegoat is the "devil" before the expulsion, and the "god" afterwards, as the source of the reconciliation. The new order that arises after the sacrificial crisis aims to prevent mimetic violence to develop, but will after some time fall back into competition and rivalry because of the mimetic nature of mankind. This process can be slowed down by *enacting* the Culture Reproduction Cycle in the form of sacrificial rituals that lead the culture through the steps of crisis, sacrifice and reconciliation in a controlled way.

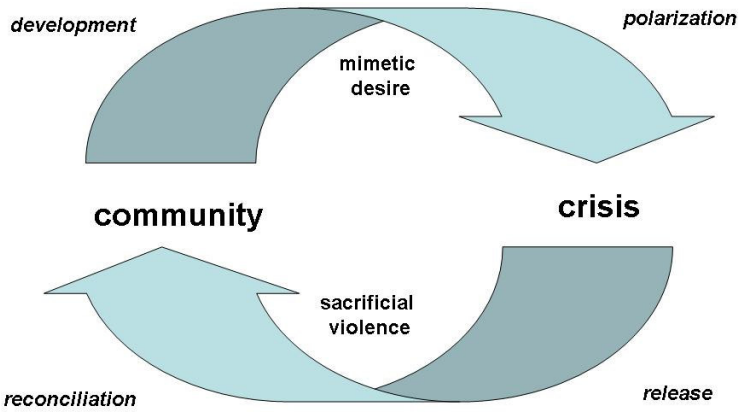

Fig. 2 The Culture Reproduction Cycle

Fig 2 depicts the Culture Reproduction Cycle from a Complex Mimetic Systems perspective. The development phase is a phase in which both competition and cooperation grow, with mimetic desire being the driving force. Ultimately, the rivalry can only escalate into a crisis, but we can roughly distinguish two stages. In the first stage, mimetic desire triggers competition about concrete objects. In the second stage, the desire of the subject shifts to the rival and his position. Girard (1961) uses the term "metaphysical desire" for a desire that basically strives to acquire the Being of the Other and that is characteristic for this phase. It is at this stage that the rivaling subjects easily become *doubles* (indifferentiation). On the social level, this is a stage where positions have been established, but now they get challenged. It is a stage in which coalitions are formed that oppose each other more and more in dualistic terms. Therefore we use the word "polarization" to characterize this stage.

According to mimetic theory, we're not only *acquisitively mimetic* -- that is, we imitate each other in acquiring what we desire; we are also *accusatively mimetic* -- that is, we band together to accuse another. The first kind of mimesis seems to divide us (we fight over desires), while the second seems to unite us and bring peace because we are all unified in desiring to do away with someone else (wording of M. Williams).

Reconciliation is the process that restores the community. Typically, this phase is much shorter than the previous ones. The expulsion of the scapegoat divides this phase into two stages: first the release phase, a process in which all the dispersed oppositions get channeled into a unified opposition against one scapegoat. Secondly, the reconciliation proper in which the community realizes the sacrificial peace it has received and affirms its new status. The community can start over, but not completely blank: the memory of the scapegoat – or the scapegoat himself, in divinized form – ensures a common good and foundation of the moral institutions that only looses its power in the course of time.

Whereas Girard has always emphasized the competition that is inherent in mimetic desire, we would like to stress in our model that both competition and cooperation develop during the development phase. As noted above, it follows from the nature of mimetic agents and the reinforcing effect of reciprocity that cooperative acts get diffused over the community. By virtue of the increase of both competition and cooperation, the development stage is typically a period of economic growth.

The Culture Reproduction Cycle can also be enacted in ritual form during stable periods. Such a ritual could start with antagonistic games (symbolic for the polarization stage), followed by a ceremony in which a sacrifice is made and/or a winner is crowned, followed by a communal party in which everybody is equal and there is abundance for everybody. Malinowski (1941) mentions a few more peaceful forms, such as the public songs of insult, by which the Eskimos even up their differences and express hatred, grievances or hostility. Regulated fights have been recorded among Kiwai Papuans, among Polynesians and among South American Indians. In Central Europe, for a long time a tradition persisted of Sunday afternoon drinking and fighting in which accumulated resentments of the week were evened up.

