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On the Sociometry of Search Engines

A Historical Review of Methods

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This contribution traces the changing history of a method fundamental to all current search engines – measuring the authority of a website through its links, and it discusses the perspectives on society underlying this. I start out with references provided by search engine designers on the historical roots of the technologies they use. Then I follow multiple traces on a search to see how these technologies determine authority. I examine concepts of *social relationships* and how they are transformed into socio-technical forms of communication that today seem natural.

I will refer to three related forms of handling social relations:

1) Ever since the 1930s, a "sociometric revolution"[2] has been advocating group-psychological interventions and the visualization of how they are embedded in social structures as a means of self-realization. To this end, mathematical methods were developed that were designed to assign authority directly based on group behavior, without drawing on any prior scheme of classification.
2) Present-day bibliometric methods for developing and surveying the sciences continue this tradition of thought. External references were eliminated in favor of an allegedly politically independent science, and self-referential models aggregating objective authority were developed – e.g. the *Impact Factor* and the *Science Citation Index* – both of which soon became benchmarks exercising a strong influence on their objects of measurement. As automation and data archiving progressed, such measuring methods turned into behavioral instructions.
3) Search engines incorporate and expose a particular relationship between social relations and authority, although clear qualitative points of reference are missing. As mediators (and notorious data collectors) search engines produce and represent authority themselves and render this self-referentiality visible. However, this strategy is not only found in search engines, it is part of a more general tendency of social optimization.

Some selected examples from the history of sociometry and bibliometrics will be referred to in order to illustrate various forms of visualizing social relations; they will include the seemingly natural imperative of networking and the fantasies

of optimization that spring from it. Social relations, the capital of the network society, are profoundly shaped by informetrics and subjected to the requirement of visibility. The algorithms of a search engine turn normative concepts into controllable, instrumental and communicative action, rendering search engines like Google into instruments of power. Their position as competent mediators in a flood of information allows them to determine the behavior of those who trust in them.

Regulating authority – legitimizing knowledge

Google's success story started at Stanford University, when Sergey Brin and Larry Page wanted to bring "order to the web".[3] Google was going to adopt an approach to hurl the most relevant sites to the top positions different from the search engines dominating the market in 1997. These search engines measured the relevance of search results by the frequency and position of key words on the websites found, while Google began to rate websites automatically on the basis of their link structure. The so-called *PageRank* qualifies a website by the hyperlinks that refer to it. However, these incoming links are not counted evenly, but weighted according to the significance of their source site; consequently, a hyperlink from a website rated as important counts more. The *PageRank* ratings of incoming links are passed on. Each indexed website in the Google archive is given a PageRank rating independently of any search enquiries.

> *PageRank* carries out an objective rating of the importance of websites, considering more than 500 million variables and 2 billion terms. Instead of counting the direct links, PageRank interprets a link provided by site A to site B as a vote cast for site B by site A. Finally, *PageRank* rates the importance of a site based on the votes cast.[4]

This is how Google explains the process. What is referred to as 'votes', without further precision, is dealt with in somewhat more clear terms in a paper by Jon Kleinberg, also known as "rebel king": "Hyperlinks encode a considerable amount of latent human judgment, and we claim that this type of judgment is precisely what is needed to formulate a notion of authority." And more precisely still:

> Specifically, the creation of a link on the www represents a concrete indication of the following type of judgment: the creator of page p, by including a link to page q, has in some measure conferred authority on q. Moreover,

> links afford us the opportunity to find potential authorities purely through the pages that point to them. [5]

In his tracing of mechanisms of order in search results Kleinberg introduces the concept of "hubs and authorities". He developed a method similar to PageRank known as "hypertext-induced topic selection" (HITS). According to Kleinberg, hyperlinks contain a certain amount of a latent human judgment that can be used for rating the importance of a page. Whoever placed a link does so for a reason and decides in favor of this reference.

Just like Page, Brin and others, Kleinberg refers to bibliometric citation analysis as the immediate source of his inspiration. Furthermore, he calls attention to the social science field of sociometry, and in particular to a method developed by Katz in 1953[6] that calculates the status of a social group, further developed in Hubbell's[7] work on identifying cliques. Nearly half a century ago, in other words, there were already methods in place that could be built upon, even though they were rooted in a social science discipline that concerned itself with social networks at this early point and became known in the 1970s as Social Network Analysis.

