The *Social Systems Citation Theory* (*SSCT*): A proposal to use the social systems theory for conceptualizing publications and their citation links

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Abstract

The normative theory of citing considers citations as rewarding tools to acknowledge the influence of scientific works, while the social constructivist theory of citing considers citations, for example, as persuasion tools used by authors to support their claims, and convince the scientific community that those claims are valid. Other citation theories and models have been proposed in recent years to overcome the limitations of the normative and social constructivist theories. Nevertheless, they have not been able to fully explain all citation motives of scientists (but have a certain focus). This study proposes a new theory (which we call "social systems citation theory", SSCT) that integrates previous theories and models on publications and their citation links and is mainly based on Niklas Luhmann's "social systems theory". Luhmann's social systems theory focuses on "communications" as the basic constituting elements of a social science system and not on humans and their motives. Humans are not part of social systems but are connected with them and irritate them. Thus, the social systems theory does not have the problem of integrating various and different motives of humans to cite in the science system. In the SSCT, authors' motives to cite belong to psychic systems while publications and their citation links belong to the social science system. The systems operate autonomously but interact with each other: the social system operates recursively with publications and citation links. Although psychic systems stimulate or irritate the science system, they do not determine communications in the science system. In this study, we explain the SSCT and demonstrate how the theory can be used to underlie empirical bibliometric studies.

Keywords

Autopoiesis; Communication; Niklas Luhmann; Publications; Citations; Citation theory; Social systems citation theory (SSCT).

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1. Introduction

Since the 1960s, with the introduction of the *Science Citation Index* by Eugene Garfield, citation analyses have increasingly become an (important) method in science of science studies. Researchers who used the data for the measurement of science also started to think about a possible theory of citation (**Leydesdorff**, 1998). The relationship between citation counts and the quality of scientific contributions has been a central question in studying scholars citing behaviour and developing possible citation theories (**Bornmann**; **Haunschild**, 2017). Two theories that can be denoted as traditional citation theories were proposed very early in this process of thinking about theorizing of citations. These two traditional citation theories in bibliometrics are the "normative" theory and "social constructivist" theory.

The normative theory, proposed by Robert K. Merton in the 1940s, focuses on the quality and influence of scientific works, proposing that citations are given based on scientific merit and reflect the impact of cited works on citing works. In the normative theory, citations are rewarding tools to acknowledge and credit the cited work for its influence on and contribution to the citing work (**Van-Raan**, 1998).

The social constructivist theory on citations can be traced back to **Berger** and **Luckmann** (1966) who proposed that social contexts define a specific stock of knowledge which predefines reality (see here **Dahler-Larsen**, 2012). The social constructivist citation theory focuses on social factors (strategic and rhetorical reasons) rather than the quality and contribution of the scientific work: citing is fundamentally a social process (**Aksnes**; **Langfeldt**; **Wouters**, 2019). According to this theory, for example, citations serve as persuasion means. In searching certain papers for citing, authors look for evidence to support their scientific claims to convince the scientific community that those claims are valid. Nigel Gilbert, a British sociologist, was one of the pioneer researchers who, in the 1970s, noted that citing is a form of persuasion (**Mcinnis**; **Symes**, 1988).

Evaluative bibliometrics aims to evaluate and rank papers, journals, scholars, institutions, and countries. **Moed** (2009) describes evaluative bibliometrics as a discipline that constructs and develops quantitative indicators for evaluating the performance of research. **Moed** (2009) explains that one of the main methodologies used in evaluative bibliometrics is citation analysis that investigates the impact, influence, or quality of scholarly works. The main assumption of evaluative bibliometrics is that authors only cite the scientific works that have cognitively influenced them (**Bornmann**; **Haunschild**, 2017). If the assumptions of the normative theory are valid, citation analysis can be used to identify the usefulness of scientific works for scholars. However, the validity of citation analysis for measuring scientific impact is challenged by scholars who support the social constructivist view that states authors have various citation motives which are independent of the usefulness and quality of the cited work (**Liu**, 1993b). For example, in the constructivist view, citations may be influenced by citing authors' mental states and emotions (**Riviera**, 2013). Thus, evaluative bibliometrics should be used with caution (or not at all) due to its limitations. The complex nature of citation motives and citation decision processes have been explained in detail by some previous studies; an overview of these studies can be found in **Tahamtan** and **Bornmann** (2018a).

Most empirical studies in evaluative bibliometrics have relied upon the normative and social constructivist theories to explain citation motives and decisions. Since both theories are basically contradictory and have specific limitations, some researchers have attempted to propose other theories and models of citations (that integrates both perspectives on citations). For example, **Nicolaisen** (2007) proposed that citing is an honest activity because authors tend to avoid peer criticism for dishonest citing.

Regardless of all the attempts made in this area, previous theories and models have not yet been able to provide a comprehensive theoretical framework. Therefore, the current study aims to introduce a theory on publications and their citation links that is based on the "social systems theory" of Niklas **Luhmann** (2012a; 2012b), a German sociologist mainly active in the 20th century. The new social systems citation theory (SSCT) integrates previous citation theories and does not have their limitations. What makes the social systems theory suitable for developing a citation theory is that it focusses on "communications" and not on humans and their motives as the basic constituting elements of a social system. With this focus, the SSCT does not have the problem of integrating various and very different citation motives of authors. In the SSCT, publications and citations can be seen as elements in the (formal) science communication network that can be observed and empirically studied independently from the publishing and citing authors (who are as psychic systems in the environment of the social science system).

2. Traditional theories on citations

Section 2 explains the citation theories proposed in the past. This section explains, first, the dominant normative and social constructivist theories on citations. Then, some other citation theories and models are described that have attempted to overcome the limitations of the normative and social constructivist citation theories.

2.1. Normative theory (on citations)

In sociology, normative refers to "norms" or "shared values" that specify what is right and desirable and what is wrong or undesirable. The norms or values encourage the desirable activities that ought to occur. The norms of science were defined by **Merton** (1968b), and include communism, universalism, disinterestedness, and organized skepticism. The four norms constitute the ethos of science.

- Communism refers to the fact that scientists know that their works depend on their predecessors and therefore scientific findings are the product of social collaborations between scientists working on similar topics (**Merton**, 1973). By citing the works of predecessors that are proved to be of value, scientists generate topic-specific networks with social links that are expressed as citations (**Nicolaisen**, 2007).
- Universalism points to the fact that the decisions about the validity of scientific claims, and what to cite, are not influenced by personal attributes of the claim maker (**Turner**, 2007) such as race, nationality, or rank, and political or religious views (**Nicolaisen**, 2007).
- Disinterestedness assumes that scientists use rigorous policing in their scientific activities (**Merton**, 1973) and are not interested to gain personal advantage by, for instance, citing their own works (**Nicolaisen**, 2007).
- The final norm is organized skepticism which requires (in the process of citing) that scientists remain skeptical of their own works as they do with the works of others (**Macfarlane**; **Cheng**, 2008; **Nicolaisen**, 2007).

