# Scientist's semantic meaning of the concept of coauthorship[1]

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**Abstract**
The purpose of this study is to determine the semantic meaning of *coauthorship* for a group of scientists, based on the assumption that the meaning of a concept is related to experience on 'how a person behaves in a situation, depending on what that the situation signifies to him' (Osgood and Tannenbaum, 1957). The semantic meaning provides for an interpretation on action in beliefs, goals and intentions, following the idea that semantic meaning is a basis for inferring intentions to perform action (Grosz & Kraus, 1996). In order to find out what is the meaning of *coauthorship* for scientists at the Universidad Nacional Autónoma de México we used the Natural Semantic Networks Method (Valdez, 1998). We interviewed 162 scientists in various disciplines in exact and natural sciences. Results show a core cluster of the semantic meaning of coauthorship in which collaboration, teamwork, work, common interest, discussion, sharing ideas, and some others, are included.

**Background**.

We define collaboration as a set of actions that take place in a group of people or other entities (scientific societies, institutions, etc…) with a common purpose. In science, collaboration ends up in a manuscript signed by collaborators in form of coauthorship, which can be an indicator that there has been interaction and agreement between collaborators about the results.

Couathorship has been widely measured through bibliometric methods. Katz & Martin, (1997) have provided evidence that *this is a partial indicator of collaboration in science, since there are as many contributing factors as there are individuals involved.*

From the point of view of small group psychology, we propose that coauthorship is the resulting '*bond*' (Liberman & Wolf, 1998) of the process of group collaboration in science; it is an indicator of interaction, communication and consensus. Coauthorship accounts for recognition of task achievement in a group, in the process of generating scientific knowledge. We consider that collaboration takes place in the process of informal communication between scientists and coauthorship is the result of the vicissitudes in a group process, observable in the formal cycle of scientific communication.

In developing a group model of scientific communication, we claim that there are two cycles of this phenomenon that have to be studied. We consider that scientific communication has an 'inner cycle', considered informal, and an 'outer cycle', considered as formal. (Liberman y Wolf, 1990).

The inner cycle takes place 'face to face' or in a personal direct situation where scientists are able to establish a direct contact or a relationship. In most cases there is geographical proximity (Kraut, Galegher, & Egido, 1990), and/or intellec-

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tual identification (Mathieu, 2000). Nowadays it can happen through electronic media, but it is still personal. It can happen establishing contacts in meetings or institutions, (Liberman & Wolf, 1997).

The outer cycle is reflected in printed or electronically archived databases that contain the universal archive of science. Through this cycle, the context and boundaries of the small group can be defined. The network perspective takes account of these phenomena in a structural visualization.

The process of collaboration is embedded in a group communication process constructed on the basis of communication variables that usually promote or prevent group productivity. We allege that in group processes there is a difference between internal tasks and external tasks. Internal tasks account for developing a common language, building consensus and establishing criteria for inclusion, distributed work, and determination of patterns of scientific recognition. Usually there is an agreement depending on norms and rules of who should get the credit in a publication and in which order since visibility is at stake. External tasks include negotiating, adapting and managing relationships with the context of the group (Wheelan and Krasick, 1993, (Ancona & Caldwell, 1991, 1992).

In a previous study (Liberman & Galán, 2005), on the semantic meaning of International collaboration, we found that there were 716 different meanings associated to the concept of *international collaboration*, coauthorship was not one of the main concepts in the overall meaning of the concept of international collaboration. For international collaboration scientists mean contacts (informal and formal), meetings, publications, common interest, short visits and others.

**Scientific Communication.**

Scientific communication can be studied in reference to a group, community, institution or communication system. At the small group level we have a chance to share tacit knowledge, explicit knowledge, symbols, meanings and information. Communication allows scientists to predict others behavior and adapt their own. In the process some of these behaviors and patterns of communication are shaped to the needs for exchange and recognition.

Since we established a difference between inner and outer cycles of communication, we claim that scientists that establish contacts with the purpose of sharing knowledge, skills, resources and sometimes reputation, engage in a process of collaboration with the expectation of signing an article together, presuming that when contacts prevail they become bonds resulting in coauthorship.

