Understanding the meaning of awareness in Research Networks

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Abstract The term awareness is often used in the context of CSCW research and connotes re-establishing face-to-face situations in so-called groupware applications. No understanding of it yet exists in the context of networked learning and networks of researchers. In this article we present a succinct description of awareness in Research Networks. It is grounded in guided, semi-structured interviews with 42 researchers that have extensive knowledge of cooperation in networked communities and the awareness issues it raises. From the analysis of the interview data we present six forms and five aspects of awareness in Research Networks. Finally, we present a layer model of awareness that describes how researchers' awareness is typically spread.

Keywords: awareness, cscw, research networks, knowledge work, research 2.0

1 Introduction

As early as 1959 Peter Drucker identified that society was moving into a post-industrial age, which was going hand in hand with a shift from manual to non-manual work [7]. While all kinds of jobs involve a mix of physical, social and mental work it is the perennial processing of non-standardized and non-linear tasks that characterize knowledge work; knowledge workers carry out these knowledge-intensive tasks during their daily work and researchers are the role models of knowledge workers. Looking at the work descriptions of researchers reveals that they have to analyze existing knowledge, deconstruct it, de- and re-contextualize it again in order to create new knowledge that then is disseminated in their Research Networks. So they need to be constantly aware of latest research results,

scientific trends and new technological developments that they can take into consideration in their own work.

While research is often deemed to be solitary work, international cooperation has become the de facto standard. Large funding programs often even require transnational, interdisciplinary project consortia as it is believed they foster innovation, multiple views on a research topic and promote dissemination in the appropriate Research Networks. Such Research Networks may be viewed as a special kind of Learning Networks [23,28], online social networks whose members are researchers that use various learning services in order to reach individual and shared (learning) goals. Sometimes these goals are externally prescribed, at other times they are formed by the intrinsic motivation to know more about a topic. Research Networks are made up of people that interact with each other. Moreover, in them there are many relevant objects (e.g., publications, events, projects, people) that influence learning, knowledge gain and cooperation, and researchers aim to be aware of this.

Despite the massive impact that Social Media have on the way research is conducted and communicated [17,27,31], it is still scientific conferences, fairs, journals and books that are most often used for the dissemination of research results. Research is currently shifting from closed to open, from hidden to visible and from passive consumptive to active, co-determinative (also see [17]). Even though the way of scientific publication has not changed much in the last 300 years, it does currently and will change massively over the course of the next 10 years. Not only the number of high-quality publication outlets has increased enormously, also the common understanding of authority in research has changed considerably.

Scientific results do not need to be published in access-controlled journals anymore in order to receive notable attention. The number and citations of peer-reviewed publications are still the de-facto currency when it comes to professional evaluation of researchers' work. However, this supremacy is beginning to crumble as an increasing number of researchers as well as society at large are digesting pre-mature results that researchers share in blog posts, presentations or tweets. Thus, there are well-known metrics for the impact of classic publications and there have to be new metrics that factor in impact and buzz in the Science 2.0 reality. Lately, many researchers are trying to establish alternative metrics that are able to assess the impact and reach of scientific publications in Science 2.0 media (see the #altmetrics movement and their manifesto [18]). Moreover, open access to scientific publications is gaining significant ground and an ever-increasing number of institutions are urging their employees not to publish research findings in closed, pay-to-access outlets or give the full copyright to publishers [4].

Traditionally the concept of awareness is used in the research field of Computer Supported Collaborative Work (CSCW) to re-establish conditions of face-to-face situations in the online realm, with visual cues showing, for example, who is online or working on a document. Research on awareness support in the CSCW context has often been directly related to the direct improvement of cooperative practices and measurable task performance improvements.

This paper presents parts of a larger study that deals with awareness issues in the context of Research Networks. In particular, we report about our findings on how properly to understand the notion of awareness in Research Networks. We hypothesize that the term awareness is more complex and touches on broader contexts than we know from existing CSCW research. The results of our study go beyond the perception of awareness as being a mere enabler and enhancer of collaborative work processes. The results are based on interviews with 42 researchers that took place in October and November 2010.

