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Article (Accepted for Publication)
(Refereed)

Original Citation:
Lüthje, Christian and Lettl, Christopher and Herstatt, Cornelius (2003) Knowledge distribution among market experts: A closer look into the efficiency of information gathering for innovation projects. *International Journal of Technology Management*, 26 (5/6). pp. 561-577. ISSN 0267-5730

Knowledge distribution among market experts: A closer look into the efficiency of information gathering for innovation projects

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Abstract

Information gathering from sources outside the company plays a critical role in most innovation projects. Particularly, it seems promising to approach external market experts to develop an in-depth understanding of current use problems, changing customer needs and trends for new product solutions. When planning expert interviews, firms are confronted with the question whether knowledge is distributed rather homogeneously or heterogeneously ("scattered") among a pool of experts. This issue strongly determines how many experts need to be interviewed in order to develop a comprehensive understanding of a given search field for innovation. In the present paper we analyse expert interviews that were conducted in the context of an innovation project in the field of surgical hygiene products. We find high heterogeneity of expert knowledge: Market experts in our sample vary in terms of market information they provide for the particular product field. We argue that this finding is in alignment with the concept of "bounded rationality" and the theory of "contextual development of knowledge". Our findings have implications for the management of external information gathering and the identification of market experts.

Key-Words: expert-knowledge, information gathering, lead user method

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1. Introduction

The ability to successfully develop and market innovative new products is critical for corporate growth and sustainable competitive advantage. For innovations projects, firms need to collect, process and filter a substantial amount of information: innovation management is therefore to a high degree information management. Particularly in the early phases of the innovation process, the so called ‘fuzzy front end’, firms need to develop an understanding of various topics: What are current and future customer needs? Which trends and technological developments are going to have an impact on the business? What might be promising avenues for new solutions? Information with regard to these questions are essential in the early phases of the innovation process since they provide hints for ideas and concepts that are both, customer and future focused [1,2]. Due to the fact that most of this information is located externally rather than internally, secondary sources of information need to be screened intensively. Besides the internet, written documents and electronic databases, external experts appear to be a key source of information in the fuzzy front end. An expert is someone who can perform, in a specific domain, at a level that exceeds ordinary individuals [3]. The advantage of experts as information providers is twofold: Firstly, experts can deliver state-of the-art information about the field of interest. Secondly, by interviewing experts, the type and amount of information gathered can be matched to specific information needs [4].

When planning to incorporate experts during the early phases of innovation projects, firms are confronted with the question how knowledge is distributed among relevant experts. Do all experts share the same knowledge about a particular field of innovation? Or does each expert develop a unique knowledge base that differs substantially from those of his expert colleagues? In other words: is knowledge distributed homogeneously or heterogeneously among a given pool of experts?

The type of knowledge distribution has direct implications for the involvement of experts in innovation projects. In particular, knowledge distribution impacts on the efficiency of the information gathering process. Due to time and budget restrictions, firms need to perform a thorough analysis of how many experts need to be interviewed to develop a comprehensive and current understanding of the search field. In the case of a homogeneous distribution of knowledge we assume that any expert provides similar information. Therefore, only a limited number of experts need to be interviewed. If knowledge were allocated heterogeneously however, the chances are high that any expert would provide distinct information. This implies that innovation teams might be forced to interview a larger group of experts.

To shed light on the question of how knowledge is distributed among experts we conducted an empirical study in the field of surgical hygiene products. Market experts in this product area were interviewed in order to analyze the type of information that could be provided by different experts.

We found that knowledge is distributed rather heterogeneously. The information provided, was very seldomly shared by more than one expert. Experts appear to focus on particular knowledge corridors that are not necessarily congruent with the knowledge field of others. The findings suggest that this is mainly due to the volume and complexity of information within one product field , hence forcing experts to focus on specific knowledge areas. We also found that the knowledge focus of a given expert is closely linked to his specific (professional) background and largely depends on the relationship that the expert has to the product area in question. As a result of our study, it seems risky during the early stages of the innovation process to restrict external information gathering to only a small group of experts. However, clearly the number of interviews could possibly be reduced by gathering information about relevant experts prior to starting the interviews.

The paper is organized as follows. In the next paragraph we introduce theoretical perspectives relevant for the research question. In the third section we introduce the context and research methodology of our empirical study. Finally, we present the results of our study and discuss their implications.

2. Theoretical framework: The distribution of expert knowledge within a search field

Are experts arbitrarily exchangeable in the information gathering process given that they have roughly the same kind of knowledge? Or is an expert unique in the way that they possess a proprietary knowledge base? There are theoretical arguments for both views.

Neoclassical theory of perfect competition is based on the assumption of perfect information. Under this constellation any agent within a market system has access to absolutely all relevant information that is needed to make rational decisions. In other words: neoclassical economists assume complete information transparency. Therefore the market system is characterized by information symmetries, as every agent possesses the same knowledge and information base [5]: in the neoclassical framework knowledge is distributed homogeneously among the agents of the market system [5,6].