The Adaptive Cycle (Holling)

The Culture Reproduction Cycle (CRC) can be compared and contrasted with the Adaptive Cycle described by C.S. Holling. Holling started as an ecologist describing biological cycles, but later applied his models to social systems as well. His adaptive cycle is often seen as a progression from Oswald Spengler's notion of cyclical changes and Thomas Kuhn's idea of scientific paradigm shifts. Visually represented, the adaptive cycle looks like a Moebius strip and contains four discrete phases.

R	exploitation phase where the system rapidly initiates its networks
K	conservation phase whereby a system proliferates its networks
Ω (omega)	revolt phase whereby a system reaches its peak of maturity. Networks become over-connected and brittle, non-linear changes such as revolution can occur
A (alpha)	reorganization phase in which the system slowly regains the organization that was lost in the revolt

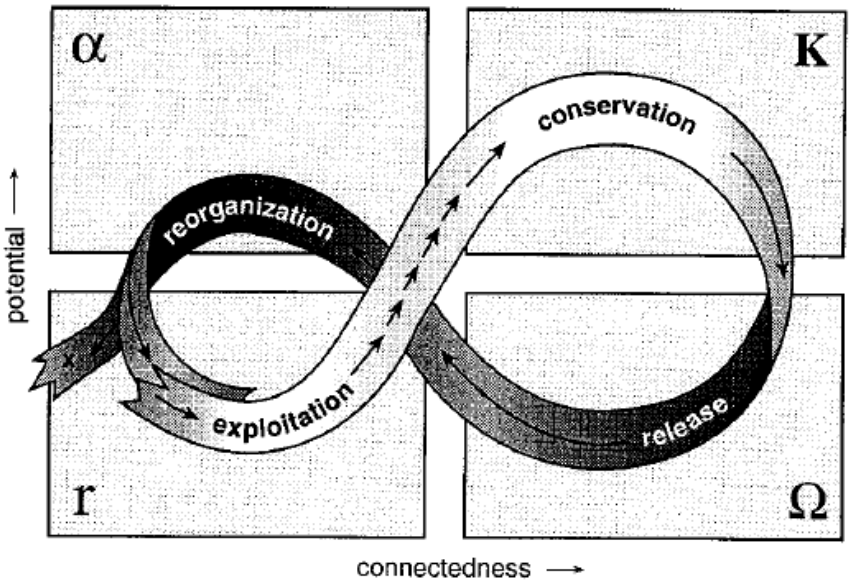

Fig. 3. The Adaptive Cycle of Holling (Holling, 2003)

The Adaptive Cycle (AC) has at least three dimensions: connectivity, potential and resilience. Connectivity increases during and after the exploitation phase, and rapidly decreases during and after the release. *Connectivity* is a measure of the quantity and quality of the connections between the elements in the system, or between different aspects of the system (for example, in a national state system, the intertwinement of government and economy). *Potential* refers to the available resources (for example, in a national state system the infrastructure or available knowledge). The potential is at its top

in the conservation state and at the lowest point in the release phase. *Resilience* stands for the persistence of relationships within a system and is a measure of the ability of the system to absorb changes. (…). The resilience is high in the reorganization and exploitation phase and lowest at the end of the conservation phase (one could say that because of the low resilience, perturbations in the conservation stage are not damped anymore and force the system to move to the release phase). Low resilience is directly correlated with vulnerability.

The AC can be illustrated by the example of the Sovjet Union in the 20th century. After a period of growth, following WW II, (exploitation), the burocratic system was at some point so overdeveloped that it was not able anymore the meet the needs of the population, leading to a legitimization crisis. The crisis leads to a disintegration of the union as well as a collapse of the burocratic system. In the years following the revolution of 1989, a reorganization started, a phase that typically includes experimentation with new combinations of resources and agents.