The normative theory of **Merton** (1968b) links citations to the impact, usefulness, and quality of scientific works (**Aksnes**; **Langfeldt**; **Wouters**, 2019), because the theory claims that scientists usually follow the norms in the ethos of science. In the normative theory, citations represent quality, importance, and significance (**Small**; **Boyack**; **Klavans**, 2019; **Teplitskiy** *et al.*, 2018). Giving credit to other scholars' works may reflect that authors are acting against their self-interest in gaining recognition themselves (**Case**; **Higgins**, 2000). However, citations are a means for social recognition (**Merton**, 1968a) or colleague recognition (**Cozzens**, 1989).

> "The validity of citation analysis for measuring scientific impact is challenged by scholars who support the social constructivist view that states authors have various citation motives which are independent of the usefulness and quality of the cited work"

Many empirical studies have supported and indicated that the normative view on citations is valid (an overview of these studies can be found in **Bornmann** and **Daniel**, 2008). However, **Judge** *et al.* (2007) maintained that the characteristics of universalism, particularism, and mixed universalism-particularism all impact the extent to which articles receive citations.

2.2. Social constructivist (citation) theory

In the social constructivist view, citations are not motivated by quality, but rather the ability of the cited work to support the validity of the citing author's claims (**Small**; **Boyack**; **Klavans**, 2019). In the social constructivist view, citations signal motivations for citing other than quality or relevance, such as gaining credibility (**Teplitskiy** *et al.*, 2018). For instance, the reason for citing well-known scholars can be gaining credibility rather than due to the quality or relevance of the cited work. In bibliometrics, this is known as persuasion by name-dropping (**Frandsen**; **Nicolaisen**, 2017) where authors cite the works by well-known scholars to gain credibility (**White**, 2004). Many previous studies have discussed the persuasion nature of citations (**Janke**, 1967) that the main purpose of citing is not to acknowledge previous scholars, but to reach scientific, political, and personal goals (**Liu**, 1993a). Scholars like **Barnes** and **Dolby** (1970) were among the pioneers who had a constructivist approach to citations (**Wyatt** *et al.*, 2017).

Latour (1987) emphasizes "that the primary goal of writing is to persuade the reader of one's argument" (**Davis**, 2009, p. 9), and citing is an important element in scientific writing that can be well used strategically. **Klamer** and **Van-Dalen** (2002) mentioned that citations are used to persuade each other of the merit of scientific works. **Cole** (1992) –an early sociologist of science using citation data– pointed to the importance of both author characteristics and social processes in authors' citation decisions, while he also believed in the importance of a paper's content on its use and citation. **Teplitskiy** *et al.* (2018) indicated that most citation decisions are following the social constructivist theory. Their empirical results showed that over 60% of authors believed the references they had cited had "minor" or "very minor" impact in their research. **Teplitskiy** *et al.* (2018) also indicated that citation counts influenced the authors' perception of the "quality", "influence", and "significance" of the scientific works. In other words, scholars may cite the works they are not influenced by with respect to the direction of research and quality of results. The interviews conducted by **Tahamtan** and **Bornmann** (2018b) also indicated that cited references had minimal impact on the creative ideas mentioned in breakthrough papers.

The social constructivist view on citations seems to have been rooted in **Berger** and **Luckmann** (1966) who

> "emphasize that the normative order –the world of norms taken for granted– constitutes perhaps the most foundational and constitutive layer of reality. In contrast to scientific and rationalistic conceptions of knowledge, the sociological view of knowledge does not seek to be based on given principles of truth or validity; instead it demonstrates that whatever is taken to be true, or valid, or useful, or effective in a given context depends on how social acceptability, legitimation, and a taken-for-granted institutional order are fabricated through social construction" (**Dahler-Larsen**, 2012, p. 22).

> "This study proposes a new theory that integrates previous theories and models on citations and is mainly based on Luhmann's "social systems theory"

2.3. Citations as markers or symbols

Small (1978) states that little attention has been paid to the "content of citation context" in previous studies and theories, and that they have missed the role of citations as symbols of concepts, methods, or theories. According to **Small** (1978), a citation is a symbol for both the physical document itself and for the concept or idea mentioned in the document. Any statement describing a citied work, such as statements from the findings or methodology, or a theoretical statement are called "ideas", and the cited work is a "symbol" representing that idea (**Small**, 1978). The idea that is cited, is an "imperfect 'copy of an original' which resides inside in the mind of an individual" (**Small**, 1978, p. 329). Each paper can be a symbol of values for an idea. For instance, a paper can be a symbolic value of a method for protein determination. The ideas cited in the citing work are the results of selection processes by the citing author (**Small**, 1978).

> In the social constructivist view, citations are not motivated by quality, but rather the ability of the cited work to support the validity of the citing author's claims

Sometimes a "uniformity of usage" of ideas can be seen, particularly in highly-cited papers, where most citing authors use a unique idea in the citing work. Highly-cited documents may have standard usage and meaning for citing authors (**Small**, 1978). "In some cases, the association between idea and document is well established by uniform practice within the community" (**Small**, 1978, p. 337) so that it creates a standard symbol. However, if an association between an idea and a document is made for the first time, such a connection remains in the realm of non-symbols (**Small**, 1978).

2.4. Reflexive indicator theory

Wouters (1998; 1999) proposes a reflexive citation theory, where references and citations are considered two different things. Each reference is a representation of the cited text that consists of characteristics of the main body, as well as author name, title, journal, year of publication, volume and issue of publication, and page numbers. The citation is a different format than the reference in **Wouters** (1998; 1999): the citation is an inversion of the reference. He mentions that citation analysis is depended on the counting of the number of inverted references (citations) in the citing text. Therefore, whenever we count the number of times a work has been cited, we are inverting references to citations (**Wouters**, 1998). **Wouters** (1998, p. 233) states that in the reflexive indicator approach, we deal thus with two operations:

> "the giving of reference is one operation. The making of citation is a second one, reflexive towards the first as well as contingent on it".

Wouters (1998) believes that the birthplace of citations is not the scientist's desk, but it is citation indexes such as the *Science Citation Index* that consist of references that have been included in scientific papers. He mentions that in citation indexes, references are transformed to citations as the end product; and this end product is the result of the indexing process and not the act of citing a document. In other words, if an author cites a work, "she does not 'give a citation'" (**Wouters**, 1998, p. 234). Therefore, citations in the index are equal, yet "references are not equal: they have different functions in the citing text, and their underlying motives are various" (**Wouters**, 1998, p. 235).

Wouters (1998; 1999) believes that the main issue with current citation theories is that they have not differentiated citations from references. In his view, most past citation theories, namely the normative and social constructivist theories, have tried to explain citation patterns based on the citing behaviour of scientists. These theories attribute meaning to citations (e.g., citations represent recognition or persuasion), while citations are all equal, and are meaningless and dimensionless, unlike references that have very different characteristics (**Wouters**, 1999). Therefore, a citation theory based on scientists' citing behaviour and citations is not promising because of

> "the variety of behavioural characteristics underlying the citation patterns found in the literature … This is, however, the consequence of the semiotic inversion of the reference into the citation. The citation no longer betrays from what type of reference it was produced" (**Wouters**, 1999, p. 574).

A citation theory that links citations to scientists' citing behaviours is a "dead end" (**Wouters**, 1999, p. 575). With our proposal of the SSCT based on the social systems theory, we agree with this assessment and break away from the focus on citing behavior in citation theory.