Advances in information and communication technologies support the idea of complete information transparency. Enabling a vast and intensive exchange of information on a global scale, these new technologies lead to a comprehensive diffusion of knowledge within the agents of a market system in short time. Particularly individuals that work on the forefront of a certain issue can benefit from the new technologies as state-of-the-art-knowledge can easily be transferred around the globe. Experts of a certain community can discuss important issues online via chat rooms, alternatively they can exchange e-mails, transfer documents and conduct video-conferences. Therefore, new information and communication technologies contribute to the extensive transfer of information and thus to a shared knowledge base among experts [7].

Drawing a sharp contrast to neoclassical theory, there are two theoretical frameworks that claim a heterogeneous distribution of knowledge among the agents of a market system: market process theories and new institutional economics.

The basic assumption of *market process theory* is that information within a market system is dispersed in a way that any agent possesses different knowledge. Market process theory therefore presumes a decentralization of knowledge within a society [8,9]. If knowledge is allocated differently among the agents of a market system, we would expect that experts, even within the same search field, develop a proprietary knowledge base that differs from the know-how of other experts within the same field.

Similar to market process theories, also *new institutional economics* abandon the neoclassical assumption of perfect information [10]. This becomes evident in the key assumption of new institutional economics that the rationality of individuals is not perfect but rather 'bounded'. The concept of 'bounded rationality', which was first introduced by Simon challenges the neoclassical concept of the homo economicus. While the latter acts under perfect rationality (full knowledge of goals, alternatives, outcomes) and is thus able to identify the optimal decision in a given environment.Simon's decision maker is restricted in terms of mental capacity [11]. The expression 'bounded rationality' is used to denote a type of rationality that people resort to when the environment in which they operate is too complex relative to their limited mental capabilities [12]. According to Simon's concept, agents are not able to gather and process absolutely all of the accessible information within a market system. Every agent perceives only a limited but unique set of information. Consequently, information and knowledge asymmetries emerge among the agents of a market system. Experts of a certain domain might need to focus their information gathering and processing activities on a fraction of the entire search field due to limited cognitive receptivity. As individuals are not able to perceive their domain as a whole, they focus on the specific context in which they operate. Information processing and knowledge development therefore can not be separated from the context. According to Fleck, the context is defined by three elements:

- *Domains:* (the more or less defined areas or 'parts of the world' to which the particular expertise applies. Thus the domain is similar to the search field of an innovation project).
- *Situations:* (components, people, domains and other elements present at any particular instant of expert activity).
- *Milieux:* (essentially the immediate environments in which expertise is exercised: comprising set of situations occurring regularly at particular locations, e.g. laboratories, offices)

As the development of knowledge is always embedded into a specific domain, a specific situation and specific milieux, the expertise of individuals is never quite the same. This holds true even for the knowledge development within a specific domain as the distinct situation and milieux lead to the development of a unique knowledge base [13]. Therefore, 'bounded rationality' together with its implied focus on the specific context suggests the development of specialized know-how and thus a heterogeneous distribution of expert knowledge. This assumption is supported by a recent study of Franke/Hippel. They focus their analysis on users of opensource software who can be seen as experts for market needs. The findings reveal that these users develop highly specialized needs due to their specific use context [14].

There is however a counterargument about the implications of 'bounded rationality' on the knowledge distribution among experts. As experts can only absorb a limited amount of information they might focus their information gathering and processing activities on only the most significant information. Examples of such significant information are the most urgent problems, the most significant trends and the topics with the highest priority in the search field. If every expert were able to identify this highly relevant information, we could expect a high consensus among experts regarding the information they would provide in interviews. Consequently, 'bounded rationality' could also imply that knowledge about the most important issues is homogeneously distributed among experts. There is empirical evidence that supports that argument. In their study Griffin/Hauser address the question of how many customers are to be interviewed to identify the customer needs in a particular market. Results of their study reveal that the interviewing of relatively few customers is sufficient to achieve a comprehensive understanding of current and presumably the most important customer needs [15]. This implies that customers share a common understanding about the most important topics related to a given product.

To sum up, there is theoretical and empirical support for both types of knowledge distribution. While neoclassical theory of perfect competition implies a homogeneous allocation of knowledge among experts, market process theories and new institutional economics propose a heterogeneous distribution. The present study therefore aims to develop insights into knowledge distribution in the specific context of external information search for innovation projects. To explore which types of knowledge distribution can be found among external market experts we conducted an empirical study in the field of medical products. The research context and methods are described in the following section.

3. Research context and methods

3.1 Research context: Lead user study in the field of medical hygiene products

The topic of this research is the distribution of knowledge among experts that are to be used as an external source of information during the early stages of innovation projects. We explore this question in the context of an application of the so called 'lead user method' [16].

Lead users are advanced product users who are both motivated and qualified to make significant contributions to the development of radically new products. Lead users' qualifications evolve from the fact that they anticipate the future needs of the market and do so significantly earlier than the majority of other customers. Lead Users therefore benefit significantly from innovations that meet their emerging needs. Manufacturers can use lead users as 'need forecast laboratory' for emerging markets [17].