There are obvious parallels between the AC and the CRC, and it is not too difficult to integrate them, although there are some interesting differences as well. Evidently, the AC release phase Ω corresponds to the release phase in CRC. The difference in perspective is that the CRC emphasizes how the release comes about (polarization against a single scapegoat, by mimetic forces) and AC emphasizes the unavoidability of the transition given the configuration of the system and the effect of the change forces on the configuration. Reorganization corresponds to reconciliation, and exploitation to development. However, where the AC states that the novel system will be build up from the remnants of the old system, the CRC would emphasize the formative influence of the sacrificial violence. In the CRC, a major element in the development and polarization phase is the rivalry between the agents, driven by mimetic desire, whereas in AC the exploitation and conservation are mainly viewed from a network evolution perspective.

Network dynamics

At this point, the recent work of Duncan Watts is highly relevant. Watts (2001) has examined networks and how changes propagate through networks when we assume that the nodes (the actors) influence each other's decisions. His basic parameters are the social influence between actors – proportional to the fraction of the total number of connections of the actor - and the threshold value that determines whether an actor changes or not (note the correspondence of this model with the Mimetic Agent model). The more neighbor actors take a certain standpoint, the more likely the threshold value will be crossed and the actor will take that standpoint as well. Watts calls this "local dependency". The effect of local dependency is that when a certain change is brought about in the system, this may cause a cascade of changes up to a global scale (global cascade). The probability of global cascades is determined by two variables. Firstly, of course the threshold value: the higher this value, the lower chances for cascades. Secondly, the connectivity: if the connectivity is very low, then a change can have a local effect, but is not able to spread out over the network. However, when the connectivity is very high, then cascades are also hard to bring about because of the many connections that each actor has. If, say, just one or two neighbors of the actor change, this has no

effect on the actor as there are so many other neighbors that do not change. A combination of high threshold value and high connectivity means that there are almost no chances for global cascades.

If we apply these insights into the AC cycle, we can see the exploitation phase as a phase in which the connectivity rapidly increases. At some point, the connectivity is so high that global cascades become rare or do not happen anymore at all. This corresponds well with what Holling calls the conservation stage. It is a stage in which not much new happens, the system is "locked in". Although the phase is very stable (not much unrest), the resilience goes down and tensions are built up. Formally, these tensions are visible in the many different standpoints that exist in the system, none of which has so much support that it can cause other agents to change.

The Complex Mimetic System perspective is based on the assumption of mimetic agents at micro level and the Culture Reproduction Cycle at macro level. Evidently, the way we have introduced it here is conceptual and in big need of further formalization. The parallels that we have drawn with Holling's adaptive cycles and network theory can also be explored in much more detail.

5. The dynamics of the European international system

By way of a first validation of the admittedly sketchy CMS model, we consider now a recent study on the dynamics of the European international system. The study is interesting for several reasons. First of all, it claims to confirm a Complex Systems perspective; as such, it would indirectly also provide empirical evidence for CMS. Secondly, it allows assessing the relative value of CRC compared to AC and other possible explanatory frameworks. Last but not least, it raises some interesting questions about the nature of war. We take Pieper's study as vantage point, although it was probably the American political scientist Quincy Wright who was the first to describe the phenomenon of regular cycles in warfare. Since then, a lot has been written on the subject. The reader must keep in mind that the discussion here does not aim to be complete or conclusive.

When we talk about the European international system, we mean a system where the actors are the European nation states. The states compete with each other, on material things like colonies, but also on immaterial things like the splendor of the capital city. States but also cooperate, for example in the form of economic alliances. The system exhibits violence in the form of war.