Visualizing social structures

Social network analysis is concerned with visualizing social structures and some of the results they yield. Its main object of research are (social) relations. Actors such as people, institutions, documents, nations, phone connections, viruses, etc., are interconnected in a wide range of different modes that are subject to mathematical methods of measurement and interpretation. Today, carefully collected data may be visualized and analyzed as a network of relations at the push of a button. The techniques of social network analysis have long left the realms of science behind and settled in commerce-oriented sociology, while academic sociologists seem to cast envious looks at the enormous data sets routinely gathered by businesses over the years.[8] While studies of network analysis were extremely time-consuming and costly undertakings in the early years, the computing capacity and the amount of data available today mean that they often outrun conventional polling and social statistics in many regards. The likely behavior of the basic population does not need to be inferred and forecast through sampling. The observing institutions archive each individual transaction, which allows them to map and rate likely behavior. Data is exchanged with partner institutions within so-called data consortia,[9] and in combination with data

provided by public administration units such as statistical and census offices, geo-demographical databases are established in many places.[10] While these kinds of systems were previously the reserve of utopian concepts of society, they are realities today, allowing precise and exemplary insights into social reality. Ironically, opinion research and control can now be carried out in all orders of magnitude, while one of the original ideas of the analysis of social structures was to counter ubiquitous "scopic regimes".[11]

Methodologies for studying social structures were developed within a predominantly relational style of thought in the early 20th century. Einstein recommended reading Pearson's *The Grammar of Science,*[12] and mathematics produced set theory, topology and game theory. In parallel to the growth of state power, an optimistic vision had gained ground, according to which "a rationality based on mathematics and empirical observation will lead to objectivity and hence to a transparency that will apply to both description and decisions".[13] Mathematical survey methods and statistical methods in turn gave rise to fields such as biometrics and econometrics. Expanding infrastructures such as telegraph wires and phone and transit networks enjoyed great popularity, undermining notions of the state as the centralized unit and of society as a community.

After leading social theorists had directly addressed social structures in the late 19th century, Simmel described the mission of a "pure" sociology at the beginning of the 20th century as follows: pure sociology was meant to

> extract the moment of socialization from the phenomena, separated inductively and psychologically from their contents and purposes which for themselves are nothing social, like grammar separates the pure forms of language from the contents that give live to these forms.[14]

He focused on the interactions between individuals and a society, and on the social dynamics and structures evolving from it. Simmel preferred researching "social forms" and "forms of socialization", i.e. networks of relationships in many different contexts, over research on the content of social realities, which to him belonged to a different kind of social sciences.[15] To him, the triad, the "social triangle" was the most important organizational form in analyzing social interactions:

> The number two represented the first synthesis and unification, but also the first divorce and anti-thesis; the emergence of the third meant transition, reconciliation, overcoming absolute opposition – although occasionally also the creation of such an opposition.[16]

In Simmel's view, the triad also represented the smallest social group and was therefore meant to be the basic analytical unit in sociology.

Sociometry and network metaphors

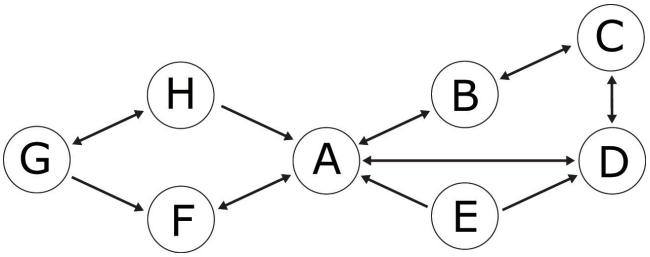
> Before the advent of sociometry no one knew what the interpersonal structure of a group "precisely" looked like.[17]

The representatives of structural approaches in social psychology, sociology and anthropology in the 1930s and 1940s, as well as their successors in the field of social network analysis, repeatedly referred to Simmel. Jakob Levi Moreno was already investigating the relationship between psychological wellbeing and the given social configurations at the beginning of the 20th century. In 1916 he submitted a proposal to the Interior Ministry of the Austro-Hungarian monarchy that would have amounted to a socio-psychological intervention based on the measuring of social relations in a group of refugees, but the proposal was dismissed. When Moreno emigrated from Vienna to New York in 1925, his objective was to further develop his socio-psychological methods of group therapy, such as role games (socio-drama) and impromptu theatre. From this point on, he called his method "sociometry" and connected it to a political goal: the "sociometrical revolution"[18] was meant to bring about equal rights among human beings. Taking part themselves in "sociometric experiments", clients and experts were able to reconfigure their situation and their structural embedding and to recreate social order according to their own perspective. Unlike statistics and survey sociology, this method was not intended to bring any pre-fabricated categories into data acquisition; instead, such categories were supposed to emerge and become visible from the observed social structures themselves.