The identification of advanced customers is supported by the lead user method. The methodology consists of a multi-phase process aiming to develop product ideas and concepts by integrating lead users into a workshop. Since it is an axiom that lead users are one step ahead of critical issues that will impact future markets, the process starts with determining those issues. To find out, innovation project teams try to identify urgent problems, ideas for slutions and, most importantly, critical trends in the particular search field. Interviewing experts has proven to be especially valuable for gathering this type of external information. Thus, lead user teams usually talk to people in the field who have a broad view of emerging trends and are leading edge with respect to the topic being studied [18].

This stage of the lead user method -the interviewing of experts to get external information for idea generation- is the context of the present survey. The information gathered in the course of expert interviews forms the basis of our analysis on how information is distributed among experts.

The focus of our empirical work in the medical market, is the research field of surgical hygiene products. This product category encompass all disposable articles aimed to prevent infections of the patient and the medical staff during surgery, such as surgical drapes, gowns, masks and other garments. The lead user project had the objective of finding advanced users in order to develop completely new products that would capture significant market share in existing markets or would create totally new markets.

3.2 Expert interviews

In order to determine actual problems, ideas for solving problems and future trends in the field of surgical infection control, interviews with experts from three areas were held:

Normal users: The first expert group consisted of users from the target market i.e. from surgeons and surgical nurses. Those questioned included doctors who were leaders in their fields and had implemented new technology in surgery.

Extreme users: Also included were ‘extreme users’. This group consisted of doctors who worked under particularly difficult conditions such as in the tropics (poor hygiene controls, poor product availability) or burns surgeons (long operations with large, moist wounds). In contrast to their counterparts in the ‘normal user’ group, they are confronted with extreme challenges to prevent infection of their patients.

Hygiene experts: In addition to the actual product users, experts in the subject of clinic hygiene were also interviewed. Hospitals have to employ medical staff in charge of ensuring that hygienic standards are met in all areas of clinics and hospitals. Frequently, hygiene experts have their academic background in bacteriology and virology.

The experts were identified by screening different sources of information like the internet (e.g. web pages of leading clinics, research institutes and medical associations) and magazine publications. We contacted the identified experts and, were able to carry out interviews with 12 normal users, 6 extreme users and 6 hygiene experts, making 24 interviews in total. The chronological order of interviews was not consciously determined by the authors, but was mainly determined by finding the earliest opportunity to fix an appointment to interview the experts.

Subject to geographical spread, we conducted either one-to-one or telephone interviews. To ensure a consistent interview structure, open questions about problems, solutions and trends in the search field were fixed in an interview guideline. However, the interviewers had the possibility to ask further questions in reaction to the remarks of the respondents (semi-structured). All interviews were recorded in writing.

3.3 Coding and evaluation of the information

To analyse the information provided in the interviews, we performed a content analysis of the interview protocols [19,20]. In the context of the present survey, the expert interviews aimed to identify hints for new product development and lead users who are ahead of the market. We therefore distinguished three categories of information:

1. Actual usage problems,
2. Solution ideas for usage problems, and
3. Trends having an impact on product use.

Each information category was specified by an operational definition. In a preliminary analysis of a sample of interviews, this category system proved to be free of overlaps and exhaustive to categorize the information provided in the protocols. The unit of analysis was one remark which provided a complete description of s problem, solution or trend. In the main, one information unit encompassed from one to three sentences from the interviewees.

The information units within the protocols were screened and coded by one author of this article. Four additional coders went through a random sample of ten of our interviews and were asked to identify the information units in the protocols. The four coders were members of the research team and were therefore familiar with the search field of infection prevention. To test reliability between the coding of the first author and the other four coders, we calculated the Cohen’s Kappa coefficient for each of the three information categories [21]. This measure takes into account that a certain percentage of corresponding assignments can already be expected in a random coding. Thus, this coefficient is stricter than the simple pair wise inter-coder reliability. Cohen’s Kappa was on average 84.9% for all three categories (0.86 for usage problems, 0.88 for solutions, 0.72 for trends). This is a very satisfactory value that indicates a high reliability of the coding procedure. Thus, the coding of the first author formed the basis for the analysis of information heterogeneity.

In order to be able to prioritise experts’ remarks of, the information units were rated according their relevance. Relevance in the context of the present innovation area stands for the impact of the particular problem, solution or trend regarding the hygiene situation in the operation room. a) Problems with direct and serious consequences for wound infection, b) solutions that would directly result in major improvements in infection prevention and c) trends with clear and substantial future impact on hygiene are to be rated as the most relevant information units. Since a five-point-rating scale proved to put too big strain on the discriminatory ability of the rating people, we made use of a three-point-rating scale (high, middle, low importance). Again, all information units provided were initially rated by one of the authors. The same four coders mentioned above rated ten randomly selected information units. On average 77.5% of the ratings matched between the author and the four other rating agents. When the rating was not consistent, the difference was never more than one scale point. In essence, the reliability of the relevance rating was satisfactory.