First, we introduce the three research questions as well as the method of data gathering, data processing and analysis we applied. After that, we present a definition of awareness in the context of Research Networks that integrates the results of our interviews with established awareness research results. This includes the introduction of various forms and aspects of awareness in Research Networks. Synthesizing these results, we propose a layered model of awareness in Research Networks, which incorporates five layers of awareness. Finally, we summarize the results of our study, give an outlook on future research and discuss important side effects of awareness in Research Networks and practical applications of the introduced model.

1.1 Research questions

Three research questions were addressed in the research presented here:

1. How do researchers define awareness in the context of Research Networks?
2. What different forms and aspects of awareness in Research Networks are there?
3. What could a model of awareness in Research Networks look like?

1.2 Method

We used open, in-depth and semi-structured interviews as our method of data collection. An interview manual provided the basis for open-ended questioning. Each interview was carried out by one of three different interviewers. In three cases the manual was sent to the interviewees via email beforehand. All participants were interviewed in their normal working context. The participants of the study have been asked explicitly for their approval to record the interview. In most cases the interviews were conducted remotely and recorded using the FlashMeeting service [29].

1.3 Sampling

The total population sampled consisted of all researchers that have been authors within the European Conference on Technology Enhanced Learning or were members of Technology Enhanced Learning (TEL) projects funded within the Framework Programme 7 (FP7).

82 researchers from different research disciplines and different countries were asked for voluntary participation in the interview series via email. More than half of the invitees (43 researchers) agreed to be interviewed. Although 43 interviews were conducted, one recording was not suitable for further analysis due to technical problems. 30 interviews were conducted in German, 12 in English. The age of the interviewees was between 27 and 61 years, 32.5 years on average. 35 out of the 43 participants are male (83%), 7 female (17%). The interviews lasted between 28 minutes and 126 minutes, 51 minutes on average. Table 1 gives the job locations of the interviewees.

Table 1. Job locations of the interviewees

Country	No	Country	No	Country	No
Austria	6	France	1	Sweden	1
Belgium	2	Germany	15	Switzerland	2
Canada	1	Ireland	1	The Netherlands	4
China	1	Israel	1	United Kingdom	5
Ecuador	1	Spain	1		

Most of the participants are involved in the field of TEL and are in possession of a PhD (44%) or Master (53%) as their highest degree. The extent of professional experience ranges from 1 to 30 years. The scope of research fields of the interviewees includes Computer Science Education, Recommender Systems, Knowledge Management, Human Computer Interaction, Semantic Web as well as Model-based Testing, Social Research and Psychology.

1.4 Analysis

The coding of the transcribed interview data took place in multiple iterations and was supported by the Atlas.ti [26] qualitative data analysis software. The continuous process of close reading of the transcripts allowed the identification of concepts and labels, which then were coded in Atlas.ti in constant comparison to previous codes. Atlas.ti supported the merging and renaming of codes. Co-occurrence tests built into Atlas.ti helped spotting inconsistencies in the coding and automatically generated visualizations of code relationships were used to identify patterns. In the following we will quote from the interview transcripts. A 3-tupel, denoting the primary document number in the hermeneutic unit of Atlas.ti, the code number within the document and the line numbers for the precise reference, will follow each quotation. Where needed, the authors translated quotes from German to English.

2 Approaching a definition of awareness in Research Networks

Awareness is an integral component of CSCW research. Dourish defined it as "*awareness is an understanding of the activities of others, which provides a context for your own activity*" [6]. In 2002, the influential CSCW researcher Kjeld Schmidt criticized the term for its fuzziness by pointing out that the term is found both "*ambiguous and unsatisfactory*" and that the notion of awareness would be "*hardly a concise concept by any standard*" [25]. He outlines the different awareness research strands by reviewing most of the existing literature and stresses the need for strong ties between awareness support and support for cooperative processes. In his understanding, any effort towards awareness support should result in enhanced individual or group task performance. Gutwin also stress that awareness' first mission should be to boost collaboration and particularly aspects of coordination, communication and assistance [12].