2.5. References as threat signals

Nicolaisen (2004) maintains that past theories, mainly the normative theory and social constructivist theory of citing have not been able to fully explain what makes authors cite others and what makes them choose to cite some resources and not others. He suggests that citation behaviour and citations can be explained based on the "handicap principle" in bibliology and evolution (see **Zahavi**, 1975; **Zahavi**; **Zahavi**, 1999). Borrowing from this principle, **Nicolaisen** (2004) points to references as "threat signals" like those that exist in nature (e.g., approaching a rival). He argues that dishonest referencing can threat the reputation and validity of authors, specifically when they are being observed and evaluated by skilled authors, who can easily detect false references. His theory assumes that authors try to make honest references in their scientific works because they want to avoid any potential criticism by the scientific community. **Nicolaisen** (2007, p. 629) maintains that

> "citing authors honestly credit their inspirations and sources to a tolerable degree-enough to save the scientific communication system from collapsing".

However, he does not believe that all citations are honest, but most are, because authors are fearful of being attacked by their peers (**Nicolaisen**, 2007).

2.6. Elements in the process of citing publications

Since the single (traditional) theories are not able to fully explain citation motives, **Tahamtan** and **Bornmann** (2018a) proposed a conceptual model to explain the core elements in the process of citing publications. This model explains the processes through which an author decides whether or not to cite a scientific work. The model has been developed based on the empirical literature on citations and includes three elements:

- cited document,
- from selection of the document to citation of this document, and
- citing document.

According to this model, the features of both cited and citing documents affect an author's decision whether or not to cite a document.

Tahamtan and **Bornmann** (2018a) explain that authors use various criteria to select a document, such as the accessibility of the document, the perceived quality of the document, the reputation of the journal in which the document is published, and its relevance. Other, rather critical factors also affect authors' citation decisions, such as the journal's referees requiring a (extraneous) document to be cited. The model by **Tahamtan** and **Bornmann** (2018a) explains that the citation decision process is more complicated than what is reflected in past theories, namely the normative and constructivist theories. The model explains that in some cases, only one criterion may be enough for an author to reject a document for citing (e.g., because it is published in a less-known journal) without considering other aspects of that document (e.g., its relevance). In other cases, more than one criterion is crucial for citing a certain document or desisting from citing. Thus, an individual and its circumstances (education, objectives, necessities) which can change in time and other factors such as collaborators can influence a citation to be given or not given.

2.7. The disadvantages of the past theories

Scholars' citing behaviours include a set of interrelated mechanisms (**Mingers**; **Leydesdorff**, 2015) and decision processes (**Tahamtan**; **Bornmann**, 2018a) that cannot entirely be explained within the contexts of past citation theories. Thus, neither the proposed models nor the normative and social constructivist theories can completely and independently explain the citation behaviour of scholars.

Authors and their motives to cite are at the focal points of previous citation theories and models. Past theories and models failed at the complex nature of motives to cite, because they are not able to reflect this complex nature. Theories and models would profit from not relying on the very different motives to cite, which are difficult to identify and integrate in one theory or model. For instance, one might have the impression that an author cited paper x, because it has been published in a prestigious journal, and for the reputation of its authors. An interview with this author may reveal, however, that she cited paper x because she knew the author of paper x (and her work) from a conference dinner. This interview may or may not reveal the author's real citation motives. Thus, there can be a difference between assumed, communicated, and real motives, and it is hard to reliably and validly explore the motives of citing authors (in empirical studies).

> "Many previous studies have discussed the persuasion nature of citations, that the main purpose of citing is not to acknowledge previous scholars, but to reach scientific, political, and personal goals"

In this paper, we propose Luhmann's social systems theory as a solution to the problem of basing a citation theory on motives to cite. The social systems theory focuses on communications and not on humans and their motives. Humans are not part of social communication systems but are connected with them. Thus, the SSCT does not have the problem of integrating various and very different motives to cite (on one side) but is able to integrate approaches of past citation theories (on the other side).

3. Luhmann's systems theory

The systems theory of Luhmann is one of the most recent social theories that is based on the premise that three basic autopoietic systems (self-reproductive systems) constitute society. These three autopoietic systems are

- living systems,
- social systems, and
- psychic systems (see figure 1).

Autopoietic systems, such as biological cells, reproduce their basic elements on their own terms for their survival; otherwise, the system will disappear, as a plant will disappear without making its own cells (see **Seidl**, 2004). The operative closeness of systems and its recursive operations have been named as autopoiesis, which means a system can maintain and reproduce itself.

> "Living systems reproduce themselves on the basis of life; social systems reproduce themselves on the basis of communication, and psychic systems on the basis of consciousness or thoughts" (**Seidl**, 2004, p. 5).

The system that composes societies is the social system (see Figure 1). Each social system (e.g., the science system) selects and builds an environment (also called a boundary) for itself that differentiates it from other social systems. While the environments or boundaries are usually complex, the social system functions in a way to reduce the complexity of its environment. For example, each system can be composed of several sub-systems that each functions to counter the complexity of its environment (**Görke**; **Scholl**, 2006; **Meyer**; **Gibson**; **Ward**, 2015).

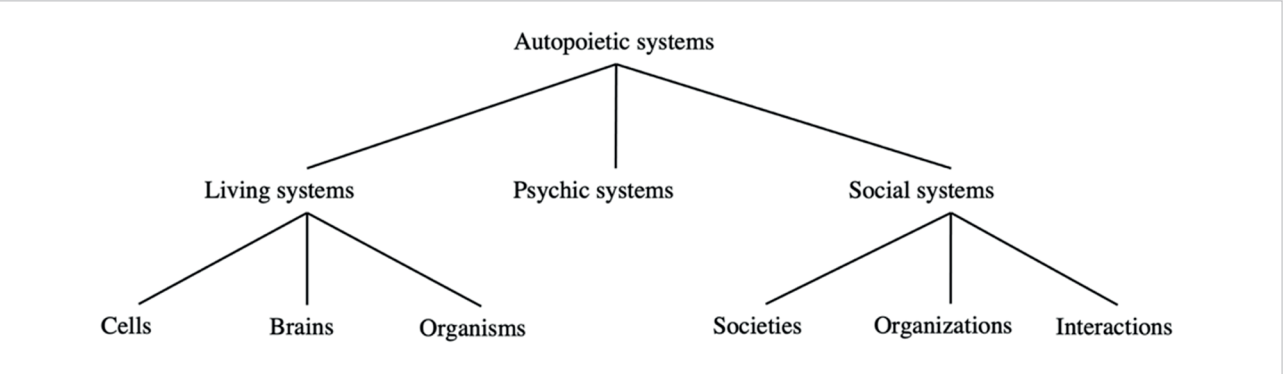


Figure 1. Types of autopoietic systems (**Luhmann**, 1986, p. 173)

According to the social systems theory,

(a) systems have different functions and operate inter-dependently of each other. They mutually interact and communicate in a variety of ways to achieve a common goal (known as structural coupling in Luhmanns' theory) (**Meyer**; **Gibson**; **Ward**, 2015). For instance,

> "social and psychic systems are conceived by Luhmann as two different types of systems, separate from one another but coupled via media such as meaning and language" (**Stichweh**, 2011, p. 295);

(b) systems are different from each other by the form and semantics of communication; and

(c) systems generate different views on reality (each system is monocontextural).