4 Findings

4.1 Distribution of information between different expert groups

A pattern of heterogeneous information distribution among the three expert groups ‘normal users’, ‘extreme users’, and ‘hygiene experts’ emerged. In table 1 it is shown whether the information that resulted from all expert interviews was revealed by only one, by two, or by all three of the expert groups.

Table 1 A Small fraction of total information is shared by more then one expert group

	Fraction of total information units that was revealed by...			
Type of information unit	...one group	...two groups	...three groups	**Total**
Notions of problems	84.7% (50)	11.9% (7)	3.4% (2)	**100% (59)**
Notions of solutions	95.0% (19)	0% (0)	5.0% (1)	**100% (20)**
Notions of trends	87.5% (14)	12.5% (2)	0% (0)	**100% (16)**
Total	**87.4% (83)**	**9.5% (9)**	**3.1% (3)**	**100% (95)**

Numbers in brackets stand for the absolute number of information units

The findings indicate that for all types of information, most units of information were provided by one expert group only (87.4%). The problems, solutions and trends mentioned by one expert group do not usually correspond with the notions of the experts in the two other groups. Consequently, a particular piece of information is rarely mentioned by members of two (9.5%) or even all three groups (3.1%). It appears that different expert groups do not have access to the same information and do not share a common understanding/opinion about the issues affecting a particular product field.

However, the heterogeneity of knowledge seems to decrease when focusing on the most relevant and important information. As mentioned above, problems, solutions and trends were rated on a three-point-rating scale (high, middle, low relevance) with respect to their impact on infection control. The results in table 2 indicate, that the information units that were provided by more than one expert group are, on average, more relevant than the knowledge held exclusively by one of the three groups of interviewees (1.93 versus 2.34; 1 = high importance, 3 = low importance). In other words, the knowledge that is distributed throughout many different types of experts tends to be more important. However, this does not imply that every piece of significant information on a given subject could be provided by any expert somehow related to a particular search field. The most information units that were rated as being highly relevant for infection control is still exclusively mentioned by the members of one expert group (75% of all highly relevant information).

Table 2 Shared information is on average more relevant

	Information revealed by one expert group only (n = 87)	Information revealed by two or three expert groups (n = 14)	Sig.[b)]
Relevance (mean)[a)]	2.34	1.93	$p < 0.05$

[a] *Relevance was measured using a three-point rating-scale (1=high, 2 = middle, 3 = low relevance); n = 95*
[b] *two-tailed t-test for independent samples*

Strong indication exists that the information held by an expert is linked to his specific relationship to the product category in question. Again, this becomes obvious by comparing the three expert groups; 'normal users', 'extreme users', and 'hygiene experts' (see table 3).

When the information units are segregated into problems, solutions and trends, we find that 'normal users' primarily mention problems that they face when using the products. To a smaller extent they suggest solutions for problems and even more seldom they mentioned trends in the search field (first row of table 3).

'Extreme users' showed a much stronger emphasis on usage problems. More than three out of four remarks made by members of this expert group were centered around a problem in product usage. Accordingly, the percentage of solutions and trends is much smaller than in the group of 'normal users' (second row of table 3). The difference is probably due to the much more challenging usage situations that the extreme users are confronted with. This group of doctors work under particularly difficult conditions (e.g. in the tropics) or have to treat extremely difficult cases (long operations with large, moist wounds). In this context the probability of problems in the application of products for infection prevention increases. Consider for example the adhesive strip that is necessary for attaching the surgical drapes to the patient. In most surgeries the existing products offered by the medical industry can guarantee reliable adhesion and, at the same time, avoid harming the patients' skin. Both requirements are much more difficult to ensure in the case of burn surgery since long operations with moist wounds and the application of large amounts of cooling water endanger the adhesion of the stripes. In addition, large areas of burned skin hamper a risk of less adhesion of the drapes to the skin of the patient.

Table 3 The expert groups emphasize on different types of information

	Type of information unit			
Type of expert group	Notions of problems	Notions of solutions	Notions of trends	**Total**
Normal users	64.4% (38)	28.8% (17)	6.8% (4)	**100% (59)**
Extreme users	80.0% (12)	20.0% (3)	0% (0)	**100% (15)**
Hygiene experts	58.3% (21)	5.6% (2)	36.1% (13)	**100% (36)**
Total	**64.5% (71)**	**20.0% (22)**	**15.5% (17)**	**100% (110)**