Awareness in Research Networks, however, concerns itself not solely with re-establishing face-to-face situations and direct impacts on bettering task performance. In Research Networks, awareness has a broader meaning and is related to trend-spotting, alerts to research results in a certain domain, changes in the structure of a network, personal changes within a project as well as knowledge about objects that may help carrying out one's task (research question 1). The interviewees pointed out that awareness in Research Networks "*is mainly to know what sort of people in the same field are doing*" (P13, 15, ll. 9-10) or "*is to know what is important to me and filter out what is not important to me*" (P27, 36, ll. 40-42). Another researcher stresses, "*If I have to search for something, that means for me, it's an active action from my part. That's not what I think about awareness. Awareness is something that is keeping remind me about something, without me actually trying actively to search that information*" (P27, 30, ll. 12-17). Moreover, "*awareness ... can have impact on the individual method of operation ... as it triggers reflection*" (P16, 58, ll. 306-320). Research shows that the availability of awareness support improves the effectiveness of how information is spread in communities [14] and positively influences social interactions taking place in those communities [11]. Most importantly, most of the interviewees stressed that they require "*awareness functionality to be embedded in [their] regular workflow*" (P9, 21, ll. 174-175).

It is quite difficult to keep up with who is doing what in the field, though many researchers are making quite an effort to monitor the data that is being spread on the Web by colleagues. In the past years research has explored collaboration of scientists by means of co-authorships of publications. In the TEL community, Henry et al., Wild et al. and Reinhardt et al. undertook such endeavors [13,21,32]. These have proven to be quite insightful, though they give only a snapshot of information and collaboration at a given moment, namely during the co-authorship of a conference paper.

2.1 Relevant objects in Research Networks

Scholarly communication is often understood to primarily refer to the publication of scientific publications. Building on Thorin [30] and in line with Procter et al. [19], we understand scholarly communication to be broader in scope and incorporate all communicative activities carried out by researchers on a regular basis. In particular we include the joint developing of ideas, conducting research and carrying out experiments, discussing ideas with one's Research Network as well as information seeking and dissemination of research outputs formally and informally. Thus, researchers are confronted with a wide number of objects that they either need to be or should be aware of: there are projects the researcher is directly affiliated with, interested in or that are somehow related to the researcher. Documents in any form are one core product of labor for researchers: notably publications written by the researcher herself, publications written by other researchers, as well as deliverables of projects, (micro-)blog entries, rules and regulations, best practice reports. People and groups of people are other objects that having awareness of is paramount. Awareness of people is relevant in multiple aspects at the same time and while it may be important to be highly aware in one particular aspect and not so in others, at other times the situation may be reversed. As researchers are often limited to a fixed domain, awareness of latest trends and new research findings in that domain and associated topics helps researchers to stay informed and up-to-date. Researchers often need to show that they are well informed about the state-of-the-art in their research domain and that they know about the key people, events and projects in that domain.

Grounded in the conducted interviews, this article discerns six different forms of awareness that are partly known from CSCW research as well as five different aspects of awareness (research question 2). Whereas forms describe generic areas of awareness, aspects focus on specific awareness characteristics relevant for the awareness of different objects.

2.2 Six different forms of awareness

1. Activity awareness Activity awareness deals with the past, present and future of an object. For people this could be realized with "*an activity stream about people that I am connected to*" (P30, 82, ll. 438-439), which would hold the latest information about their work in general, planned event participations, new collaborations or published content. From a broader perspective, activity awareness for a research domain is concerned with the "*state-of-the-art in a particular research area [...] where things are at the moment, who is contributing to that area, what is the latest thinking in that area*" (P1, 37, ll. 13-16). Activity streams and awareness dashboards seem to be helpful tools to support awareness if they could provide historical data, trend detection and forecasting in order to make claims like "*this author was very nice 10 years ago, but now is not any more. To know whose ideas are the current ones, it's difficult*" (P27, 56, ll. 186-191).