Sociometrists continuously worked on new techniques of measurement and representation. Observation, interviews and role plays were used to learn about attraction and repulsion experienced by individuals, and social choice was displayed in matrices. In this way, following an analysis of the group and its relationship types, social cohesion could also be measured. Sociograms were introduced as important methodological tools, allowing graphic representations of group structures and relationship patterns among individuals. Dots or symbols represented individuals, while lines represented connections among individuals. The resulting visualization had the purpose of allowing social structures to be handled and reconfigured. By visualizing the embedding of the actors and

thereby rendering it evident, these actors could be brought to take charge of their own social position and initiate changes or optimize order.

It was the sociogram that first allowed the experimental study and "precise exploration" of complex relationships, since that time considered as "social networks" and "places of origin of public opinion".[19] The social mapping applied in this way allowed the discovery of the so-called "sociodynamic law", the predominant choices in a group, and also the development of patterns and forms such as the "star", which would certainly be called "hub" today.



The sociogram displays a simple network based on choices of actors A – H. Actor A is called "star", because more than 4 people chose A, who holds a central position in the network. The matrix represents the same dataset.

	A	B	C	D	E	F	G	H
A	0	1	0	1	1	1	0	1
B	1	0	1	0	0	0	0	0
C	0	1	0	1	0	0	0	0
D	1	0	1	0	1	0	0	0
E	0	0	0	0	0	0	0	0
F	1	0	0	0	0	0	1	0
G	0	0	0	0	0	0	0	1
H	0	0	0	0	0	0	1	0

Mathematical networks or graphs

In the early years, the sociometrists created their sociograms manually and in an ad-hoc fashion, giving rise to widespread criticism for lack of the methodological stringency appropriate to science. In the 1940s, this continuing criticism of the intuitive sociogram led to priority being given to data displayed in matrices. The resulting standardization of data on social interaction was meant to allow a more objective handling of the data.[20] Representing data on social relations in the form of matrices promoted the mathematization of sociometry.[21] For the first time it was possible to identify sub-groups with mathematical means, and to calculate the status of a person, as well as his/her prestige within a social network, all on the basis of the measured social relations. In the 1950s and 1960s this form of notation led to the first emergence of topological and graph-theoretical approaches in sociometry. As a consequence, it was possible to topographically represent social space in the form of its relationships.

The first methods of electronically computing sociometric data paved the way to graph-theoretical sociometry. This was made possible by social matrices, while for the time being sociograms lost in importance. The advocates of sociograms[22] criticized that matrix notation made it difficult to see social patterns such as triangles, stars, and chains, and they demanded a mathematical method that would allow such techniques of visualization to be applied to matrices and result lists.

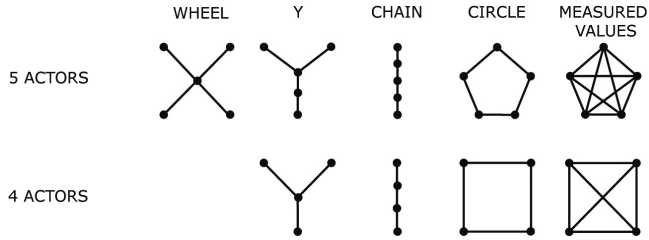
The formal processing of network data allowed the operationalization of weighted and rated connections, and, above all, the analysis of a group's structure from the point of view of each individual group member.[23] This approach was of interest to the emerging theory of group dynamics, allowing it to model group cohesion, social pressure, cooperation and relationships of dominance. However, the application of these kinds of algorithms was slow and cumbersome. Computers were virtually non-existent, and in the rare instances where they were available, the production of punch cards consumed a large amount of resources. Consequently, drafting a sociogram and computing a small network would require a lot of time,[24] if one wanted to detect particular structural patterns or test existing concepts such as "isolates", "cliques",[25] "density" and "centrality".[26]