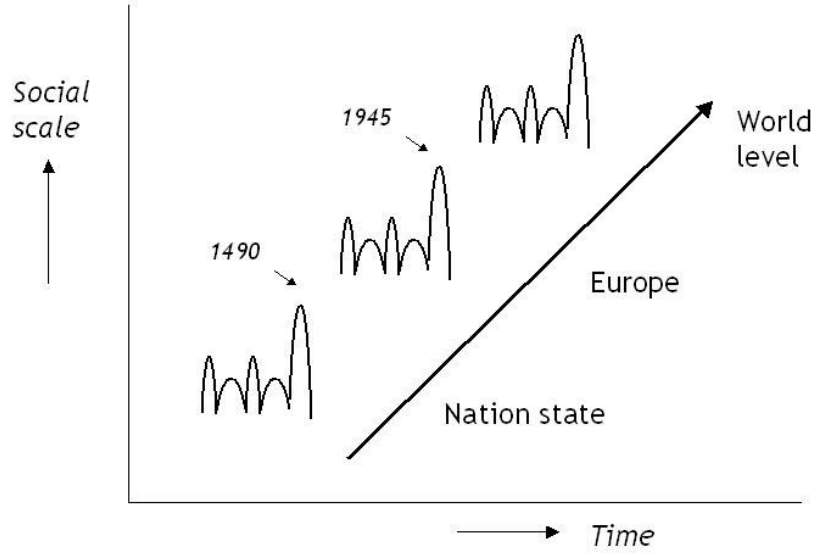

Fig. 4. Schematic development of the European international system, based on Piepers (2006). The peaks denote punctuations (major wars) in a punctuated equilibrium dynamic.

Wars as punctuations

According to Piepers (2006) the development of the international system can be characterized as a "punctuated equilibrium dynamic". This means that relatively long and stable periods, during which the system develops only gradually, are periodically and spontaneously interrupted by punctuations. During these punctuations, more fundamental development of the system takes place, which often leads to a series of qualitatively new systems. Periodically in European history, wars with an exceptional size and intensity have occurred, resulting in a so-called 'systemic' change of the international system. Four of these wars have occurred during the period from 1495 until 1945: the Thirty Years War (1618-1648), the French Revolutionary and Napoleontic Wars (1792-1815), the First World War (1914-1918) and the Second World War (1939-1945). Each time these wars produced 'new' systems, systems which differ quantitatively and qualitatively from the preceding ones. For example, the Napoleonic Wars lead to the period of the "European concert" (Vienna Congress, 1815), WW II to the foundation of the United Nations. The Thirty Years War was ended by the Westphalia treaty that codified the sovereignty of the national state. This dynamic can be typified as a punctuated equilibrium dynamic, in which these wars are the punctuations of this dynamic. From this punctuated equilibrium perspective it is possible to define five international systems and four punctuations (the First and Second World War are form this perspective two separate wars, and not two phases of the same war as some historians argue). On the one hand, these five consecutive international systems and four punctuations have a number of typical -

distinctive - characteristics; on the other hand it is possible to identify a remarkable continuity in the development of some system variables.

Punctuations in the international system require a specific combination of system conditions. The relatively stable periods between punctuations can be defined as the life cycles of the (consecutive) international systems. During these life cycles the average fractions of five consecutive wars - a measure for the size of wars - developed according to a similar pattern: initially (directly after a punctuation) these average war fractions are always small, but then start to increase until a 'local' maximum is reached. Next, - after passing a tipping point - these average war fractions decrease again until a value of almost 'zero'. Then, 'suddenly' these average war fractions increase explosively: the next punctuation is imminent.

Pieper speculates that these fraction patterns are generated by the increase of the connectivity of an international system during its life cycle. In this line of thought, the punctuations in the international system are always preceded by some specific conditions: a very high connectivity of the international system, in combination with a large local stability, a tight coupling of the international system and long correlation lengths. 'Local' incidents are as a result of these characteristics 'enlarged' and affect the total system: shortly before punctuation the international system is in a critical condition and a phase transition is unavoidable. This speculative explanation is clearly based on Watts' theory of network dynamics, but unfortunately, Pieper does not provide supportive empirical evidence.

