CRAFTING SONIFICATIONS: LEVELS OF INTERDISCIPLINARY EXCHANGE IN GROUP DISCUSSIONS AND THEIR EMPIRICAL ASSESSMENT

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ABSTRACT

This paper proposes a methodology to empirically assess the level of cross-disciplinary collaboration. Drawing on a variety of concepts established within Science & Technology Studies (STS), it develops an operationalization of a framework developed by Michael E. Gorman. The data this methodology relies on are quantified transcripts of discussions within groups trying to collaboratively develop sonifications of given scientific data sets. The proposed methodology has been applied to data from a sonification workshop to evaluate its usability, and some results are reported.

1. INTRODUCTION

Artists and scientists engaged in the theoretical and technological development of sonification have long recognized the importance of a well-structured collaboration across disciplinary boundaries. Programming skills, experience with (digital) audio synthesis, and knowledge of psychoacoustics are as necessary as a profound understanding of the data at hand and the ability to anticipate whether and how sonification of data helps answer scientific questions. Sonification, thus, appears to be "interdisciplinary by nature" [1].

Although this crucial importance of successful cross-disciplinary exchange for sonification has been widely acknowledged, the question of how to most effectively organize collaboration in order to promote interdisciplinarity has been addressed rather hesitantly. Probably the most promising approach is to conceive of interdisciplinarity as outcome of a process [2]. Nonetheless, to assess whether or not cross-disciplinary exchange actually takes place in any given setting requires some form of measurement. And such measurement must in turn be based on a firm methodology.

Drawing on the Science and Technology Studies (STS) literature, this paper proposes such a methodology. It describes an operationalization of a framework developed by social psychologist Michael E. Gorman and reports results from a study which tested the proposed methodology. Thus, the proposed methodology for measuring the level of cross-disciplinary exchange is both theoretically grounded and proved to be practically applicable. It is claimed that the methodology allows for rating interdisciplinarity in many similar working contexts.

2. THEORETICAL BACKGROUND

The framework for describing interdisciplinary collaboration developed by Gorman [3; 4; 5] integrates a variety of STS concepts – trading zones, shared repertoires, boundary objects – with a typology of expertise.

2.1. Trading Zones

The anthropological notion of trading zones was transferred into STS by Peter Galison to describe local contexts in which, "despite of the differences in classification, significance, and standards of demonstration," groups can exchange goods [6, p. 803]. Just as trade among culturally heterogeneous tribes, cross-disciplinary collaboration to Galison is first a problem of language, and he discerns several types of languages along their degree of complexity: he speaks of pidgins, extended pidgins, and creoles. Pidgins are languages "composed of no more than a few hundred words and (...) designed to coordinate a highly specific exchange of goods;" extended pidgins are characterized by a "significantly larger lexicon and more flexible syntax;" and creoles are, finally, "languages powerful enough to support the range of poetic, metaphorical, metalinguistic, and referential work." [6, p. 48] Pidgins can develop into creoles, and back, depending on the intensity of trade, i.e., in our context, of cross-disciplinary exchange of knowledge.[1]

2.2. Shared repertoires and time

The importance of language in cross-disciplinary collaboration has been widely acknowledged. Cross-disciplinary working teams in science must develop a shared repertoire in order to achieve their aims. By comparing the repertoires and assessing their overlap, the researcher can attempt to determine the degree of mutual understanding. It has, not surprisingly, been observed that shared repertoires within cross-disciplinary work groups require a certain amount time to evolve. Duncker notes that "The emergence of a shared symbolic repertoire in a multidisciplinary

[1] The argument of language as *conditio sine qua non* trade can be challenged. 'Silent trade,' i.e. trade between two partners who directly interact, but do not share any common language, is at least a theoretical possibility, though it is doubted that it empirically ever existed [7]. In the realm of science however, where the concept of trade is used as a metaphor, the idea of silent trade is nonsense. Even if there can be trade without language, there is no science without language.

environment is a long-term development; it needs much more than six years." [8, p. 382]. Consequently, much empirical research done on this topic was concerned with scientific collaborations that experienced an ongoing duration for at least some years [8; 9; 10].

2.3. Boundary objects

As we have seen, trading zones allow for the development of shared repertoires. These repertoires can be used for trade, i. e. for an exchange that is crucial for a collaboration across disciplinary boundaries and hence for the production of new knowledge. Often, this cross-disciplinary production of scientific knowledge is centered on an object. This object might be a document, a catalogue, a machine, or, as with our case, a sonification. Such objects are "boundary objects" [11]. They are located at the boundaries between different groups. They allow for communication, and function as a "means of satisfying (...) potentially conflicting sets of concerns." [11, p. 413] They "organize shared but simultaneously distributed cognition among various social worlds," and are used "without presupposing a fully shared definition of an object" [8, p. 357]. They therefore mediate between different groups, allowing for collaboration without having to rely on the development of a more comprehensive shared repertoire. People can contribute to the development of the object without necessarily discussing its trajectory with others.