Coauthorship is provided by shared meanings on the content of the produced knowledge, norms and rules at work and in relation to the context of the group, the field of knowledge or the institution.

The communication process involves an expert definition, an agreement and finally a consensus through which knowledge flows. In a practical sense, scientists communicate in order to collaborate, sheltered in a wider consensus in which collaboration has an end. Joint scientific publications are the reflection of this process. Therefore in this case we define scientific communication as a small group process in which scientists share meanings and socially distributed representations resulting from direct interaction.

The communication process is constant, dynamic and it is the basis for argumentation, shared meaning, and consensus, needed to allow the flow of knowledge. Shared meanings represent implicit knowledge on content and appropriate behaviors in the production of scientific knowledge.

In our model of scientific communication, collaboration is a process that takes time, resources and a group of scientists with shared interests interacting dynamically.

**Scientific collaboration and coauthorship.**

Collaboration is a set of coordinated actions that take place in a group of people with a common purpose. Cognitive and social factors have a bearing on the type and length of the collaboration. Sometimes collaboration is between two colleagues in the same institution or abroad. Collaboration also takes place with students or new graduates who are seeking for a position.

Scientist's behaviors in collaboration are fuzzy and very hard to measure. Scientists confirm that anybody related to the research, either by generating an idea, method, using an instrument, collecting data or interpretation should be included as a coauthor. (Liberman & Russell, 2004). We can infer some of the behaviors involved in this process, but we cannot confirm each one of them or suppose any regularities for generalization.

Kraut, Galegher & Egido (1987), propose that there are three stages of development of group interaction in science; Initiation, execution and presentation. These three stages imply a set of activities that alternate at two levels; The relationship level and the task level. From finding a partner to writing a manuscript, scientists have to confront with many activities that involve some problems that are usually solved during the process, based on a broader agreement of the outline of their work. Their conclusion states 'that establishing and maintenance of a personal relationship is what glues and holds together the pieces of collaborative research'.

Since these activities could help describe the process of collaboration in a small group of scientists, they should be accounted for and therefore social influence, norms, division of labour, conflict and other small group processes that have rarely been measured in scientific groups should also be measured in order to understand how collaboration takes place and how and why sometimes ends up in coauthorship. Group formation and decisions of who does what are constantly evaluated since scientists look forward for recognition based on the order of authors in the publication.

If we assume that coauthorship is the resulting '*bond*' of the process of group collaboration in science (Op. cit.), we can claim that it indicates that scientists have a shared meaning of their collaborative activity. For this to happen, shared representations or cognitive representations of the knowledge have to be created, so we can conceptualize teamwork, group rules and norms, the context and the patterns of recognition between the group members and the context of the group.

Collaboration takes place in the process of informal communication between scientists and coauthorship is the result of this group process, coauthorship is then agreed, based on what happened in the inner cycle, and what does the group of scientists wants to report or deliver in the outer cycle of scientific communication.

Collaboration in science is already a common practice, advanced technology is becoming part of this process and it is having an effect on the structure of science. It is also becoming clear that different scientific communication practices are characteristic of different scientific disciplines (Lima, Liberman & Russell, 2005).

**Shared semantic meaning.**

In psychology, the semantic meaning is related to words associated to beliefs, attitudes and behavior, based on the assumption that the meaning of a concept is related to experience on 'how a person behaves in a situation, depending on what that the situation signifies to him' (Osgood and Tannenbaum, 1957). Johnson-Laird (1988) has alleged that the association is just a link between words and meaning that should be labelled somehow. We propose that this link is part of tacit knowledge acquired through exposure and experience.

The theory of semantic networks is based on an associative theory in which meanings are represented as links. Semantic network analysis is a research method for examining the relationships among a system's linguistic components based on the shared meanings of symbols. Semantic networks, also known as concept maps, are spatial representations of concepts and their relationships intended to represent the knowledge structures stored in semantic memory (Marra, & Jonassen, 2002). Semantic networks methodology has been widely used in the design of collaborative computer models (Novak, 1998). The relation between words has been largely used by network methodologies.