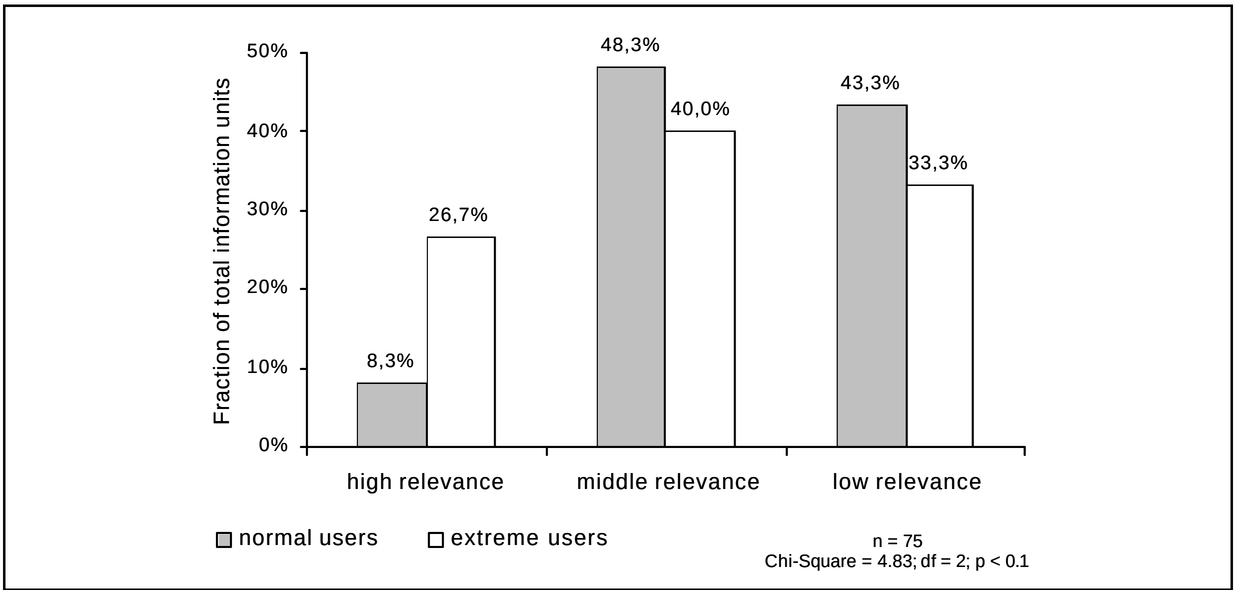
Chi-Square=21.19; df=4; p<0.001; numbers in brackets stand for the absolute number of information units

The 'hygiene experts' were able to indicate more trends than the respondents in the other two groups (third row of table 3). They seem to focus more on the general context of product use and are able to take a forward thinking perspective on the broader field of hospital hygiene.

Surgical hygiene products such as drapes, masks and gowns are only one aspect of hygiene-related issues. The experts in this group seem to perceive a certain amount of problems in product usage as they endanger infection prevention. However, they seldom thought about specific solutions for these problems probably because they do not use the hygiene products themselves. Instead, they are in a much better position to report about developments and trends that might have an impact on the future demands on surgical hygiene products. For instance, changes in the norms and standards for hospital hygiene are an important issue that clearly falls into the responsibility of hygiene experts, but are hardly known by the nurses and surgeons as the product users. Not surprisingly, this 'trend' information was mostly provided by the hygiene experts.

Another indication for a strong association of the information provided by experts and their usage context is presented in figure 1. Again, this analysis differentiates the information according to their relevance for infection control on a three-point-rating scale (high, middle, low relevance). Extreme users mentioned more problems, solutions or trends with a high and direct impact on infection control than their counterparts in 'normal' surgery fields. Similarly to the line of reasoning above, this might be explained by the more challenging product usage by the doctors working in fields like tropical and burn surgery. The problems that they encounter seem to be more severe and consequently their suggested solutions have a clearer and more direct impact on the prevention of infections during the course of operations.

Figure 1 Information provided by extreme users tends to be more relevant for infection control than remarks from the normal user group



In total, the type and relevance of information provided by the respondents is determined by the particular relationship that an expert group has to the product field. The different experiences and usage of the experts explains why knowledge and information is rather heterogeneous. Expert groups stress different topics because they deal with the products in a different way. However, with respect to the most important information, the knowledge is slightly more homogenous. The relevance of information tends to be somehow associated with its distribution.

4.2 Distribution of information within expert groups

In summary, the findings in section 5.1 suggest that knowledge about problems, solutions and trends in a particular product field is in the main not shared by different expert groups. Of course, one could argue that while this is comprehensible when analyzing different types of experts, this might not be the case when comparing the interview outcomes within a given expert group.

To test this possibility we analyzed the redundancy of information within the three expert groups 'normal users', 'extreme users' and 'hygiene experts'. More precisely, we explored how many additional information units were provided by each interview when compared with the interviews that have been conducted in the same group before. For this analysis, it was necessary to bring the interviews within each expert group in an interview sequence. Since the amount of information varied significantly between the experts of the same group, the chronological order of the interviews influences the amount of additional information gained during the course of the interviews. For instance, if the sequence started with the most informative talks, information redundancy would be comparatively high in the interviews that followed and vice versa. The particular order of interviews that was realized in the present survey is incidentally and mainly due to time restrictions and availability of the experts we contacted. It seems therefore inappropriate to base the analysis on this particular sequence of interviews.