Measuring centrality and diffusion

Centrality is one of the most widely known concepts of network analysis. Building on the topological psychology of Kurt Lewin, it was developed by the Bave-

las group in psychological laboratory experiments at the MIT and applied to structures of communication.[27] The experiment consisted of five students sitting at a round table, separated from one another by screens. They were asked to jointly solve a problem, but allowed only written communications. The information comprised six symbols. Each participant had a card with five symbols, with a different one missing on each card. Through cooperation, the students were supposed to find their missing sixth symbol. At the sound of a signal, the color-coded communications could be exchanged. Following the experiment, the participants completed questionnaires on how they rated their performance and their emotional state. Frequently, the participants were purposely interrupted by interventions by the directors of the experiment, and communication channels were cut. This strongly simplified communication setting was supposed to yield data on diffusion and authority in purpose-oriented group behavior.

The study concluded that in efficient communication networks there was always one person who became the central passage point, collecting information and therefore moved into a position of power. Consequently, the flow of information in de-centralized networks was inefficient. This and similar studies were furnished with graphs that were meant to show the ideal-type patterns of communication: circle, chain, Y and wheel (X). Subsequently, these patterns could also be applied to measured values.



The network models most frequently used in communication studies.[28]

A central actor has many social relations, although what is decisive in terms of his/her position of power are social status and authority.[29] Control over scarce resources only manifests in the direction of the relations. If additionally a high-prestige actor positions him/herself between disconnected groups, he/she occupies a key position in the network. Calculations of centrality and social status entail a range of different formal methods to rank the nodes of a network.

Another variation of the idea of social positions and communication pathways is Stanley Milgram's well-known and much criticized "small world" experiment.[30] In an attempt to identify patterns of diffusion, participants were asked to send a package to its final destination as quickly as possible by passing it on through acquaintances. Counting the number of stops, Milgram coined the idea of "six degrees of separation", extrapolating the results of this study and subsequent ones to the US population.

As collaboration with statisticians and communication researchers increased and computers were more frequently used, the focus of social science network research shifted to the modes in which information is disseminated in society. Social groups and networks were analyzed in terms of their permeability, their social gravitation, and their different logics. In 1957 Coleman, Katz and Wenzel published a seminal paper[31] on the communication patterns that resulted in the introduction of a new pharmaceutical. The authors conducted interviews with physicians, enquiring about their professional and private contacts in relation to the introduction of the medicine. They were asked to indicate the names of three doctors with whom they were friends and with whom they consulted. This study focussed not so much on the content of the communications, but rather on the ways the communication took place and with whom, until the innovation was finally introduced. The study showed that the physicians were strongly influenced by their direct informal and professional environment: the readiness to accept the new medicine increased with the degree of the physician's networking.

Further studies[32] on cliques, elites and social movements were focused on identifying nodes of opinion formation. These studies were no longer concerned with the original demands to apply sociometry only in agreement with the clients. The progressive mathematization and the concomitant standardization not only equipped empirical observation and interviews with instruments, but also allowed it to structurally picture complex subjects by filtering documents by names and terms. The social relations of subjects, their social ties and social choices could now be determined from data collections and texts by identifying specific types of relationships. Increasingly, the analysis of social structures turned into data mining, opening interesting options to an audience located beyond the realms of the social science research community. Next to typical

sociometric studies, socio-psychological interventions or anthropological investigations of rural or small-town communities, rules of marriage, social interactions in the workplace, and social conflicts, there emerged countless studies on communication behavior, opinion formation, productivity, as well as social innovation and optimization, all of them drawing on the graph-theoretical models of sociometry and social psychology.

Informetric optimization

On the other hand, socio-technical networks were the subject of both operations research and cybernetics. Flow graphs for process control and also network maps were constructed as topological graphs, suggesting analogies between the measuring of social groups and electronic networks.[33] While military logistics and the automatization of weapon systems were the initial basis of cybernetics, cybernetic theories of automatization and control of complex machine systems soon developed into a science of control and communication and the regulation and optimization of information resources.[34] Information was elevated to the constitutive principle of a progressive, telematic society and immediately became the measure of probability of social as well as machine processes. The goal of cybernetic social management was the minimization of insecurities and, consequently, the informatization of society. In this kind of vision of society, social relations are transformed into communication links. Communication behavior and information diffusion are modeled as epistemic units, while the focus is shifted away from the content towards socio-technological patterns of diffusion. The latter were also used in attempts to answer the question of knowledge and its authorization: "Who decides what knowledge is, and who knows what needs to be decided upon?"[35] The socio-informetric answer to that question might be: "This follows from successful transmission."