2.4. Levels of trading zones

Gorman [3] integrates these concepts and perspectives into a framework for describing multidisciplinary collaboration (see Table 1). He distinguishes three kinds of trading zones, which he then relates to different levels of expertise as defined in Collins and Evans [12; 13].

Trading zone	**Expertise**
Elite	None
Boundary object	Interactive
Shared representation	Contributory

Table 1: ***Trading zones and related forms of expertise***

The elite trading zone can be understood as "a network controlled by an élite in which there really is no trade: those not in the élite either obey or they are ignored" [3, p. 933]. There is no exchange of knowledge, only of order and service. Apart from one's own specialization, no specific expertise is required. While, formally, all the members on the list are equally important to the cross-disciplinary project, a small group dictates its direction and takes the core decisions.

The second is a boundary object trading zone. "Here the system of concern serves as an object that links the participants in the network, but experts from different fields see the boundary object in ways dictated by their expertise." [3, p. 934] The participants require interactive expertise, i.e. the ability to understand the basics of the fields outside one's own specialty.

Finally, the third trading zone is defined by the fact that "participants share a common understanding of a goal and collaborate closely. In the parlance of cognitive science, they must share a continually evolving representation of a techno-social system." [3, p. 934] They develop a shared symbolic repertoire, and have contributory expertise, which means that they all are able to contribute to the developing knowledge system [4; 14].

3. DATA

The operationalization of this framework as measurable criteria is based on data collected during a three-day sonification workshop. It took place in March, 2006, at the premises of the Institute for Electronic Music and Acoustics (IEM) of the University of Music and Dramatic Arts Graz. Cross-disciplinary groups had between 1 and 1.5 hours to design a sonification of a given scientific data set. Groups assembled programmers, sonification experts, (domain) scientists, and moderators (see Table 2).

progr	Programmer
sonex	sonification expert
domsc	scientist, data come from his/her domain
othsc	scientist, data do not come from his/her domain
moder	moderator
mess	not applicable due to mess
sil	not applicable due to silence

Table 2: ***Properties of variable role***

The sessions of the work groups were audio-taped by MD-recorders. Based on a qualitative evaluation of these recordings, a category scheme was developed that was then used for a quantitative content analysis of the audio-taped group discussions. The elementary unit of this transcription was five seconds. For every five seconds, it was documented who was speaking about what. The decision for using five seconds as coding unit was based on the insight that continuous coding decisively increased the workload tremendously. Hence, one case is made up by a unique time stamp plus a pair of variables (called speaker and content) that inform about the identity of the speaker and the content of her/his statement. A further variable was introduced to denote the role assigned to each participant (role). After a first trial run, the category scheme was revised and then applied to all the available group discussions (see Table 3).

mod	moderation, management of time and organization of work
dat	understanding data and scientific question
des	sonification design
sou	sound design
tec	technical implementation, programming

doc	documentation, reflection of the group process
lis	listening to, describing, and discussing sonification
jok	making jokes, "informal" communication
mess	not applicable due to mess
sil	silence

Table 3: ***Properties of variable content***

In the two days of the workshop, four data sets were sonified. These were data of the electric power consumption in Graz (set 1), human EEG data (set 2), social data of the world population (set 3), and finally precipitation data from the European Alps (set 4). The sessions on these data sets took place on two sub-sequent days, the first and second on Day 1, the third and fourth on Day 2. On both days, three separate groups were working in parallel, which results in 12 group sessions to be analysed (see Figure 1 for an example of the distribution of discussion time).

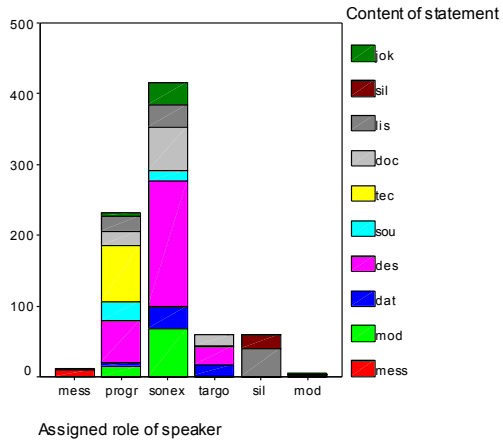

Figure 1. ***Example of the distribution of discussion time in one session (unit = 5 seconds)***

4. METHODOLOGY

4.1. Elite trading zones

We can speak of an elite trading zone when the group discussion is dominated by specific individuals. The discussion time filled by other group members is relatively low. The threshold used for determining a dominated group discussion was 15%; this value is not derived from empirical study and therefore not stable, but it receives some backing from the standard literature on group dynamics. A group discussion thus can be defined as an elite trading zone when the speech time is dominated by the programmers and the sonification experts so that the time filled by the domain scientists, the other scientists present, and the moderator sums up to less than a 15% (excluding silence and mess): in the following, I will refer to this as criterion 1.