In the following analysis we assume a setting where no preliminary information about the knowledge and the cutting edge status of potential interviewees exists. We therefore also assume that any sequence of interviews within an expert group has the same probability to occur. The interviews are interpreted as a finite set of events with an equally distributed probability. Consequently, a particular order of interviews can be seen as one permutation that is equally probable as any other permutation of interviews. [1]

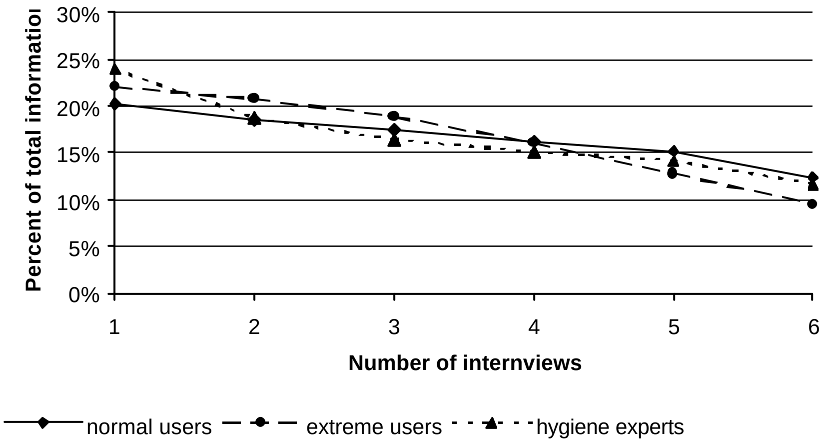
The analysis was based on six talks in each group leading to 6! different permutations for the interview sequence in each expert group. Since this is a large number, we randomly simulated 700 orderings. For each permutation, the amount of non-redundant information units gained in interview to interview was calculated and averaged over all permutations. The results in figure 2 stand for the expected net information gain per interview as a percentage of all information gathered in the six interviews – the percentages within each group therefore add up to 100%. It is important to note, that the findings are based on the assumption that no preliminary selection of the experts is possible.

As indicated in figure 2 the trend seen in the graphs is similar for all three groups of experts: The number of new information units decreases during the course of the interviews.

[1] We conducted 12 interviews in the group of "normal users", and respectively six interviews in the group of 'extreme users" and 'hygiene experts". To simplify the interpretation of the findings we standardized the data on six interviews in each group. For the 'normal users" each permutation was created as a random selection of six out of twelve interviews.

Interviewing more experts leads to more useful information. However, the decline is not substantial. More than 40% of all information is provided within the second half of the sequence of interviews. At least 10% of the total information can still be expected in the last interview.

Figure 2 In a random order of interviews a significant fraction of total information is still provided during the last interviews



To identify most of the problems, solutions and trends that are known in a particular expert group, it is not sufficient to interview one or two experts. Even the experts in the same category seem not to share the same core of knowledge. Instead, knowledge seems to be heterogeneously distributed due to different personal experiences of the experts – even if they are experts in the same field.

This finding is supported by another analysis of information redundancy. We investigated how many information units exclusively one expert within a group mentioned and what fraction of total information was jointly revealed in two, three and more interviews (see table 4). These percentages do not vary significantly among the three different groups of experts. It becomes obvious, that in all three groups a large fraction of the total information was exclusively provided by one interviewee (77.5%). Only 12.6% of all information units were shared by two interviewees and even less were mentioned by three (6.3%), four (1.8%) or five experts (1.8%). No single information unit was mentioned by all six interviewees within a particular group of experts.

Table 4 The majority of information was not shared by more than one expert

	Fraction of total information that was revealed in altogether...						
	1 interview	**2 interviews**	**3 interviews**	**4 interviews**	**5 interviews**	**6 interviews**	**Total**
normal users	78.3% (47)	11.7% (7)	6.7% (4)	1.7% (1)	1.7% (1)	0% (0)	**100% (60)**