Recognition by reference

From the 1930s on, Robert Merton and his sociology of science sought to define the conditions for a scientific method that would be independent from politics. His studies[36] showed that the legitimization of knowledge is subject to historical transformations, that it involves specific social processes of negotiation and strategies, and that it establishes itself within social relations. Merton was convinced that the scientific system itself should be the highest authority for the knowledge

produced in it. In his view, research results were common property subject to examination by peer review and to the possibility of reproducibility and criticism. Scientific research was supposed to be assessed independently of the scientist and of his/her social attributes. One of the methods that allowed this kind of assessment was bibliometry.

As a statistical examination of publication behavior and libraries, bibliometry has a long-standing tradition. Citation analysis, one specific field of bibliometry, originally used relatively simple statistical methods and indexing systems to produce one-glance visualizations of various fields of knowledge. As early as in the 16th century, passages of the Bible were marked and filtered by means of citation indexes.[37] And as early as 1926, Lotka calculated and interpreted scientific productivity in physics and chemistry by analyzing publication behavior.[38]

In the 1940s, Eugene Garfield, the founder of the Science Citation Index, was inspired by the law citation index "Shepard's" to apply a similar system to other fields of knowledge. Starting in 1873, Shepard's had collected court rulings and references to precedents in the form of a citation catalogue. This system operated with a time-based concept of authority, with the most recent ruling being the most relevant. Garfield understood the potential that such a tool could have for the vast and previously unmeasurable field of technological patents and scientific publications:

> The amazing efficiency of the citation method is such that once the starting case or statute is found, it becomes a key that unlocks the entire store of law on a given point. It is this function which it appears would be of great value in other fields. An article on any scientific subject would be the key to all others.[39]

In this way, one single scientific document could provide an entry point to the entire scientific landscape. Garfield liked to refer to himself as an "information engineer", and from the very beginning conceived of the SCI both as a tool of analysis and an instrument of evaluation like a "hyper search engine". "That's why I call it 'hypersearch'. I've said that the SCI is the ultimate hypersearch product. I think Ted Nelson is credited with the notion of hypertext, but I doubt that he knew the SCI even existed."[40] Garfield dreamed of a unified science, and consequently wanted his scientific index to cover all the disciplines. Unlike Shepard's, which depended on the expert knowledge of editors, his index was meant to generate itself on the basis of scientific journals. The peer reviews practiced by these would ensure the scientific quality of the index. The Science Citation Index does not measure and assess the contents of the cited works, but only the points

of reference and thus their reputation. In as much as this is the case, the SCI produces a socio-structural model of publication behavior, turning the footnote into the most important source of information.

After the first version of the citation database was implemented using funds provided by the US National Institute of Health, an SCI for the year 1961 was extracted as early as 1963. At the same time, a patent index registering all the US patents of a particular year was set up. In 1965, the database comprised 1057 journals, nearly 50,000 patents, and more than 2 million "registered access points to the world's science and technology literature"[41], all of which were available as punch cards allowing automated processing. Thanks to automatization and the restriction of citations to their referring function, the index could be analyzed statistically. If the number of citations made within a particular year to articles published within the two preceding years is divided by the number of articles of these two years, one arrives at a number that soon was to enter the history of science, the "impact factor".

The SCI was "mainly developed in order to solve problems of information retrieval. Later additional applications were found that are of significance to historians, sociologists, administrators, etc."[42] Sociologists of science, network researchers and communication researchers frequently met with Garfield and ISI staff. The subjects discussed at these meetings went beyond the social context of knowledge production and the diffusion of innovation, often focusing on specific possibilities of assessing scientific knowledge. The SCI's impact factor represented such a possibility and today has a decisive influence on scientific career patterns. The impact factor operationalizes an evaluated social relationship, for setting a reference is equivalent to an acknowledgement of expertise.