In our perspective we assume that a shared meaning exists when a group of people use the same words to designate a concept related to their task. In this direction the structure of a semantic domain, may be interpreted as a cognitive representation. Moscovici (1973), states that social representations provide people with "a code for social exchange and a code for naming and classifying unambiguously the various aspects of their world and their individual and group history". The meaning allows for recognition of others intentions as shared cognitive representations (Cannon, et. al. 1993). Through the use of the intentional schema, the observer could generate a representation of the intentional relation that could be applied equally to the looking activity of either self or other. (Barresi & Moore, 1996).

Scientific knowledge is dependant on sharing linguistic meanings (Romney et. al. 1996). Groups go through sequential stages of development that are marked by specific thematic content (Bennis & Shepard, 1956) and through these, the shared meanings relative to the group allow for interacting and predicting others interaction through a series of contacts between group members, focused on achieving a task. In scientific groups, usually the task is the production of scientific knowledge accredited through a publication that all or some of the members of the group sign. Coauthorship is considered a benefit for the scien-

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tist, especially when it has the same meaning to all authors included.

As a part of the cognitive representation of the whole process, scientists give credit and recognition depending on what happened during the development stages of the group. Studies of science assume that coauthorships and the order of names in publications have been agreed before they are printed.

We are interested in finding out the shared semantic meaning of coauthorship considering that the semantic meaning of core concepts in scientific endeavour provides for an interpretation of action in beliefs, goals and intentions, following the idea that semantic meaning is a basis for inferring intentions to perform action (Op. cit.). We cannot support the idea that coauthorship means just signing an article together, many times the names in the paper did not necessarily collaborated. We intend to describe the meaning of coauthorship assuming it is the result of a group process in which scientists share this cognitive representation.

**Method**

This is a descriptive study in order to find out what is the shared semantic meaning of *coauthorship* for scientists at the Universidad Nacional Autónoma de México. We used the Natural Semantic Networks Method (Op. cit.). The natural semantic network is a representation of all meanings attributed to a concept. Through this technique we invoke the semantic memory in relation to a concept in the context of a specific group of people through designated free associations defined as links from one representation in memory to another, (Johnson-Laird, 1988).

The procedure is based in a first step on eliciting associations to a stimulus word, and second assigning a hierarchy based on perceived proximity to the stimulus concept. We attain a cluster of the main concepts as a representation of a semantic network of the concept. It allows to develop a map of decomposition of meanings into semantic primitives, therefore allowing for the description of a semantic network as a semantic universe in terms of shared meanings.

Data are collected through interviews in a real setting avoiding artificial taxonomy and our choice of the technique responds to our intention of finding a non-intrusive, not preconceived taxonomy and independent situation to generate the semantic network

We interviewed 162 researchers at the National University of México in four disciplines, Biotechnology, Physics, Mathematics and Chemistry. These researchers are all senior researchers with a graduate degree and have at least five or more publications in indexed journals.

We obtained a total of 1130 words, which is the Value J that indicates the richness and the size of the network, with an average of 6.9 definitions per person. Then we calculated de *M* value that is obtained by adding the values of the multiplication of the appearance frequency by the obtained hierarchy for each one of the definer words generated by the subjects. This is an indicator of the semantic weight for each generated concept. For the semantic distance we  And finally we proceeded to define the set of words that have the highest semantic weight (Value *M*).

There is no agreement on how many words should be included in the core of the network (*SAM* cluster), in some cases the core of the network is defined by droping all the concepts that are located after the asymptotic curve falls drastically, in other cases, the semantic distance is obtained assigning 100% to the highest values and producing the following values thorugh a simple rule of three. From what various authors of this technique have argued and the results obtained, we decided to include up to 16 definers of coauthorship, in order to demonstrate the richness of the network.

**Results**

After analyzing the data from the interviews, we show the first 16 concepts with higher semantic values, which we define as the core concepts of the semantic network of coauthorship. (Figure 1).