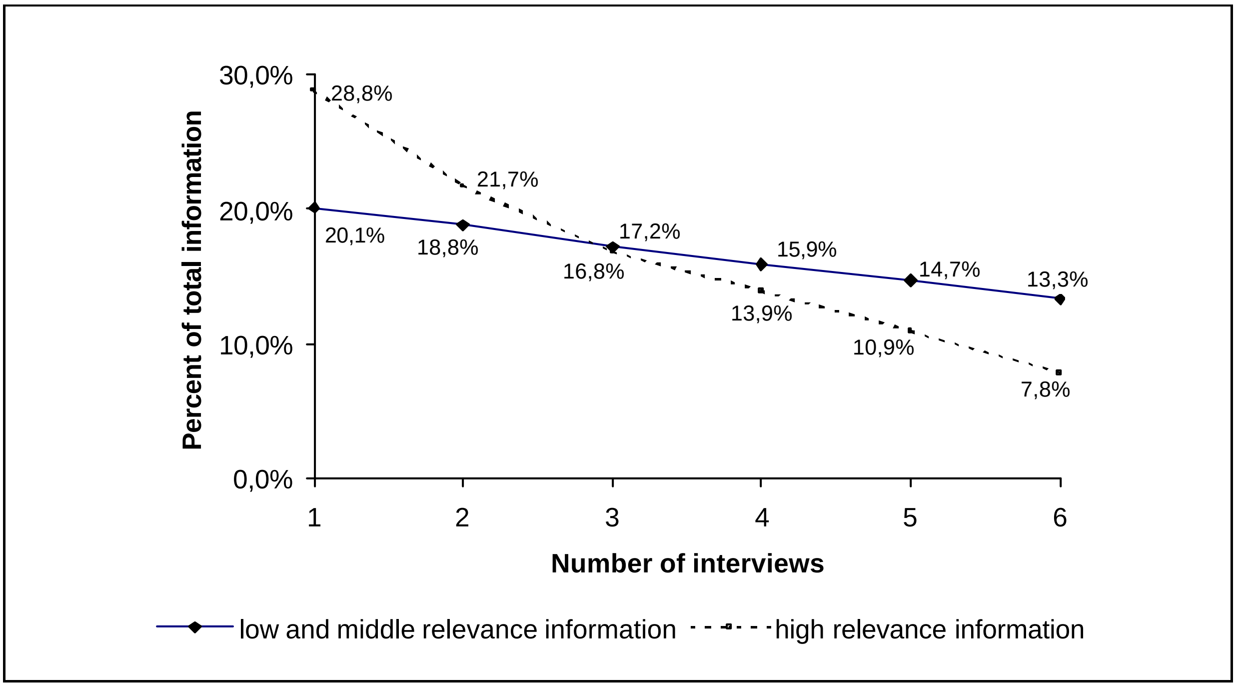
extreme users	66.7% (10)	26.7% (4)	6.6% (1)	0% (0)	0% (0)	0% (0)	**100% (15)**
hygiene experts	80.6% (29)	8.3% (3)	5.6% (2)	2.8% (1)	2.8% (1)	0% (0)	**100% (36)**
Total	**77.5% (86)**	**12.6% (14)**	**6.3% (7)**	**1.8% (2)**	**1.8% (2)**	**0% (0)**	**100% (111)**

Chi-Square=4.17; df =10; n.s.; numbers in brackets stand for the absolute number of information units

To illustrate the link between the particular use context and personal experience of any expert and his information input, consider the case of one member of the expert group 'hygiene experts' who had been working for many years as a surgery nurse before taking on the task of hygiene agent in a hospital. This person noted many hygiene problems directly associated with the use of hygiene products in surgery since she had made personal usage experiences. The problem remarks provided by the other experts were more focused on logistics, storage of products and the general hygiene discipline of the medical personnel – issues that usually form the core of hygiene agents' tasks. Problems relating to product use were hardly mentioned by these experts without personal experience in surgery.

Similar to the analysis in section 5.1, the general finding with respect to information distribution differed between the most relevant information on the one hand and the information of middle and low relevance on the other hand. In figure 3 the findings show that the net gain of non-redundant information decreases more significantly for the most relevant information. This means, that the knowledge with the strongest impact on infection prevention is, again, more widely shared among the members of an expert group than other, less important information. However, neither of the graphs show a substantial difference in terms of percentage values. The findings therefore do not at all imply that the important knowledge can be elicited by interviewing one or two experts of the same type. Even in the last interview, very relevant remarks are made that were not mentioned by the other respondents in the interview sequence.

Figure 3 In a random interview sequence the acquisition of non-redundant information decreases more significantly with high relevance information than with the information of low and middle relevance.



5 Conclusions

The results of the present survey show high heterogeneity of expert knowledge. Experts in our sample vary in terms of the problems identified, proposed solutions and trends in a particular product field. This is equally valid for the group based analysis between the expert groups as well as in the individual based analysis within each expert group. In essence, the homo oeconomicus that is acting in contexts of transparent and perfectly distributed information is not reflected by the findings.

The difference of information held by different parties can probably not be explained by a lack of information exchange between experts in the present product field. The medical community is a close knit community that is very open to the exchange of the latest knowledge via conferences, journals, internet-forums and informal networks.

This exceptional situation might initially be due to the common sense of obligation to diffuse information that might be necessary to save lives and re-establish the health of patients. In addition, by freely revealing personal knowledge, manufacturers of hygiene products can be prompted to realize product improvements that the users can benefit from [22].

Secondly, the apprehension to loose proprietary knowledge – a potential barrier to the free sharing of information - seems not to be relevant for the product field in question. Hygiene products, such as surgical drapes, gowns and masks, while indispensable for preventing infection do not improve competitive advantages in surgery. Doctors interested in pushing their field will innovate in surgical methods and complex instruments instead. Furthermore, most surgeons, due to geographical spread or different specializations, are not necessarily direct rivals in the same area. To reveal information about problems, solutions and trends in a product field will therefore not compromise competitiveness [22].