The notion of elite reflected in criterion 1 does not a priori assume power differences between the participants, but accepts that in respect to speech time, one role can appear dominant in the discussion just because the others are curious and listen to what happens. They do take part, but do so in order to learn, e.g., by questioning other group members they view as having more experience. Thus, the notion of elite does not imply that the elite group has a determined interest in maintaining their status and/or oppressing the others.

4.2. Boundary object trading zones

Here, the group discussion is centred on the sonification (as the boundary object). Each group contributes to the discussion based on its understanding of the object and of its role in producing the object. Consequently, one main task per group is defined. The main task of the domain scientist is to provide insights in the data (*dat*). The main task of sonification experts is to develop and explain approaches to the design of the respective sonification (*des*). The programmers' main task is to deal with technical concerns (*tec*). The other two groups are not included in the analysis. The moderator's task is, of course, moderation (*mod*); target scientists who are not familiar with the data of concern (*othsc*) do not have a specific task.

In addition to criterion 1, which determines that the amount of discussion time filled by other group member than the programmers (*progr*) and the sonification experts (*sonex*) must exceed the 15% benchmark, there is then a second criterion for the boundary object trading zone: the representatives of three core roles (*progr*, *sonex*, and *domsc*) used the largest share of their discussion time to contribute to their main task as described above (criterion 2).

4.3. Shared representation

The characteristic feature of a shared representation is that the members have developed a shared repertoire. It was decided that the operationalization of this trading zone should be based on the assumption of a uniform distribution of speech time over the relevant groups, and a similar distribution over the speech contents for each group. This resulted in two criteria and related steps: the first is to assess whether the discussion time is distributed equally, for instance by using a χ^2 test method (criterion 3). The second step then is to analyse the distribution of speech content within the groups (criterion 4); again, a χ^2 test method is feasible.

5. RESULTS

Table 4 provides an overview of the data. The first line in each cell gives the number of participants and how they distribute over the most important roles. The first cell, reading "7 (0/2/1)", tells us that group A, when dealing with data set 1, consisted of 7 persons of which none was a domain scientists, two were sonification experts, and one acted as programmer. The second line in each cell displays the duration of each group discussion. Bold letters indicate that criterion 1 was met. Further, shaded cells indicate that criterion 2 was met. Criteria 3 and 4 were not met; which is not surprising given the short-term character of the collaboration.

	Day 1	
	Set 1	**Set 2**
Group A	7 (0/2/1) 65 min	**7 (2/2/1)** **82 min**
Group B	7 (1/2/2) 69 min	7 (0/2/2) 84 min
Group C	8 (1/3/2) 71 min	**8 (0/3/2)** **96 min**

Table 4: ***Results of data analysis, day 1***

	Day 2	
	Set 3	**Set 4**
Group D	6 (0/2/2) 93 min	6 (0/2/2) 93 min
Group E	7 (1/3/2) 94 min	7 (1/3/2) 96 min
Group F	**7 (1/2/2)** **89 min**	**6 (0/2/2)** **88 min**

Table 5: ***Results of data analysis, day 2***

We can thus state that even in these very brief periods of time, trading zones did develop and exchange across disciplinary boundaries did happen. Most of it was elite trade, with one role actively leading the cross-disciplinary collaboration. However, in two of the twelve cases, there emerged a boundary object trading zone, which means that the exchange was closer to the ideal of interdisciplinary collaboration. None of the groups, for obvious reasons, could develop a shared repertoire.

6. CONCLUSION

This paper proposed a methodology to measure collaboration across disciplinary boundaries. This methodology is well-grounded in current STS theory and has been successfully applied on a large amount of empirical data. It appears justified to claim that the methodology can be used for measuring interdisciplinarity in many similar working contexts.

Still, the methodology could be extended to take into account various types of speech acts, e.g. answers, proposals, explanations, rejoinders, and orders. If these are discerned, they can be used for formulating alternative criteria. It could then be assessed, for instance, whether the sonification experts propose and discuss various sonification designs or whether they just explain and decide. Of course, this extends the time necessary for transcription and data preparation. Further, the theoretical background would have to be adapted to interpret the new variables. This would have to go beyond the Gorman framework.

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