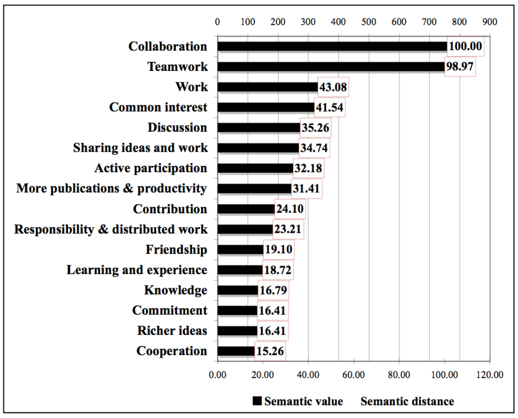


Figure 1. General natural semantic network of coauthorship.

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Results with the highest semantic value show that coauthorship means collaboration, teamwork, work, common interest, as representing the closest semantic meanings to 'coauthorship', followed by discussion, sharing ideas, active participation, more publications, contribution, responsibility and distributed work, friendship, learning and experience, knowledge, commitment, richer ideas and cooperation. If we followed the criterion set by the originators of this technique, we should drop almost all the meanings leaving as the core of the network the first four meanings. Our intention was to show the prolificacy of the technique.

While examining our data we decided to demonstrate that the semantic weight is different from frequency of *first association appearance*, so we present an analysis of a frequency of appearance of the semantic meanings of coauthorship in the total of elicited concepts in this sample, which was calculated following the first step of the methodology of Natural Semantic Networks without considering the hierarchization made by the subjects (Table 1).

| | |
|---|---|
| Teamwork | 783 |
| Collaboration | 775 |
| Work | 346 |
| Common interest | 302 |
| Discussion | 262 |
| Active participation | 257 |
| Sharing ideas and work | 257 |
| More publications & productivity | 241 |
| Friendship | 201 |
| Responsablity & work division | 192 |
| Contribution | 163 |
| Learning and experience | 161 |
| Commitment | 129 |
| Cooperation | 123 |
| Richer ideas | 119 |
| Knowledge | 116 |

Table 1. Frequency of appearance of the meanings of coauthorship.

**Conclusion.**

Following the statement that semantic meaning is a basis for inferring intentions to perform action (Grosz & Kraus, 1996), we have found a list of possible conditions for scientists to appear as coauthors.

*Collaboration and teamwork* are the two concepts that have the highest semantic value, and are the ones that characterize the semantic universe of the concept of *coauthorship*, followed by *work* and *common interest*. We consider these, the most consensually shared meanings of coauthorship in this population. After these, the concepts of *discussion*, *sharing ideas, distributed work* and *active participation*, refer to actions involved in the process leading to coauthorship. And then *more publications*, *productivity*, *responsibility*, *friendship*, *learning*, *knowledge*, and *commitment* are related to attitudes and beliefs of scientists involved in collaboration towards coauthorship.

The Natural Semantic Network analysis can be useful to build a theory which could allow to document a process that otherwise is very hard to measure.

Theoretical models of small group processes are shifting their conceptualizations of groups as closed systems into a perspective where teamwork is not only dependant on the internal cycle of the process of group communication, but it is always in relation to the context of the group, the external cycle. Therefore although we may consider that coauthorship is contained on the small group process before it becomes a delivered communication outside of the group, the essence of scientific teams is to produce knowledge that is universal and public.

Likewise, collaboration is not necessarily an internal process given that many times tacit knowledge and skills are shared in contact with groups with the same interests. Since coauthorship means collaboration and teamwork, we may propose to study groups in science not as isolated units, but as part of a wider system that has parallel groups doing similar studies in other places. When scientists in these groups come in contact they have an identification process that at certain moment of the development of their research might include both teams as one in a process of collaboration. An example of this is the study made by Collins (2001) about the quality factor (Q) of Sapphire, or the studies that focus on experience and expertise (Collins & Evans, 2002), especially when two disciplinary fields interact to solve one problem. Interactional expertise and the existence of trading zones are based on sharing a common declarative knowledge (Gorman, 2008).

In general we can assume that coauthorship is indeed related to individual behavior in small group processes, giving us a path through which, studies on scientific communication from the point of view or Psychology of Science should be oriented to in the future.

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