Besides the identification of the war fraction pattern, Pieper also notes an overall linear *decrease* of the war frequency over time. On the basis of this, he concludes that the European international system has developed towards a condition of increased stability. Over the ages, there is a steady *increase* in connectivity, as has been argued earlier by Holsti (1995). With the far-reaching European integration after WW II, European hegemonic wars are not likely anymore. However, it can be predicted that a war cycle dynamic will develop at the global level, including actors like the USA, China, Russia and EC – just like the European international system dynamics started after the resolution of city state conflicts and the formation of national states in the late 15th century.

Connectivity and mimetic rivalry

Assuming that the data of Piepers are correct, the question is how to interpret them and use them as a causal explanation of large wars. Piepers hypothesizes that the connectivity of the international system is the "driving force" behind the war cycle. That this connectivity increases in the exploitation phase, after the system has recovered from a crisis (war), is to some extent trivial – the point being that the connectivity can hardly go down anymore after the crisis. The growth will be reinforced by the mimetic growth of cooperative behavior. However, our claim on the basis of the CRC is that at a certain point, rivalry will grow to a critical level so that polarization will take off. After that point, the parties get more and more locked in into the positions taken and the reciprocal hostility between the coalitions, resulting in a decrease of the conflict index (average war fraction). Although the low resilience of this system phase may contribute to the tensions

being built up, we think that it cannot explain the tensions themselves. The problem is that Piepers does not make the rivalry between the nations explicit in his model, although he frequently refers to it in his text. If we make the rivalry explicit, then the real "driving force" becomes clear.

Similarly, the focus on the major European wars as far as they are "punctuations" is revealing, but it does not by itself explain why they are realized as wars, involving large-scale violence and bloody sacrifices. From a CRC perspective, the war is an expression of sacrificial violence. It is both the natural result of the polarization and escalation of internal conflicts, and the redemption of these conflicts by bloodshed. We will say a bit more about this below when we discuss the sacrificial nature of war, but notice again the power of the CRC perspective to make underlying dynamics more explicit.

Alternative war cycle theories

Piepers explains the war cycles on the level of the international system without considering the internal dynamics of its subsystems, the nation states. He states that on this level no significant correlations can be found. However, there are alternative explanations that claim the opposite. According to Wright (1965), wars may be scattered more or less randomly scattered throughout history, the incidence of major wars is not. Using Levy's historical data on wars and their death rate over the period 1520-1914, Wright identified clusters of major wars spaced about 50 years apart. To explain this pattern, Wright advanced the idea that war cycles are related to Kondatriev cycles (the Russian economist Kondatriev analyzed long-term price waves and suggested that economies follow a pattern of growth, stagnation and crisis over a period of roughly 50 years). Furthermore, generational cycles may play a role. After a major war, the new generation will be raised with a certain fear for war: the "national will" – already identified by Clausewitz as an important factor – is then low. The "national will" grows when a next generation arrives that has no direct experience of war and tends to romanticize war.

We are not in a position to compare the alternative explanations here, but from a CMS perspective we expect them to be complementary in the sense that for a war to start, *both* the conditions at the international system *and* the conditions within the subsystems must be "favorable". A basic tenet of complex systems is that each system or subsystem is closed in terms of its rationality. How a system responds to external events is dependent on the internal state of the system at that moment (in our words, the phase of its own reproduction cycle).

War as sacrificial violence

Major wars act as punctuations: they do create a new world order. They do this by means of massive bloodshed. According to the "realist" school in political science, the wars are simply needed to break open established power positions that do no reflect political reality anymore. From a mimetic theory point of view, one can wonder whether this position is not mythical in the sense of hiding the victims.

According to Malinowski's anthropological analysis of war, "once armed military operations start in a region, they tend to the formation of the nation-state". This can be attested from the history of the Maori in New Zealand, the pre-Columbian history of Mexico and Peru, as well as the Mediterranean world (Egypt, Babylonia etc.). "Wars of nationalism, as a means of unifying under the same administrative rule and providing with the same military machine the naturally homogeneous cultural group, that is, the nation, have always been a powerful force in evolution and history". However, the effectiveness of the institution does not yet explain its origin.