2. Cultural awareness Cultural awareness refers to a person's knowledge and perceptions about foreign cultures, their values, beliefs and perceptions. Cultural awareness is crucial when interacting with people from other cultures [20]. At the same time, research cultures differ massively between research domains. Some interviewees explicitly referred to this by calling it "*culturally informed awareness, e.g. where computer scientists have another focus than educational scientists*" (P39, 64, ll. 337-339). Differences exist both implicitly and explicitly in shared knowledge, social aspects of the research community, practices and conventions, common theories and cognitive processes, and with respect to theoretical assumptions. Awareness of those differences becomes increasingly important, as research projects are ever more multi-cultural and multi-disciplinary. Whereas training for intercultural competence and sensitizing is very common in economy, academia is slow at offering it.

3. Social awareness Social awareness describes the things people become conscious of in a social context. This includes information about the attentiveness of others, gestures and facial expressions that mirror the emotional state of a person as well as clues about a person's interest in a topic. Whereas social awareness is easily realized when workers are co-located, it has to be mediated in distributed working environments. [2] point out that supporting social awareness will help to minimize unwanted interruptions and disturbances of individual work as coworkers are supported in "*knowing that they're available to talk, when they're available to talk*" - (P8, 24, ll. 15-16). Social awareness also helps co-workers to align their work and alerts them about "*what we can contribute to each other and how we can assist each other*" (P1, 43, ll. 26-27).

4. Workplace awareness Workplace awareness refers to knowledge about the workplace design and job characteristics of co-workers and is strongly related to other forms and aspects of awareness. For example, it is import to know about the affiliation of a colleague and about the people working there. Workplace awareness is strongly related to knowing what colleagues in one's own research organization are working on, with whom they collaborate and "*where are possibilities to collaborate*" (P36, 39, ll. 294-295). Moreover, the interviewees expressed the need for background information about the job descriptions and responsibilities that their co-workers have within their affiliation and projects in order to enhance workplace awareness and subsequently improve the collaborative work. Information about the number of projects they are involved in, the thematic priority they have in their research projects, and if they are involved in teaching activities and supervision of PhDs would contribute in assessing the institutional involvement and engagement.

5. Location awareness Location awareness refers to knowing the physical location of an object. It can be related to one's own location – "*where am I right now*" (P17, 26, l. 40) – as well to the locations of others: "*where is the other one*

right now" (P40, 20, ll. 33-34). Location-aware applications support the user with contextual access to information and user-specific recommendations. Location-based information systems help becoming aware of spatial collaboration patterns [16] and may support location-based task execution [24,1]. Many researchers directly referred to "*a location-based awareness, like offered by services like Dopplr, TripIt etc.*" (P19, 42, ll. 187-194). They also underlined how such awareness impacted on social interaction opportunities: "*It is relatively trivial but sometimes also very helpful to know that someone from my Research Network is accidentally in the same city or at the same conference at the same time. That way it is easy to find connections*" (ibid.).

6. Knowledge awareness Knowledge awareness refers to the ability of a person to judge another person's knowledge about a given object [8,5]. Moreover, knowledge awareness may refer to the knowledge about someone else's competencies and skills as well as his method of operation. The interviewees would have liked support to assess "*which expertise has a person?*" (P16, 48, l. 227). Traditionally, knowledge awareness is created through intensive social interactions like working on a joint artifact, in a common project, or sharing an office. With the advent of Social Media, knowledge awareness can be increasingly gained through following someone's activities on the Web, the objects created and shared by him. Regarding the scientific publications of a researcher, knowledge awareness may be supported through "*awareness of references, so that you can see what the person also published. So you would further narrow it down and understand how the authors works*" (P26, 26, ll. 93-95).

Besides these forms of awareness, the interviews pointed towards the existence of five aspects of awareness that are relevant in the context of Research Networks.