Thus, a society is composed of different perspectives on reality. Different views on reality, different functions, and different forms and semantics make communication among systems problematic. For instance, research ideas are being generated by the psychic system (a researcher) and are being communicated within and by the science system, while at the same time, the research ideas may have been proposed to influence "a system responsible for the public policy" (**Meyer**; **Gibson**; **Ward**, 2015).

> "We propose Luhmann's social systems theory as a solution to the problem of basing a citation theory on motives to cite"

The relatively new theory of Luhmann (compared to traditional social theories) is of special interest to be used in the development of a theory of citations for two reasons:

(1) it integrates previous, yet conflicting social theories (i.e., the relativistic and structure-functional approaches) in its conceptualization (e.g., **Berger**; **Luckmann**, 1966; **Parsons**, 1951). Thus, the theory can be used as an integrating theory for the citation process.

(2) The social systems theory focusses on communications (and not humans) as the basic constituting elements of a social system. According to Luhmann, the basic unit or element of a social system should not be humans, because the constituting element of the social in the community is communication (**Görke**; **Scholl**, 2006).

Luhmann believes that it is inappropriate to describe a society on the basis of humans and their behaviours,

> "because individuals' contexts differ in so many respects that it seems more adequate to analyse different spheres, contexts or problems as units than subjects" (**Görke**; **Scholl**, 2006, p. 643).

This (new) focus on communications rather than humans can be considered as a paradigm shift in sociology (**Leydesdorff**, 2001) which makes the theory of great interest for explaining the citing process. Therefore, it can be said that the formal citation process consists of communicative events, and the links within citation networks constitute social systems in science.

In the following section, we explain the constitutive elements of the social systems theory and discuss them in the context of a theory of citations (SSCT). The description of the elements will be mainly based on **Luhmann** (1992). In this book, Luhmann describes and explains the science system based on his social systems theory. Since the introduction of the theory, some papers have been published in scientometrics that have made a connection to that theory. For example, **Riviera** (2013, p. 1449) conceived science as an

> "autopoietic cognitive domain [i.e., a social system], and communicative events as the elements of this system, allows us to interpret citations as devices through which the structuration process in scientific communities is accomplished".

Many connections to the social systems theory can be found in **Leydesdorff** (2001) and other publications by him (e.g., **Leydesdorff**, 2009; **Leydesdorff**; **Hoegl**, 2020).

3.1. Communications as the elements of social systems

Traditionally, the basic elements of a social system have been mentioned to be people and their actions. In contrast, Luhmann chooses "communications" as the main element of a social system. **Luhmann** (1986, p. 174) noted that

> "social systems use communications as their particular mode of autopoietic reproduction. Their elements are communications which are recursively produced and reproduced by a network of communications and which cannot exist outside of such a network".

For Luhmann, communication is not the process of transmitting information from A (sender) to B (receiver); instead, it consists of four components (**Seidl**, 2004):

- Information (selecting information from a variety of choices),
- Utterance (how and why the information is being communicated),
- Understanding the meaning (no matter what information the sender has in mind, it is the receiver who interprets the message),
- Selection between "acceptance or rejection of the meaning of the communication" (**Seidl**, 2004, p. 9).

The four components indicate that a series of selections constitute communication (see Figure 2):

> "first, an information (out of a horizon of possible meanings) must be selected; second, this information must be addressed by an utterance (out of a horizon of possible addressees and modes of expression); and third, this difference between information and utterance must be understood. It is only the third selection of understanding which at minimum completes communication. The utterance can be viewed as the action component of communication" (**Görke**; **Scholl**, 2006, p. 648).

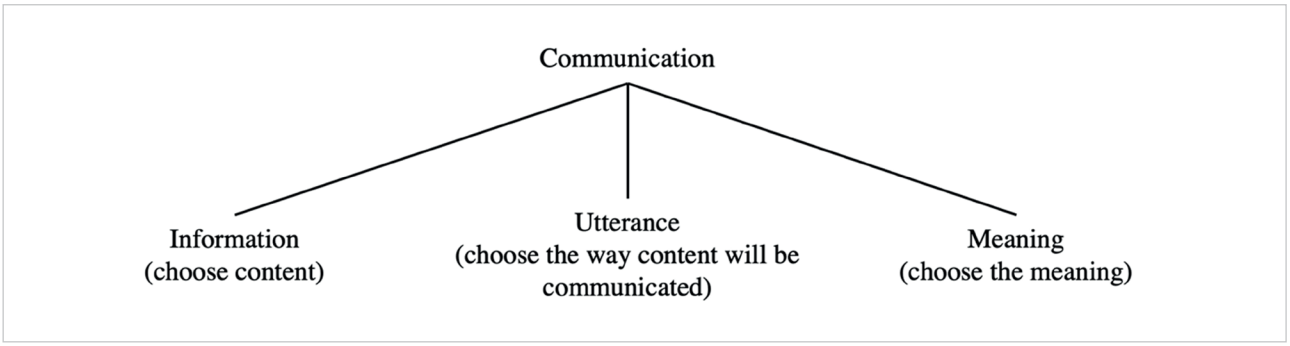
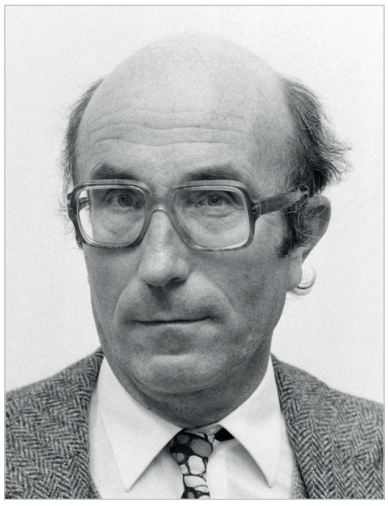


Figure 2. Social system's communication (**Silva**; **Sibertin-Blanc**, 2017, p. 125)

The main element in communication is understanding. In communication, the receiver's understanding of the message is important, no matter what the speaker has in mind (**Baecker**, 2001). Understanding is part of the first communication, and the selection between "acceptance" or "rejection" is part of the proceeding communication that takes place later. Both guarantee reproduction of communications over time (**Seidl**, 2004).

Other autopoietic systems besides social systems in Luhmann's view are psychic systems. How the psychic systems comprehend the communication is not initially important for the communications that are about to take place. For instance, "yes" could be understood as a question, while another psychic system could interpret it as an approval. However, what psychic systems think about communications may eventually lead to different communications to take place (**Seidl**, 2004).

> "Thus, although psychic systems are necessarily involved in bringing about communication, the communication (as this unit) cannot be understood as the product of any particular psychic system" (**Seidl**, 2004, p. 8).