According to a cross-cultural study by Kelly (2000), *Warless Societies and the Origin of War*, the highest incidence of warlessness is found among unsegmented societies. Segmented societies display a principle Kelly calls social substitutability, which means that the killing of any member of another segment is considered a group offense, and should be avenged by killing any member of the offender's segment. In this way, *raiding* starts as a group vs. group action, and can grow into war as societies grow in scale and complexity. Note that the groups here are not total strangers to each other, but subgroups of the same society, like clans of the same tribe. A recent article on ancient Mexico provides additional archeological evidence to this thesis (Flannery & Marcus, 2006). It appears that in the Valley of Oaxaca, raiding started around 800 BC. In a temple monument dated around 590 BC, a carving has been found that depicts the naked corpse of a captive whose heart has been removed. Between his feet is the Zapotec hieroglyph for his name (this custom seems to be the origin of writing in this region). The stone appears to commemorate the sacrifice of a chiefly rival taken in combat. That a name is given is significant. As Buck (1949:400) wrote about Maori warfare: "No matter how great the casualty list after an engagement, if there were no chiefs killed, there was nothing more to talk about". The theory of Kelly seems to position the preconditions of war in the *polarization* phase of the CRC where groups are formed, or gain in status, as bundles of resentment and objects of social identification (cf. Polletta & Jasper, 2001). At the same time, the example from Oaxaca draws our attention to the sacrificial character of the war: the raiding is not just (or not only) a group revenge action, but the killing of the enemy chief is a sacred act with a sacrificial effect on the community. That is to say, the community of the subsystem, not necessarily the society as whole; again, we see that the system and subsystem perspective are to be distinguished.

A related but slightly different view on the origins of war has been put forward by Marvin and Ingle (1996). In their view, sacrificial death defines national identity, and if war has the same function (cf. Malinowski), this is precisely because war is a form of sacrificial death and religious in nature. The national flag has a visual power and sacred status comparable to totems. They make the radical claim that the primary purpose of war is not to kill the enemy, but the sacrifice of our own. The death of thousands of enemies does not make a lasting contribution to national unity; what counts are the bodies of group members (supposedly "giving" their lives voluntarily). Marvin and Ingle do not claim that these soldiers are *ritual victims* (scapegoats), but that they act as *surrogate victims*. Note that in this view, war is positioned in the sacrificial violence phase. What constitutes the nation in any moment is the memory of the last successful blood sacrifice

that counts for living group members. In the Netherlands this is WW II, whereas in France it is WW I (Verdun).

In our view, the sacrificial character of war, both in its origin and in the present, should be accounted for and we posit that the CRC is able to do that. We also note that the system and subsystem level of analysis must be combined. As far as the scapegoating is concerned, we probably need to expand on the global idea that the scapegoat is both the object of collective hate and violence as well as the sacrifice brought by the community. In some original event, this may have been the case, but in the ritual, the roles can also be divided, like it apparently it was in the ritual of the Day of Atonement (Yom Kippur) where the name "scapegoat" takes its origin (Lev. 16). Here, we find both a goat sent into the desert after having taken symbolically the sins of the people and a goat for the Lord, sacrificed on the altar.

6. Conclusion

In this paper, we have introduced the notion of Complex Mimetic Systems. We have described an agent architecture at the micro level and a Culture Reproduction Cycle at the macro level. We have illustrated how it can be used to analyze social phenomena, like the European wars. Equally interesting would have been the application to organizations and phenomena like reorganization, but we leave this for future research.

The embedding of CMS in the field of Complex Adaptive Systems and network theory also raises interesting questions to mimetic theory. Not much attention has been given yet to the *context* in which mimetic forces operate, and the influence of the structure of this context on the outcome. Revealing the mimetic forces in social systems is useful as these are often left implicit both by the social agents themselves and by the social scientists. However, it is also an important scientific question *how* these forces work. To address this question, there is a plenthora of social science literature to draw upon, as well as many research questions still to be explored. Simulation by means of computational agents is a useful instrument, if properly used in interaction with empirical studies. In most of the current research projects, the agents are not intrinsically mimetic. In this paper, we have aimed to make a next step by adopting mimetic agents right from the start. An important topic for future research is the validation of this approach by means of actual simulation experiments.

