Do Knowledge Sources Matter? Exploring the Effect of Knowledge Sources on Knowledge Integration Processes

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Abstract

Knowledge integration (KI) is the process by which organizations identify, acquire, and utilize knowledge from external sources. Existing studies on KI have either researched what knowledge organizations gain from which sources or what processes are needed to do that. This study assumes that bridging these two research areas will contribute to a better understanding of KI processes. This is particularly needed to design (information) systems that are to support these processes. The results of an international survey amongst high-tech small and medium sized companies indicate that the use of knowledge sources is associated with KI processes but that this relationship is complex. Further descriptive and explanatory research is suggested on both higher and lower levels of detail than of the current study. Subsequently, the use of particular sources and processes should be compared to organizational performance and analyzed for its implications for the design of information systems.

Keywords: knowledge integration, knowledge sources, information sources, knowledge processes, exploratory research, kernel theory

Suggested track: Knowledge sharing within and across organizations and cultures e.g., in off-shoring arrangements

1. Introduction

Existing studies in the area of information seeking have extensively researched what information companies need and from which sources they get it (Allen, 1993; Ellis & Haugan, 1997; Keegan, 1974; Rosenbloom & Wolek, 1967). These studies, however, hardly analyze *how* companies identify, acquire, and utilize knowledge; a process we call knowledge integration (KI). Conversely, KI literature (Argote & Ingram, 2000; Grant, 1996; Huang & Newell, 2003; Szulanski, 2000) concentrates on knowledge processes while largely ignoring information sources. However, information sources and knowledge processes are not independent. While the differences between information and knowledge have been stressed frequently (see Stenmark, 2001 for and overview),

this paper assumes that they are two sides of the same coin. We follow Wijnhoven's (1999) view that knowledge consists of norms, values, explanations, predictions, methods, and skills. This knowledge belongs to certain individuals or collectives (like groups and organizations). The explicit part of this knowledge can be extracted and represented in, for example, numbers, text, or figures. These representations of knowledge we call information. Thus, in this paper we assume that information is representations of knowledge. For the sake of simplicity we use the term knowledge throughout this paper when we refer to knowledge and information. Dependent on the context it will be clear whether were refer to knowledge or information. We believe that not only knowledge and information are highly related but also knowledge sources and knowledge processes. This is obvious when we compare, for example, searching for relevant knowledge in a database with searching for relevant knowledge on a trade fair. While both are examples of knowledge seeking, they involve completely different processes. We suspect that this is true for many other knowledge processes as well and that research that bridges the two worlds will substantially improve the understanding of the KI-process. This understanding is needed when we want to support KI processes by, for example, information systems (ISs), since, if the processes are different for various sources, they require different support (Keen & Scott Morton, 1978; Markus, Majchrzak, & Gasser, 2002).

Since we are not aware of any previous study that has systematically researched the relationship between knowledge sources and knowledge processes we chose for an exploratory approach that tries to answer the following four questions:

1. Is the use of various sources associated with different ways of identifying, acquiring, or utilizing knowledge?

2. Are some sources affecting KI processes more than other sources?

3. Are some KI processes more source-sensitive than other processes?

4. Is this different for various types of knowledge?

In this paper we develop a model of the KI process that consists of three stages that each consist of several subprocesses. The first research question asks whether the subprocesses that are used to identify, acquire, and utilize knowledge are different for the sources that are used. The second and third research question concern the sensitivity of the relationship between sources and processes. Research question 2

asks whether some sources have more effect on KI processes than other sources. Research question 3 asks whether some processes are more affected by sources than other processes. Thus, research question 1 focuses on the relationship between knowledge sources and processes, research question 2 on the knowledge sources, and research question 3 on the knowledge processes. Finally, research question 4 asks whether the answer to these three research questions is different for different types of knowledge that are used. This is depicted in Figure 1.
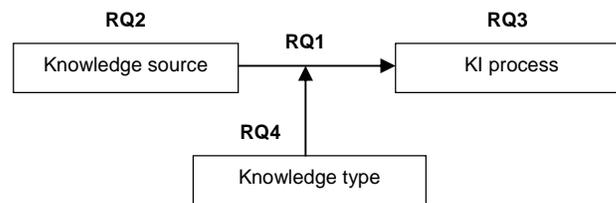