2.3 Five different aspects of awareness

The five different aspects of awareness are relevant in any of the above forms of awareness. The importance of a single aspect, however, strongly depends on the object of interest.

A. The technological aspect of awareness The technological aspect of awareness is strongly affiliated with tools and techniques that are relevant for carrying out tasks. On the one hand there is always the question: "*where do I get the information from? Now we're on a technological level, which is more or less push or pull*" (P24, 28, ll. 32-34). On the other hand different technologies support different forms of awareness. Answering the question "*Which tool was used to create this object?*" may help repeating research results and understanding the methodology used. Moreover, answers to the questions "*Which tools could I use to accomplish this collaborative task?*" and "*How can I reach this person?*" are direct enablers of social interactions and cooperative work. With the increasing

number of tools that are used for consuming, producing and sharing information, awareness of one's own digital representations and those of others becomes crucial. Being able to easily find out through which services one is connected to colleagues or which username someone is using in a given tool constitute support of the technological aspect of awareness. This aspect of awareness is also related to the current trend of giving more people access to scientific resources.

B. The relationship aspect of awareness Awareness in Research Networks is strongly enhanced by providing information about the existing relations between objects, their status and dynamics. Researchers mention the need to know about *"the relations to people and groups of people that dealt with [an] artifact or where the artifact comes from"* (P30, 35, ll. 35-38) but also how they are affiliated with other researchers, which of their colleagues may help them in contacting to a yet unknown person or which institutions and projects some researcher is affiliated with. Automated notification about the fact *"that someone is leaving an institution and someone new steps in"* (P19, 22, ll. 65-67) would help researchers stay aware of changes in affiliations. Relationship awareness is also about connections between objects (e.g. by co-authorship or co-citation in the case of scientific documents but also by semantic relatedness or collaborative filtering in other cases) and people more specifically (what do these people have in common and what connects them?).

C. The content aspect of awareness The content aspect of awareness in Research Networks is very important as most objects researchers deal with are at least partly textual. This awareness aspect deals with assisting to more easily grasp the content of an object, e.g. by providing visual analytics, content aggregations or presenting metrics about the content. One interviewee said, *"Speaking about artifacts; in the case of research networks those artifacts are very often scientific papers, blog posts, presentations or even demonstrations that are available as video. If I take such an object, such an artifact, awareness means to me to get an overview about it. How is this artifact connected to others? What is the content? I mean an aggregation of the content, so I can more easily understand what it is about."* (P30, 105, ll. 26-35). The content aspect of awareness is also about support to easily grasp the essence of a document, and the topics, theories and concepts that scientific work and projects are based on. Moreover, it is related to detecting and presenting trends, approaching which topic someone is working on and which sources he is using to do so. Another perspective is on the timeliness of information and the quality of information.

D. The personal aspect of awareness The personal aspect of awareness is mostly relevant for people and groups of people. It is closely related to workplace awareness and refers to background knowledge about the persons one interacts with. Awareness of approaching deadlines or the family status contributes to a better collaboration with other people as it helps understanding and judging certain activity patterns. Similarly, awareness of other people's job status

(full-time, part-time, student assistant), their possible teaching obligations and involvement in other projects enhances mutual understanding and strengthens the ties between collaborators. Often, awareness on a personal level is also part of the more generic form of knowledge awareness, e.g. when "*looking at how long they have been in the field*" (P37, 56, ll. 117-118).

E. The contextual aspect of awareness The contextual aspect of awareness is complementary to location awareness. Whereas location looks at physical environments, context refers to other objects as well. Contextual awareness seems to be very relevant for people and groups of people, as the interviewees repeatedly expressed their "*need for context-dependent awareness information*" (P35, 47, ll. 236-243). Contextual awareness information for researchers would include information about where and when they last met or who is taking part in the same event or project. Moreover, this awareness aspect matters to both classic scientific media – "*If one of my colleagues publishes today a paper on something that I'm also working on*" (P9, 13, ll. 12-14) – and to more recent scientific objects – "*in which context have those [Twitter] messages spread or haven't spread*" (P39, 54, ll. 284-285). Finally, in Research Networks it is strongly related to one's own writing and that of others. Recommendations for matching content is needed during both consuming existing and producing new writings: "*based on your context and being aware of what you're doing, we'll suggest you, "Hey, here are actually slides that you did earlier that you may want to reuse now. And here are two slides that someone else has done and made available for reuse, etc."
And so it becomes part of your workflow*" (P9, 24, ll. 194-199).