If it is not the lack of information exchange, then it seems reasonable that the heterogeneity of knowledge is a matter of information complexity and volume [8]. The sheer volume of information that has been generated for a given product field seems to exceed the mental capacity of individuals – even the capacity of experts. Cognitive limits and specialization of knowledge inhibit that a single experts can provide all of the information relevant to a particular subject. As a consequence, in alignment with the concept of 'bounded rationality', individuals gather only a limited subset of relevant information.

For our sample it was shown that the specific knowledge base of a particular type of experts can be explained by their unique use context and relationship to the search field. As proposed by the theory of contextual development of knowledge, information gathering depends on the specific context in which the expertise is built on. Extreme users, when asked, stress problems in product usage to a greater extent than their counterparts in hygienically less challenging surgery fields. Hygiene experts - generalists without a large amount of personal usage experience- mention more trends and less concrete product solutions than the experts in product use. Also, for experts of the same type, anecdotic evidence indicates that the knowledge differences are associated with the personal experiences and usage patterns. The different domains and Milieux that the people are working in and the different situations with which they are confronted, in fact, drive knowledge development.

This pattern can be understood in terms of costs and benefits of information gathering. With respect to information costs, consider that experts will often acquire information without additional effort in the course of their work activities. If an expert decides to engage in information search outside his own scope, higher investments in time and financial resources are usually required. The costs of information gathering are particularly high in cases where the information is 'sticky' [23]. Information stickiness can be due to attributes of the information such as how easy it is for information seekers to encode the information. For the expert users interviewed in the survey, it seems reasonable that a considerable part of their knowledge is rather tacit, since it is acquired in the course of product use [24]. Often it is a problem for customers and users to clearly articulate the problems they face when using the products and to suggest how these problems could be solved.

The same can be argued for the benefit of information. Information relating to their specific working context should have the highest personal benefit for the experts. Through the 'in-house' use of this information they can directly enhance their working situation. In contrast, the anticipated reward of information that is rather relevant for others is lower. As mentioned earlier, monetary gains by licensing or selling this information are quite improbable, particularly in the search field of this survey.

Strongly connected to the issue of local knowledge variations is the question of how many experts need to be interviewed in order to identify most of the relevant information about problems, solutions and trends in a product field. It becomes apparent that the present research has a direct practical implication for the information gathering during the early stages of product development. Firstly, the pattern of heterogeneous knowledge among experts implies that it is risky for an innovation team to restrict external information search on one type of experts. We found, that only a small fraction of the total information, was provided by experts in all three of the interviewed expert groups. Secondly, it also seems risky to narrow interviews to a group of similar experts on a very small number of interviewees. Our data suggest that interviews with 2 to 3 experts of a particular knowledge field should identify less than 60% of the information that would be obtained by asking six experts in the same key field. Even though the most relevant information on a subject is distributed slightly more homogenously and is more often shared among experts of different groups as well as among experts of the same type, the risk of missing very relevant information remains high.

At first sight these results imply that there are clear benefits for a high number of interviews. However, this implication only holds true under the assumption of no preliminary information about the amount of knowledge and information base of any particular expert. The experts in our sample, for example, vary with respect to the amount and quality of information input. To reduce the number of interviews, an innovation team could try to interview the individuals with the highest amount of knowledge as early on as possible in the process of information search. One approach is to track down especially promising experts by networking through the expert communities. In a network search the innovation project team would begin to interview one expert with apparent knowledge in the field and then ask them if they know of other experts who might be able to provide even more valuable information. The advantage of this approach is that experts tend to know others who are at the cutting edge of the subject. [25] A team should therefore quickly identify the most attractive experts and, hence, should be able to reduce the number of interviews without loosing much of the most important information on a particular topic.

However, the networking search process is less promising in fields where it is difficult for one expert to assess the leading edge status of other experts. This might be the case if no tight networks between individual experts exist and therefore no direct interaction takes place. At the same time, the lack of close interaction would imply that the knowledge and information is more heterogeneous among experts. Therefore, it seems reasonable that an innovation team should explore the ties between experts, before deciding to take the networking approach and before assessing the number of interviews. For instance, answers to the following questions can serve as indicators for the ties between experts and the homogeneity of knowledge distribution:

- Are there institutionalised platforms for a formal information exchange between experts (e.g. conferences, publications, chat rooms)?
- Are there active informal networks activities (e.g. on the basis of mutual trust)?
- Are there strong interdependencies between the work of different experts?
- Can experts benefit from formal and informal information transfer?

Given that an expert population is rather heterogeneous with respect to the knowledge and information in stock, it seems risky to inconsiderately restrict external information search to a very small number of experts. To reduce costs and time delays in the early stages of innovation projects the project teams needs to gather preliminary information about the expert community and, if possible at reasonable costs, about individual experts. On the basis of this information it can be decided how many experts need to be interviewed and which search strategy should be followed. Moreover, our findings suggest that it is possible to predict the type of information provided by experts on the basis of the background and personal experience of the interviewee (contextual knowledge). This paves the way to efficiently gathering knowledge of any specified type if personal information about the experts is available before starting the search process.

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