Niklas Luhmann

The focus on communication in a theory of society is very suitable for a theory of citations: publishing and citing are communicative events by their natures. **Luhmann** (2012a; 2012b) locates psychic systems (i.e., human brains) outside the social systems (see Figure 1). When we embed the citation process in this theoretical framework, psychic systems (authors) would irritate or stimulate formal communications (publications and their citation links) in the science system. The citation links exist in the matrix of cited and citing publications in the social system (defining the web of knowledge). By excluding humans from

social systems, the theory of **Luhmann** (2012a; 2012b) displaces humans' motives and reasons to citing scientific works in the periphery of the social system (i.e., in the psychic systems). In other words, authors' motives, and reasons to cite belong to the psychic systems while citations as communicative elements reside in the (social) science system. Both systems operate autonomously (i.e., have their own independent identity) but also communicate and interact with each other (and with other systems) to achieve a common goal: the psychic systems of authors are structurally necessary for establishing publications and citation links in the science system (both systems are structurally coupled). Psychic systems (authors) irritate or stimulate the science system:

> "every system needs stimulations or irritations from outside the system, although these external stimuli cannot determine the operations of and within the system" (**Görke**; **Scholl**, 2006, p. 648).

3.2. Science is a social system that is based on communications

The science system can be considered as a social system capable of reproducing its elements through its components. Social systems themselves generate all system processes, and no operation in the system is being carried out from outside. This does not imply that the system is not in contact or interaction with the environment outside the system. It only means that the system itself is carrying out the operations, although operations inside the system are influenced by external forces in the environment (**Seidl**, 2004). For example, a science system is being influenced by economics, pandemics, sanctions, wars, and other (global) issues. However,

> "these influences can never determine what operations come about … external events may trigger internal processes, but they cannot determine those processes" (**Seidl**, 2004, p. 3).

Therefore, like many other systems, the science system is structurally coupled to other systems in its environment (**Seidl**, 2004).

Luhmann (1992) conceives science as a social system. Like any other social system, the main element or unit in the science system is communication: the system exists and operates based on communication. The science system is composed of "communicative elements": communicative elements are recursively linked to other communicative elements and constitute the system in this way. Science without communication would not exist (exactly as the legal system cannot exist without communication). This focus on communication in the science system implies (among other things) that communication is not directly connected to thoughts (e.g., ideas or facts) by researchers. Thoughts are only directly connected to other thoughts in the mental processes of single researchers. The emphasis on the importance of communication in the description of the scientific endeavour is not unique to the social systems theory by **Luhmann** (1992) but can be found in other publications of the sociology of science literature. For example, for **Abelson** (1980, p. 60),

> "the key element in the building and preservation of this marvellous edifice is communication. Without communication, there would be no science".

3.3. Science is based on publications and their citation links

Like other social systems in society, many different types of communications (publications, personal communications, group discussions, presentations, etc.) exist in the science system. The science system mainly reaches its compatibility (in the sense of connectivity and closeness) through communication based on publications (**Luhmann**, 1992). Publications are the operative medium for the spreading and storage of knowledge proposals. Without new publications (including knowledge proposals), the science system would no longer exist. Nearly all disciplines in science are not imaginable without the continuous stream of new publications with the corresponding knowledge proposals and their rooting in previous proposals by citations.

The (worldwide) archive of publications is a place that absorbs and stores an immense volume of publications that are connected by citations. The archive (as a social system) is differentiated by various disciplines (as its sub-systems), which helps to reduce the complexity of the archive. For example, researchers in a specific discipline do not have to search relevant literature in the whole archive. Researchers focus on the knowledge stored in the archive in the same disciplines, because researchers are –as a rule– the audience of other researchers from the same discipline (**Luhmann**, 1992). Although each discipline has its own discipline-specific environment (boundary), they mutually interact with other relevant disciplines. Interactions between disciplines can be traced and manifested in citations listed in publications and co-authorships.

3.4. Science is conceived as an evolutionary system

Luhmann (1992) views the science system as an evolutionary system. In his view, the evolutionary system produces publications in a similar way as the surrounding world produces organisms –with a lot of surpluses, openness for selections, and missing predictability. Research ideas stem from psychic systems and are random events in the science system that turn up in publications (seldom) or not (mostly). Many publications are rarely read by researchers or used in subsequent research. Since the total stock or archive of publications and its complexity increase every year, one could question the necessity for new publications. The operational continuity of producing new publications is ensured yet, because

(i) most of the publications end with at least one new research question that arises from the reported research;

(ii) communicating research results based on publications is a standard approach in most disciplines; and

(iii) governments implement measures based on research to tackle societal problems (e.g., research on the COVID-19 outbreak).

Three features of the evolutionary science system are "variation", "selection", and "stabilisation". The variation within the evolutionary science system refers to the processes that are located inside and outside the science system. Researchers have new research ideas, some of which are possibly investigated in research projects, the results of which are perhaps communicated within manuscripts. New research ideas are random processes in the science system that are located outside of the social science system, primarily in researchers' psychic systems. The variation within the evolutionary science system is triggered by the focus on problem-identification and problem-solving in science (**Luhmann**, 1992), opening up various combinations to investigate the same phenomenon. Inside the science system, manuscripts are submitted to journals, and reputable journals select only a few manuscripts for publication. Many manuscripts are published in less well-known journals or on preprint servers (such as the *arXiv*). The available space on servers and journals lead to a continuous and broad stream of newly published research. The process of selection within the evolutionary science system refers to the usability of reported results in publications. Some results attract attention from other researchers and are included in the stock of useful knowledge, but many results do not reach this status. Valuable knowledge can be found, e.g., in the thematic literature, overviews, and textbooks (for students). In the context of an evolutionary view on the science system, **Armstrong** (1982, p. 85) speaks about a

> "'marketplace for ideas' [that] provides an efficient way to separate the good ideas from the bad. Under this system, scientists write papers to advocate their viewpoint. These papers are examined by secret peer review, and then are published and subjected to further review by readers".

The continuity of its specific (publication-based) communications ensures the "stabilisation" of the science system: it is nearly all researchers' task to write down their results in publications and researchers are assessed by their ability to fulfil this task. The science system differs from evolutionary processes in the animal world, because in science, intentional processes are involved: researchers' purposeful actions in research lead to new publications. However, these intended actions are events in the environment of the science system (see above). A publication might be produced based on specific intentions, such as societal or topic-specific needs; the community decides at the end (e.g., based on peer review decisions or citations) whether the publication is compatible or not. One could imagine that innovative and risky research that continuously questions basic knowledge in disciplines lead to a loss of a stable science system: the system may move from the prevalent normal science to a predominant revolutionary science system (**Kuhn**, 1962). The stabilisation of the science system profits, however, from the tendency of researchers to critically react to novel (revolutionary) research. For example, the journal peer review system has been criticized with respect to the so-called conservative bias, the tendency to reject innovative and risky manuscripts (**Campanario**, 1996).

3.5. The science system operates its closeness by formalized links: citations

In the modern science system, researchers are requested to separate own discoveries from knowledge generated by other researchers. Since discoveries are usually reported in publications, the separation occurs by providing sentences with citations to other publications. It is specific, therefore, for the science system that links between communications on research are formalized and visible through citations. In other social systems, communications are also linked together, while the subsequent communication refers to the previous communication content. The usual social system emerges yet by self-referential communications that can be identified by revealing their meaningful connections. Since most social systems are transitory events that are not recorded, it is not naturally possible to track their operations. In the science system, however, the tracking of operations is possible for the communication channel (i.e., academic publishing) that mainly defines the closeness of the system. Conventionally, the links to previous research (publications) are included as citations in the text body; the cited publications are reported then as references (mostly at the end of a publication in a listed form).