Table 2. Overview of forms of awareness versus aspects of awareness. Asterisks (ranging from 1 to 5) indicate the relevance of particular aspects to a particular form of awareness

	A. Technical aspect	B. Relationship aspect	C. Content aspect	D. Personal aspect	E. Contextual aspect
1. Activity awareness	★★	★★★	★★★★	★★★	★★★
2. Cultural awareness	★	★	★★	★★★	★★
3. Social awareness	★	★★	★★	★★★★★	★★★★★
4. Workplace awareness	★★★	★★★★	★★	★★★★	★★★
5. Location awareness	★★★★	★★★★★	★★	★★	★★★★★
6. Knowledge awareness	★	★	★★★	★★★★★	★★★

Table 2 presents a matrix of forms of awareness versus relevancies of awareness aspects. The analysis of the interview data reveals that relevancies very much depend on the object of interest. While some aspect might be highly relevant for a publication, it is pointless for a scientific event.

Besides the above forms and aspects of awareness, the interviewed researchers discern different layers or circles of awareness. The next section introduces a layered model of awareness in Research Networks that reflects their distinctions.

3 A Layer Model of Awareness in Research Networks

The Layer Model of Awareness in Research Networks (LMARN) describes how the overall awareness of objects declines the farther an object is away from oneself (Figure 1). Answering research question 3 the conducted interviews reveal five layers of awareness in Research Networks:

1. Self-awareness,
2. Awareness of current projects,
3. Awareness of the local research organization,
4. Awareness of the personal research network, and
5. Awareness of a research domain.

The remainder of the research world surrounds the five layers. The LMARN also reflects the continuous competition for time that most researchers are faced with. They use a plethora of different tools, are often part of multiple projects, communities and sometimes even different research domains. Even though researchers are trained to work with multiple heterogeneous information sources, the advent of Research 2.0 has marked a new era of complexity, connectedness and information usage. The war for attention [10] as part of the attention economy [9] underscores the need for individual awareness support for researchers. Knowledge workers can only give their attention to objects and circumstances that they are aware of and because attention is a good in very short supply, objects that they have stronger personal ties to or that are perceived as more appropriate to one's own identity and task will more likely get the knowledge worker's attention than other objects whose usefulness cannot be assessed easily.

The LMARN is centered on an individual researcher for whom the model presents his individual reality. The t-axis of the model indicates that the socio-technical system surrounding the researcher is continuously changing together with the information he should be aware of. Objects may change their position within the model at any time. A spontaneous talk with a colleague from another research group, for example, will have immediate effect on the researcher's awareness of the colleague. The LMARN is grounded in empirical data and aims at providing a reference scheme of how overall awareness of an object increases the closer its physical proximity.

Any object in the awareness space of a researcher can be placed in one of the layers of the LMARN. However, there are exceptions where the overall awareness of an object in a layer further afar is higher than of one in a closer-by layer.