However, at that time the impact factor was only one among several possible forms of analysis. Garfield thought up additional ways of exploring the available data:

> It is reasonable to assume that if I cite a paper that I would probably be interested in those papers which subsequently cite it as well as my own paper. Indeed, I have observed on several occasions that people preferred to cite the articles I had cited rather than cite me! It would seem to me that this is the basis for the building up of the "logical network" for the citation index service. [43]

Garfield soon found out that there was not only an interest in getting access to relevant scientific publications, but also in others' publication behavior and in the control of intellectual property. In the future, he was sure, scientists would

have better possibilities of bibliographical control – and of tackling information overflow, which at the time was dramatized[44] as a crisis by many, including public institutions.

In fact, the interest in SCI data constantly increased. Citation analysis was applied as a method to historical documents, monographs, and networks of correspondence. Studies on "invisible colleges"[45] clarified a wide range of different modes of knowledge production independent from any supposed unified metanarrative. Differing from the ideal of a cumulative growth, knowledge actually combined in loosely connected configurations. Analyses of "bibliographic coupling"[46] and co-citation[47] yielded more information on the diffusion of scientific literature. Co-cited documents appeared together in a list of references of a third document, allowing for them to be counted, while bibliographic coupling only determined which works referred to the same source.

Derek de Solla Price was interested in the life cycle of a scholarly paper. "More work is urgently needed on the problem of determining whether there is a probability that the more a paper is cited the more likely it is to be cited thereafter."[48] Subsequent analyses of citations confirmed his hypothesis, according to which "the rich get richer". Price's model of a citation network consists in directional relationships and is acyclical, as only texts that already exist can be referenced. In today's terminology, such a network would be called a scale-free network, for it essentially comprises a large number of nodes with a low status, little prestige, etc., and only a few high-ranking nodes. There is a significantly greater likelihood of references being made to works that are already popular.[49] Thus, the number of references, referred to as "edges" in graph theory, generates visibility and recognition.

Merton, an advocate of a structural perspective in sociology, articulated his thesis of the "Matthew Effect"[50] on the basis of the work of Harriet Zuckerman. Within the recognition system of the scientific community, this effect means that "renowned scientists receive a disproportionate amount of recognition for their contributions, while recognition is withheld from junior scientists who have not yet established a name".[51] Merton identified citations as the "routine form" of perception in science. In addition to opening access to "borrowed" knowledge, citations act as an institution of recognition embedded in science's system of norms and rewards,[52] and in turn feed back into the system.

The SCI soon turned into a key global actor in science. The referencing of scholarly literature thus became the measurement of its reach and importance, and subsequently the indicator for evaluating scientific productivity. Consequently, citation analysis also became a tool for disciplining scientific actors. A scientific career is measured, amongst others, by the impact factors of the

publications produced. Thus, epistemic citations become objectified in so far as the citing actors have come to recognize them as social capital, leading to consequences that in the long run might undermine citation analysis itself. Strategic citations, self-citations, and the so-called citation cartels, where a group of scientists continuously refer to one another, are reminiscent of search machine optimization designed to give websites greater visibility in the search results. Currently, academic search engines not only make the publications of large and dominating publishers searchable, they also list freely accessible academic publications. As the trend in scientific citation is clearly towards freely available content[53], publishers, and along with them the standard SCI and its impact factor, might become obsolete.

Networks, optimization, and control

The citation, objectifying a certain type of social relationship in science, became the guiding concept for the ordering algorithms used by current Internet search engines. The bibliometric reference provided the blueprint for the way in which hyperlinks are assigned relevance and ranked on the results pages. While early bibliometry defined a vote as a social choice to be identified within the given social embedding and involving those who choose, sociometrically informed communication research operationalized social relationships with a view to the instrumental diffusion of information. References in scientific publications in turn drove the logic of recognition within the referencing system, providing the basis for "authoritative judgement"[54] in search engine technology. Citation analysis only turned into what we understand it to be today by being assigned the explicit purpose of a tool of assessment. Its methodological authority stems from the field of science itself and is based on the norms and values that apply there.

Ranking algorithms reduce social relations to a specific dimension of communication – the placing of a reference. As communicative relationships hyperlinks connect information. Moreover, the direction taken by this connection indicates authority in the form of prestige or social status. However, in times when optimization, mash-ups and automatic feeds are common, such a concept of authority becomes questionable. Automated collective identities produce Matthew Effects, preferential attachments, etc., and one longs for the editorial teams of the Shepard's index, where each reference was exposed to a qualitative examination.