References

Mark Anspach, *À Charge de Revanche: Figures Élémentaires de la Réciprocité*, (Paris:Seuil, 2002).

Robert Axelrod, *The Evolution of Cooperation* (Basic Books, 1984).

Samuel Bowles and Herbert Gintis, "The Evolution of Strong Reciprocity: Cooperation in Heterogeneous Populations", *Theoretical Population Biology* 65 (2004): 17-28

John Briggs and F. David Peat, *Seven Life Lessons of Chaos* (Harper Perennial, 2006).

Peter H. Buck, *The Coming of the Maori's* (Whithcombe and Tombs, 1949).

Paul Dumouchel and Jean-Pierre Dupuy, *Colloque de Cérisy: L'Auto-organisation, de la physique au politique* (Paris:Seuil, 1983).

Kent V. Flannery and Joyce Marcus, "The origin of war: New ^{14}C dates from ancient Mexico", *PNAS* 100, no. 20, (2003): 11801-11805.

René Girard*, Mensonge Romantique et Vérité Romanesque*. (Paris: Grasset,1961).

Alvin W. Gouldner, "The Norm of Reciprocity: A Preliminary Statement" *American Sociological Review*. 25, no.2 (1960):161-178

John Holland, *Hidden Order, How Adaptation Builds Complexity* (Perseus Books, 1995).

C.S. Holling, Understanding the Complexity of Economic, Ecological and Social Systems. *Ecosystems* 4 (2001):390-405.

K.J. Holsti, 7th ed. *International Politics, A Framework for Analysis* (Prentice-Hall, 1995).

L.P. Kaelbling, M.L. Littman and A.W. Moore, "Reinforcement Learning: A Survey", *Journal of Artificial Intelligence Research* 4 (1996): 237-285.

R.C. Kelly, *Warless Societies and the Origin of War* (Ann Arbor: Univ. of Michigan Press, 2000)

Bronislaw Malinowski, "An Anthropological Analysis of War". *The American Journal of Sociology,* 46, no. 4 (1941): 521-550.

Carolyn Marvin and David Ingle, "Blood Sacrifice and the Nation: Revisiting Civil Religion", *Journal of the American Academy of Religion* 64, no. 4 (1996).

John H. Miller and S.E. Page, *Complex Adaptive Systems. An introduction to computational models of social life* (Princeton University, 2007).

C. D. Parks, A. C. Rumble and D. C. Posey, "The Effects of Envy on Reciprocation in a Social Dilemma", *Pers Soc Psychol Bull* 28, no.4 (2002): 509 - 520.

C. D. Parks, L. J. Sanna and S. R. Berel, "Actions of Similar Others as Inducements to Cooperate in Social Dilemmas", *Pers Soc Psychol Bull* 27, no.3 (2001): 345 - 354.

Ingo Piepers, Dynamiek en Ontwikkeling van het Internationale Systeem (Ph.D. diss., University of Amsterdam, 2006) (in Dutch). Summarized in I. Piepers, "Dynamics and Development of the International System: A Complexity Science Perspective", Proc. 50th Annual Meeting of the ISSS, 2006.

Francesca Polletta, James Jasper, "Collective Identity and Social Movements", *Annu. Rev. Sociol*. 27 (2001): 283-305.

Ron Sun, ed., *Cognition and Multi-Agent Interaction: From Cognitive Modeling to Social Simulation* (Cambridge University Press, 2006).

C. Stanfill, C. and D. Waltz, "Toward memory-based reasoning", *Communications of the ACM* 29, no.12 (1986):1213-1228.

Duncan J. Watts, "A simple model of global cascades on random networks", *PNAS* 99, no. 9 (2002):5766-5771.

Quincy Wright, *A Study of War* 2nd ed. (Univ of Chicago Press, 1965)

Michael Wooldridge, *An Introduction to MultiAgent Systems* (John Wiley & Sons Ltd, 2002).