The citation of publications is a strong type of scientific behaviour that is normatively prescribed (see **Luhmann**, 2006c). Nearly all scientific publications contain at least a few cited references. In science communication, reporting references is so crucial that many researchers even include these links in their presentations (at conferences or meetings). Citations establish relations selectively, since in research on many topics, not all relevant publications for particular research can be cited. In the case of new research areas, it might be possible to cite all relevant publications (e.g., at the beginning of the *h* index research, in 2005 and 2006, all research papers on the *h* index could be cited in principle), but this is not possible in mature areas (e.g., the area of measuring impact through citations). In mature areas, mechanisms of selection have been established to reduce complexity. For example, "obliteration by incorporation" describes the phenomenon that accepted and well-known knowledge in the community is no longer provided with citation links (**Merton**, 1988). The continuously used knowledge has condensed to lessons learned in the community (**Luhmann**, 2006a). For example, the *Journal Impact Factor* indicator is so well-known in the scientometric community that it is mentioned currently in the literature without reference to the paper introducing the indicator.

Citation indexes such as the *Web of Science* (*WoS*, produced by *Clarivate*) or *Scopus* (*Elsevier*) provide access to the science communication structure based on publications and their formalized links. The social system structure based on both communicative elements (publications and their formalized links) can be visualized by using data from the citation indexes. As an example, Figure 3 demonstrates a social system that consists of a citation network of papers published

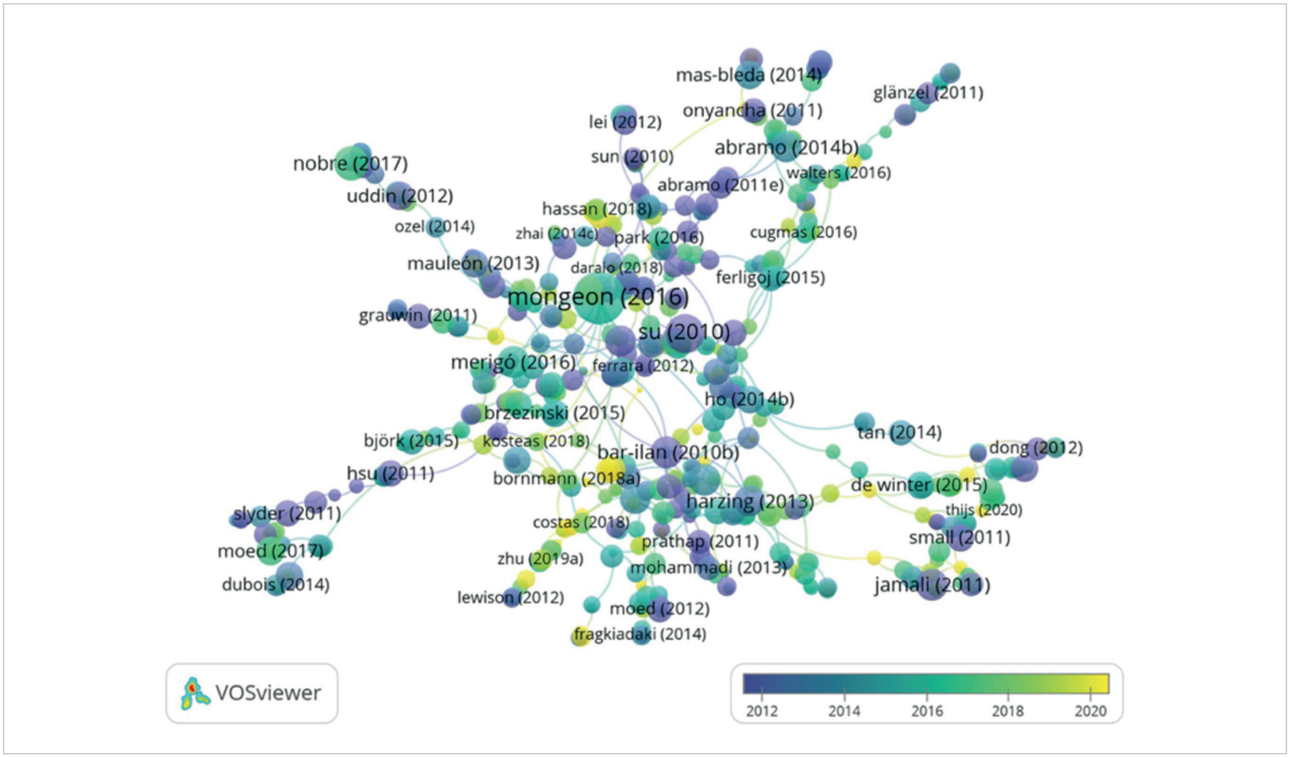


Figure 3. Citation network of papers published between 2010 and 2020 in *Scientometrics* (based on *Crossref* data visualized by the *VOSViewer* software). Nodes are single papers (node sizes reflect overall citation counts), and lines denote citation links within the journal. The nodes are coloured by the publication year.

between 2010 and 2020 in *Scientometrics*, based on *Crossref* (*https://www.crossref.org*) data visualized by the *VOSviewer* (*https://www.vosviewer.com*) software.

In this system, nodes represent single papers connected through lines that denote citation links within the journal. The nodes are coloured by the publication year of the cited paper. Such networks based on publication and citation data reveal field-specific parts of the complete science system's structure, where publications are nodes and citations are links between nodes. On one side, the structure is dynamic and changes with the appearance of new publications and their connections to other publications using cited references. On the other side, the system is closed, since it is defined by publications and their citation links.

3.6. Truth and autopoiesis

According to **Luhmann** (1992), any functional social system (such as law, politics or science) uses a code of its own that is specific for the communication in the system. The scientific communication is oriented towards the code "true" or "not true": communication (established knowledge, new ideas, etc.) is processed in the science system against the background of "true" or "not true". Every knowledge proposal coded as "true" may be read, published, and cited, and every knowledge proposal coded as "non-true" may be sorted out.

The code can be seen as a catalyser that animates to assess information somehow; it predetermines the medium in which the scientific communication happens. Only by the existence of the code "true" or "not true", the system

(I) is differentiated from other societal systems, that each uses its own codes;

(ii) is able to operate autonomously; and

(iii) is able to accumulate knowledge (**Luhmann**, 1992).

The focus on "truth" in the conceptualization of science is not only specific to the social systems theory of **Luhmann** (2012a; 2019b), but can also be found in the conceptualization of science by **Popper** (1959). **Williams** (2012) explains that according to Popper,

> "the search for truth was … the strongest motivation for scientific discovery. His role was to determine how we can ascribe truth to the claims made by science, religion and politics".