Yet the ineluctable guiding metaphors of the network, "modern capitalism's current from of socialization" obscure any perspectives beyond the "networking's

claim to absoluteness".[55] "Get networked!" is not only a technological slogan, it is also directed at people's professional and private lives, requesting individuals to establish potentially beneficial contacts, to interact on social networking platforms or events, to behave flexibly in the labor market, and to locate responsibilities within the processes of the network. Individuals who are already well networked are subjected to the paradigm of optimization and challenged to improve their position both in the temporal sense and in terms of their social capital.

Today, visible networking is meant to ensure autonomy and individual responsibility as well as testimony and authority, but never social security.[56] An "audit society"[57] both incorporates and decentralizes its techniques of control and therefore remains obscure. The SCI Journal Impact Factor is an example of the systematic assumption that somewhere in the chain of relationships – in this case of references – a collective quality control has taken place. Internet search engines make use of the same kind of leap of faith, and although authorities become diffuse in an automated, networked system, they are "obligatory passage points".[58] They collect data and interpret search profiles seemingly for the purpose of optimization, but mostly for target oriented advertising. Studies such as one on understanding the spread of a flu epidemic based on search enquiries[59] are designed to ensure customers their "digital groundedness"[60], securing their trust by showing openness, transparency, and a willingness to serve society.

The sociometric art of measurement and its socio-grammatical forms of representation allow it to display search results as node-edge diagrams, to examine friendships in terms of their other friendships (friend of a friend, FOAF), to bring professional contacts a few handshakes' distance closer to one's own position, or to identify the alleged head of a terrorist group in a diagram. In a network, every relationship counts, and the "panoptic diagram"[61] allows for them to be handled. Thus, authority no longer rests in the relationships and instead migrates towards the measuring instrument and its forms of visualization. Whether the results are displayed as list, matrix, or diagram – once they appear, they both represent and establish relationships whose social content was subjected to informetrization. Search engines and their politics of visualization, then, should be understood as instruments of spectacularization and as part of a sociometric management of society. As the case of citation cartels shows, the latter is inevitably accompanied by possibilities of manipulation.

Today, the sociometric revolution is understood as network-oriented optimization: search engine optimizers construct authorities around their customers' websites in order for these to appear among the top results; search engines optimize the diffusion of their advertising customers and investigate the world of

information seekers through their profiles; epidemiological studies on the spread of pathogens resemble studies on intersected financial markets not only formally, but also in terms of their appearance and rhetoric; the flexibilization of production processes, the shortening of product life cycles and the (claimed) individualization of goods result from the adaptation of mass markets to the network logic of process optimization; researchers of network economics teach structural blocking strategies against competing businesses;[62] defense departments and other executive organs around the world sponsor network research, hoping to benefit from improvements in logistics and key player analysis brought by network-centric warfare.

Locating central positions – key players – in a network in order to monitor them, act against them, circumnavigate or even eliminate them – these are interests the military and business worlds share with scientists seeking to identify the works that will allow innovative insights, to enhance their position in the scientific system, or to intervene in the field of research. Epidemiologists, financial service providers, marketing strategists, insurance representatives and election campaign consultants are also interested in key players and pursue their own strategies of network optimization. Could it be that such optimization strategies will act as cybernetic feedback cycles facilitating the systems' self-regulation, or is it more likely that they manifest the absurdity of certain systems of analysis? For the present, it seems clear that they lead to a sociometric subjectivization of actors who now understand themselves as nodes and seek to optimize their social relations.

Notes

1 This article is based on research carried out for other publications, including my PhD thesis on network visualization in social network analysis (Mayer, K. forthcoming. *Imag(in)ing Networks*. Doctoral Thesis, University of Vienna, Department of Social Studies of Science), and an article (Mayer, K. 2007. "Who shall survive? Die Netzwerke des Jakob L. Moreno"; in: Bredekamp, H., Werner G., (Eds.), 2007, *Bildwelten des Wissens. Systemische Räume*. Berlin, Akademie Verlag). I wish to express my thanks to Konrad Becker, Gerhard Dirmoser, Arno Böhler, Ulrike Felt, Lin Freeman, Thomas König, Astrid Mager, Patrick Pulsinger, Theo Röhle, Felix Stalder, Wolfgang Sützl and the contributors to the SOCnet mailing list for their valuable insights and suggestions.

2 Moreno, J.L. 1967. *Die Grundlagen der Soziometrie*. Köln u. Opladen: Westdeutscher Verlag.

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