For instance, there are examples of researchers that have a much higher overall awareness of a colleague in their Personal Research Environment than of a colleague working in the same working group. Also, researchers will not be highly aware of all objects in their local research organization, especially if this is a large institution. The stronger personal ties become, the more personal details the collaborating partners have about each other and thus the higher the overall awareness in the described different aspects and forms of awareness is.
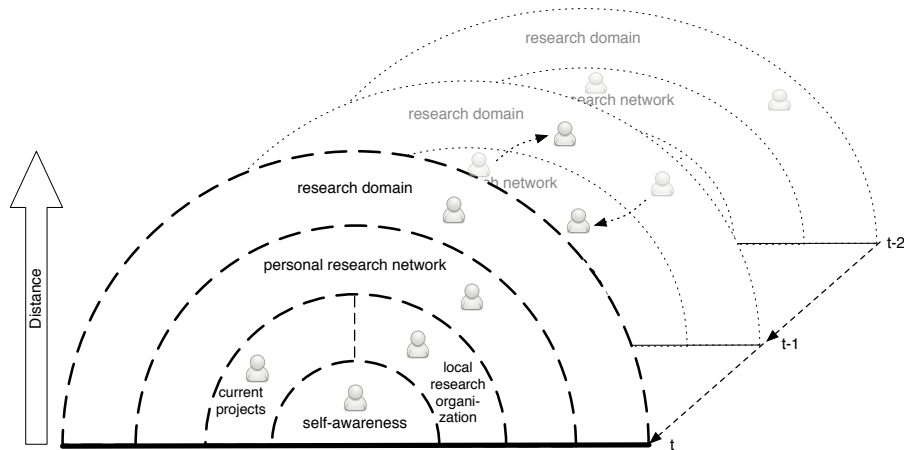

Figure 1. A Layer Model of Awareness in Research Networks

We will now describe the five layers of the LMARN that were derived from the interviewees' descriptions and discuss what impacts the overall awareness of objects in the respective layers.

3.1 Self-awareness

Self-awareness refers to a researcher's consciousness of his own identity as a researcher and how colleagues assess his work. The critical approach to one's own strengths and weaknesses, skills and competencies is also part of self-awareness as is the estimation of one's research opportunities and connections. Self-awareness is heavily related to reflection about one's own practices and how others perceive one's work. Based on a clear understanding of one's identity in a Research Network it becomes feasible to value recommendations, contextualize them and connect them to one's own work (see Berlanga and Sloep [3] for related work on learner identities).

3.2   Awareness of the local research organization

The first layer of awareness that we could derive from the interviewees is awareness of the local research organization. This refers to the knowledge "*about [one's] own workplace, what is really happening in [one's] own group*" (P10, 23, ll. 251-253). Depending on the size of the organization there might be additional nuances of awareness for one's own small team, the group in which the team is located, as well as the institute or department in which the group is residing. The interviewees also were very clear about the fact that "*the research organization [they] work in, is itself distributed and that's quite a complex social and organizational network for awareness of what [they] are all doing with regard to [their] work together*" (P1, 39, ll. 32-38).

3.3   Awareness of current projects

Also within the first layer of awareness is the awareness of current projects a researcher is involved in. Regardless of the specific role and position of the single researcher, being an active part of a project has major impact on the awareness of the activities, people and decisions within that project. Based on regular meetings and intensive collaborative work, project members are able to develop mutual awareness in multiple aspects, which could hardly be gained by outsiders to the same extent. This awareness often goes beyond the pure project-related issues and spans social, personal, and relational issues; it also strengthens the personal ties between project members and participating affiliations.

3.4   Awareness of the Personal Research Network

The Personal Research Network is composed of people and objects that a researcher is interested in, that he worked with in the past or plans to do in the future. "*Awareness of what people are doing within the broader [...] very distributed community*" (P1, 36, ll. 9-39) that they operate in and which is "*akin to [their] personal learning network*" (ibid.) seems to be crucial in order to keep track of the work of close-by researchers. Often, ties to fellow researchers loose their strength once a common project has finished and thus the overall awareness of their activities is declining. Also, it often requires much personal engagement to keep the mutual awareness alive. If this effort is not fueled, it may happen that colleagues vanish in the less aware layers of a research domain.