Second-order observations (i.e., peer reviews) have an essential meaning in science: researchers (peers) are necessary in the system to operate in the medium of "truth" by differentiating between "true" and "not true" knowledge proposals in publications. Researchers try to have a chance of being accepted by second-order observations by providing evidence and validation (**Luhmann**, 2020b). Truth functions as a symbol for "being reliably reviewed" or "being reliably confirmed". For example, in the journal peer-review process, at least two experts from the same field (as the authors) review

a manuscript to recommend publication or rejection of the manuscript. Published research results are only accepted by the community in a discipline when they have been confirmed in independent studies. Since the attribution of "truth" to certain results is always a hypothetical event, it can be said that the examination and validation of knowledge is never finished. In the process of producing and validating of knowledge proposals, each researcher has a double role: he/she is producer of knowledge proposals and at the same time observer of other researchers' proposals. The essential meaning of second-order observations in the conceptualization of science emphasizes the importance of communication in the system: only communicatively proposed and assessed research can finally lead to valid knowledge.

The operative closeness of the science system can be observed by the fact that academic publications mostly cite other academic publications (and not newspaper articles or tweets) (**Haunschild**; **Bornmann**, 2020). The reported research might be stimulated by non-scientific material, but the (communicated) research is operatively connected to previous (communicated) research. The autopoiesis of the science system is formally ensured through publications: most of the publications have cited other publications and are selected for being cited in future publications. Therefore publications and citations hold what characterizes autopoietic systems in general: every end is a beginning at the same time (**Luhmann**, 1992). Citation links establish and enable the science system's autopoiesis: citations guarantee the connectivity (compatibility) of research and connectivity allows information retrieval and navigability through the science archive.

3.7. Structural coupling and irritation

As mentioned above, in the social systems theory, systems operate autonomously (autopoietically) but also interact with other systems. Autonomy is not equal to self-sufficiency because a system needs to be connected to and interact with other systems to achieve certain (superior) goals (**Görke**; **Scholl**, 2006). For example, innovative products (such as quantum computers) can be preferably developed in the interaction of science and economy. The link between a system and other systems "within its environment is called either interpenetration or structural coupling" (**Görke**; **Scholl**, 2006, p. 648). This means for the science system that it is connected to other (social) systems through structural couplings, although the system operates autonomously with recursive operations.

Several structural couplings can be seen between sub-systems of the science system and other systems. For example, research on climate change or COVID-19 is coupled with certain (researchers') psychic systems or the policy system (**Bornmann** *et al.*, 2022; **Yin** *et al.*, 2021). Ideas of psychic systems can be read in publications; and policy-science interactions are reflected in citations of papers in policy documents (**Yin** *et al.*, 2021). Interactions within and between systems are facilitated by "brokers" who influence each other, affecting the whole system (**Meyer**; **Gibson**; **Ward**, 2015). For example, authors are "knowledge brokers" who select and cite scientific works, or reviewers are "science evaluation brokers" who operate in second-order observations.

The precise boundaries of systems (e.g., the science system, psychic systems, or the policy system) guarantees that there are no crossing operations between (sub-)systems (specific communications or thoughts), but there are inter-dependencies between (sub-)systems through reciprocal irritations. For example, in the science system, communication of knowledge proposals is dependent on new ideas (psychic systems) and public funds (policy systems). Relevant events in the environment are registered in the (disciplinary) recursive network of the science system. Irritating events lead to structural changes (i.e., changes in the communication structure) in the science system: the science system is financed by the policy system, and the financial input may be combined with specific interests in certain research topics (e.g., the development of a certain vaccine). These processes are important for the scientific endeavour's success, but they do not change the fact that the science system operates autonomously with its specific structure producing knowledge with the requirement of "truth" (**Luhmann**, 1992). Social constructivists have a strong focus on these elements that have been named by Luhmann as irritating events. By relocating these elements in the environment of the science system, the social systems theory is able to integrate the structure-functional position that science acts as a functional system in the society (by producing reliable knowledge) but is influenced by non-scientific elements at the same time that irritate science communication.

Some science disciplines such as medicine have stronger interdependencies with other systems (e.g., the public health system) than other disciplines such as mathematics. Stronger interdependencies might lead to higher societal recognition, awareness, and reputation of a particular discipline (**Luhmann**, 1992).

3.8. Programs of the science system

The assignment of "true" and "not true" can only be performed in the science system, because only the science system has established the necessary programs for reliable and valid assignments. These programs are structural elements of the system that are applied by researchers. Specific methods (e.g., statistics) and study designs (e.g., random sampling or surveys) belong to these elements and include rules and approaches for scientists' work. Scientific statements are formulated in the context of theories –another structural element– that support the decisions whether statements are "true" or "not true". Other elements (besides methods, designs, and theories) are norms formulated in the ethos of science (see section 2.1) and reputations gained by researchers, institutions, or journals. Norms (as moral and technical instructions in science) and reputations (as mechanisms for allocating rewards and recognition) regulate scientific communications by channelling and regulating actions and communications of scientists. Reputation serves as a preselection

mechanism that initially acts as an indication of "truth". Research published by reputable journals or researchers has a higher probability of being "true" than research published by unknown journals or researchers. On the one hand,

> "reputation reduces complexity for scientists whose limited span of attention necessitates decisions about whom to listen to, whom to ignore, whom to ridicule, and whom to take very seriously" (**Fuchs**, 1992, pp. 71-72).

On the other hand, reputation is

> "a resource scientists can use to give their statements more credibility" (**Fuchs**, 1992, p. 72).

3.9. Normative and constructivist roots of the social system theory

Luhmann (1992) treads the path of integrating the social systems theory in the (i) structure-functionalism and (ii) social constructivism (tradition).

(i) According to **Luhmann** (1992), it is specific for the science system that knowledge proposals are produced, and the existing knowledge pattern is changed over time (e.g., by dismissing existing knowledge and including new knowledge). It is a specific structure-functional position that only the science system can fulfil the function of producing new and "reliable" knowledge by orienting towards "truth" in its communication (**Weingart**, 2003). The science system, with its specific communication and programs, has been established to fulfil this function over decades. The focus on this function differentiates science from other social systems, with their own specific functions in society (see **Weingart**; **Pansegrau**; **Winterhager**, 1998).

(ii) **Luhmann** (1992) roots the social systems theory in a mathematical concept proposed by **Spencer-Brown** (1969). The starting points of the concept are two operations of psychic or social systems: to "distinguish" and to "observe". In the science system, psychic or social systems "create" (construct) the external world by distinguishing and observing (and indicating) different phenomena (in empirical or theoretical studies). Psychic or social systems observe phenomena in the environment that might be of interest to study and present the results of these observations in publications. Knowledge then is the result of "observations" and "descriptions," and these are communicated in the social system by publications (**Luhmann**, 1992). The framing of the social systems theory by **Luhmann** (1992) in the mathematical concept proposed by **Spencer-Brown** (1969) means that knowledge cannot be uncoupled from the observer (i.e., the context of the observer with specific research conditions and colleagues) (see here **Simon**, 1988). Knowledge can only be objectivized (validated) interpersonally (independent of only one observer) if different studies come to similar conclusions (under similar research conditions).