3.5   Awareness of a research domain

A research domain is the most abstract layer in the LMARN. Here, insight in the general connections, experts, projects and trends in a domain like TEL, Recommender Systems or Microbiology is relevant. Being able to trace "*what projects are being started*" (P22, 33, l. 76) and "*what are the latest, the hottest trends*" (P39, 44, ll. 205-207) in a domain is deemed of great importance to stay updated. Many researchers said they serve as reviewer for conferences, journals

and books on a regularly basis in order to "*get, you know, early copy of what the people are working on*" (P13, 30, ll. 106-108). Researchers stated that they are "*trying to follow what is done in the other research projects*" (P34, 40, ll. 122-123) in order to keep up-to-date about progress being made in their domain. Having awareness of a research domain is important for contextualizing one's own ideas, approaches and methods but also matters when it comes to bids for funding. Then researchers need to know what has been done in the past, what is in the making presently and where the challenges for future research are. Being aware of where the research domain is moving and who is working on what then enables researchers to approach colleagues saying "*I'm working on a similar thing, perhaps we could write a grant together*" (P15, 23, ll. 90-95).

Based on the above elaborations and empirical results of the conducted interviews and contributing to the answer of research question 1, we propose a succinct description of awareness in the context of Research Networks:

> *Awareness in the context of Research Networks is an understanding of one's own work and that of others in a given research domain. It bears on many different objects and supports the perception of how one is connected to others, what they are doing and how those activities shape the Research Network as a whole. Awareness in Research Networks involves multiple forms and aspects and is dependent on the physical location and strength of relational ties of objects in the individual awareness space. Generally, the overall awareness of objects declines gradually the farther an object is away from someone's current working focus and personal interest. Awareness is an enabler of social interactions, provides a framework for collaborative activities and may positively influence information sharing.*

4 Discussion

In this paper we presented the results of an interview study with 42 researchers that led to the empirical identification of six different forms and five aspects of awareness. Some of the identified forms are also commonly used in CSCW research. Knowledge and cultural awareness, however, have not yet been discussed within the CSCW community, as they not directly impact on the productivity of knowledge workers, which is an important criterion in the research community. The derived aspects of awareness, on the other hand, are indicators for areas to further support researchers' awareness with future developments and specifically tailored tools. Awareness requires a general interest in others and their work and even the best tools to support scholarly awareness will not overcome narrow-mindedness and egocentrism.

The layer model of awareness in Research Networks is directly derived from the interview data with experienced researchers and their gradations of awareness combined with the decrease in overall awareness. We acknowledge that this model is not universally valid but serves as a general heuristic of the awareness of objects

in Research Networks. The applied method, modeled after Mayring [15], limited our possibilities for interpretation as it only allows to inductively form categories and report about the statements of the interviewees. As it is generally true that researchers will be less aware of more distant objects, we also presented counter examples to this. Moreover, we know that often the presented layers will overlap and thus obfuscate the strict separation of the five layers.

The presented succinct description of awareness in the context of Research Networks may help researchers to better grasp the complexity of the term in networked collaboration of researchers that is heavily entangled with staying up-to-date about activities, trends and social interactions. Different from the CSCW research, awareness support in Research Networks should therefore be broader in scope in its social, methodological and technological aspects. Moreover, the metrics of evaluating the success of awareness support have to be fundamentally different from those in CSCW research.

Now that we have discerned various forms, aspects and layers of awareness in Research Networks, further research should investigate how the complex networks of different objects can be visualized in a way that respects the privacy of single researchers and prevents the unwanted sharing of personal information. It could also seek to support researchers in identifying how their networks overlap with those of other researchers (P36, 34). Such representations need to allow for the interactive change of levels of details and would be best integrated in awareness dashboards for researchers. Such dashboards would allow access to relevant objects in the researchers' Personal Research Network, from their Local Research Organization and from their current projects. Moreover, it would help researchers to retrieve their own objects and those from the overall research domain [22].

Finally, and paraphrasing one of our interviewees, it is important to state that awareness can be a problem when there is too little of it as this may lead to double work and delayed innovation. On the other hand, awareness can also be a problem if there is too much of it, as it may overburden the individual with too much allegedly relevant information. The key to creating added value with awareness support is to find the optimal balance.

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