By rooting the social systems theory in the mathematical concept proposed by **Spencer-Brown** (1969), the theory is genuinely grounded in a constructivist approach: the (science) system observes (investigates) the world (its environment) by communicating about the world. The world only exists as communicative elements; the reality of the science system is constructed in the system by its specific code that is oriented towards truth (**Luhmann**, 1992). In other words, the system is an observer who perceives its environment by using its own –"truth"– lens (**Lau**, 2005). The specific programs for observing the environment through this specific lens ("true" or "not true") has been evolved in the development of the modern science system.

4. Conclusions

4.1. The need for a new theory

Most empirical studies in evaluative bibliometrics have relied upon the normative and social constructivist theories of citations (see sections 2.1. and 2.2). Both theories use human motives to explain links between publications via citations. Since both theories have specific limitations, some attempts have been made over the past several decades to propose other theories and models of citations (see sections 2.3 to 2.6). However, none of them have been able to provide a comprehensive theoretical framework for citing. The main issue with past theories is that the basic elements constituting them are citation motives of scholars which have a very complex nature. The motives to cite are very different and identifying and integrating them all, which past theories tried to do, seems to be almost impossible. Thus, we propose that a citation theory should instead focus on (an) element(s) other than citation motives (i.e., communications).

4.2. The new citation theory –SSCT– and its potential

To avoid the problem of basing a citation theory on citation motives, we propose that a citation theory should focus on communications, and not humans and their motives. We adopt this idea from the social systems theory of Luhmann, who maintains that the basic element of any social system is communications and not humans. Thus, the social systems theory does not have the problem of integrating various and very different motives to cite, which makes the theory of great interest for the citing process. Although motives to cite are not part of the social science system, they are part of the social systems environment (the psychic systems), they can be theoretically considered.

According to the social systems theory, systems have different functions, views on reality, and semantics, build their own boundaries, and operate interdependently of each other, which in turn make communication among systems problematic. For instance, the psychic system (researchers) generates research ideas, the science system communicates some of these ideas, and a social system responsible for public policy may be impacted by or use a selection of those ideas (**Meyer**; **Gibson**; **Ward**, 2015).

Traditionally, the basic elements of a social system have been humans or actions, while Luhmann believes humans have very different behaviours (in different social contexts) so that the constituting elements of a social system should not be

based on humans, but based on communications (**Luhmann**, 1986). Psychic systems or humans perceive communications differently, resulting in different communications to occur. For instance, "yes" could be understood as a question by one psychic system or as an approval by another psychic system. Thus, although a presence of a psychic system is pivotal to the communication to occur, it is not the product of any psychic system (**Cooren**; **Seidl**, 2020; **Seidl**, 2004).

The citation process can be explained based on Luhmann's theoretical framework: authors' motives to cite belong to the psychic systems while publications and citations belong to the science system. Both systems operate autonomously but also interact with each other: the psychic systems of authors are structurally essential for establishing citation links between publications in the science system, because it is the psychic systems that stimulate or irritate the science system, but the psychic systems cannot determine the operations of and within the science system (**Görke**; **Scholl**, 2006).

4.3. Practical implications

Luhmann's theory –the SSCT– has the potential to underly and reorient empirical research in bibliometrics.

For example, citation networks (see Figure 3) can be produced (based on *WoS* or *Crossref* data) that reveal social systems in science (e.g., topic-specific networks). A science system created in this way reveals a citation network where nodes are publications connected through lines that represent citation links. Each citation network reveals certain parts of the science system's structure. The structure is dynamic and changes with the appearance of new publications and their connections to other publications using cited references. The network can be described and explained based on the terms and concepts of the SSCT.

Another related example is the promising use of the SSCT in evaluative bibliometrics. The SSCT gives advice and support to a new (promising) trend in evaluative bibliometrics to go away from simple citation counting towards analysing citation networks. This trend has at least two reasons: (1) scientific impact is a complex phenomenon with many facets that cannot be deduced to a single number such as citation counts. (2) Publication and citation data are rich meta-data that allow more than simple citation counting. The increasing popularity of the *VOSviewer* program for analysing data from *WoS* or *Scopus* for conducting bibliometric studies (see Figure 3) reflects this trend in bibliometrics. In the bibliometric literature, many empirical examples can be found that demonstrate the trend in recent years.

One example of this trend is the study by **Ràfols** *et al.* (2021) who map publications to *United Nations*' sustainable development goals (SDGs) to measure societal impact (relevance) of research. The authors explain their network approach for measuring impact as follows:

> "given the variety of understandings regarding the relationship between research and SDGs, we propose that bibliometrics analysts should not assume that there is one single, preferred or consensus way of mapping SDGs to publications. We propose instead that, since different stakeholders have contrasting views about the relationships between science and SDGs, the contribution of bibliometrics should be to provide a plural landscape for stakeholders to explore their own views" (**Ràfols** *et al.*, 2021, p. 1).

Another example is the study by **Skov**, **Wang**, and **Andersen** (2018). The authors propose science networks –knowledge domain visualizations– that are based on keywords in papers on a certain topic or field. It is an explicit aim of the visualizations not only to reflect (field-specific) science communications, but also to use the maps for strategic functions (in evaluative bibliometrics). For example, the maps can be used to

> "invade new areas (the analysis shows that a research group is not present in a new and promising part of the map –should they try to include it, e.g., by letting a member of the group specialise in it, hiring an established researcher or setting up a collaboration with another institute?)" (**Skov**; **Wang**; **Andersen**, 2018, p. 273).

Other studies reveal that citation data can be analysed not only as communicative events, but also as events that are irritated by certain motives to cite. For example, **Bornmann**, **Wray**, and **Haunschild** (2020) introduced the so-called citation concept analysis. The method can be used to explore why highly-cited publications were cited later on: which concepts from the publications were of interest for the citing authors? The study by **Catalini**, **Lacetera**, and **Oettl** (2015) investigated citation impact with a focus on negative citations. With the focus on negative citations, **Catalini**, **Lacetera**, and **Oettl** (2015) analyzed –in terms of the SSCT– irritations of the social system (citations) by psychic systems (critical assessments of cited papers).

4.4. Future research

Our proposal to focus on the social systems theory for conceptualizing citation decisions can be understood as an attempt to overcome, improve or converge previous theories into a theory with greater explanatory capacity. However, our attempt needs to be further explored, substantiated, and theoretically contrasted in future studies. For example, the potential of the SSCT could be investigated by contrasting it with theories of other sociologists such as Pierre Bourdieu. With respect to the complex nature of citation motives, it might be interesting to incorporate Bourdieu's concepts referring to power or symbolic capital into the contrasting citation theory. Further contextual factors such as the language of publication, the fame or reputation of the journal, the country, sex or academic rank of the authors, among others are linked to citation decisions and could be additionally considered. Citation decisions are also influenced by factors of a more psychological nature, which do not seem to have been investigated in depth in empirical studies. Since in the SSCT,

citations are dissociated from their context (e.g., social, historical, cultural, economic or political) and from the people who have produced them, in order to state them as abstract "communications," Pierre Bourdieu's theoretical attempt might offer another interesting path to understand citing processes.

> The SSCT gives advice and support to a new (promising) trend in evaluative bibliometrics to go away from simple citation counting towards analysing citation networks

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