Fig. 1 Research questions

These research questions are answered by an international survey in a domain where the use of external knowledge is both highly relevant and challenging: new product development (NPD) in high-tech small and medium sized enterprises (SMEs). Following Schumpeter's (1934) thesis that innovations generally are combinations of existing knowledge and incremental learning, KI is of crucial importance for NPD (which is a specific type of innovation). Rothwell (1994) observes that the effective use of external knowledge is indeed a significant success factor for industrial innovation. This applies particularly to SMEs because of their general lack of internal resources (Rothwell & Dodgson, 1994). In the course of their NPD processes, SMEs depend on various types of external knowledge including market, technological, and organizational knowledge (Allen, 1993; Ellis & Haugan, 1997; Faulkner & Senker, 1995). Previous research has shown that this knowledge is mainly – but not limited to – tacit and originating from personal and informal sources like their customers and suppliers (Allen, 1993; Johnson & Kuehn, 1987; Julien, 1995; McGee & Sawyerr, 2003; Ramesh & Tiwana, 1999). Because the use of external knowledge is so widespread and diverse during NPD in SMEs, this domain is highly suitable for empirical research on KI processes. Being exploratory, this study's purpose is not to provide conclusive answers to the research questions, but to establish whether it is fruitful to research this topic and to provide directions for future research (Babby, 1995).

2. Research Framework

Figure 2 clarifies our perspective on KI in high-tech manufacturing SMEs as the process of identification, acquisition, and utilization of knowledge from external sources for the NPD-process within an SME. While the KI process is in practice not linear and highly intertwined with the NPD process, we have represented it as a linear process in Figure 2 in order to stress the distinction between the three stages and between the KI process and the NPD process.
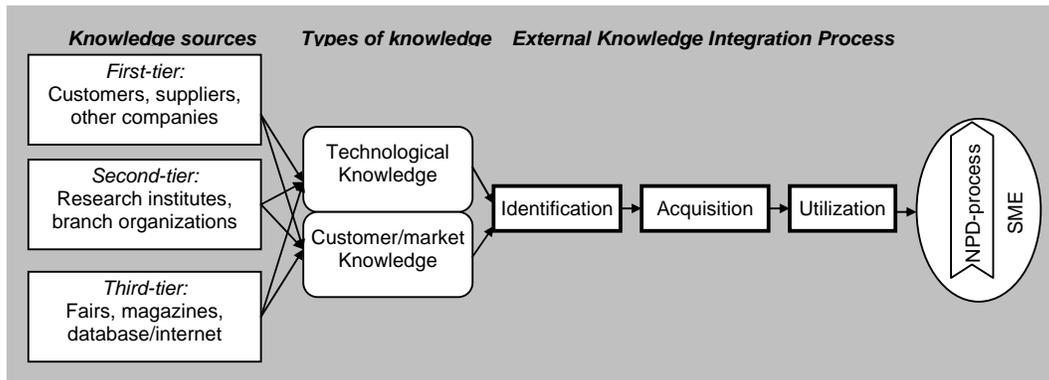

Fig. 2 Overview of external knowledge integration

2.1 Knowledge Sources

When we look at the diverse set of knowledge sources that SMEs use during their NPD process, we can broadly distinguish three tiers or knowledge sources (Julien, 1995; White, Bennett, & Shipsey, 1982). At the first tier we find sources that are in a company's close network of partners. Sources included here are customers, suppliers, and other companies like their competitors and sales representatives. At the second tier we find sources that are outside this close network. Exemplary sources are research institutes and universities, and branch organizations and innovation centers. Though these first tiers concentrate on organizations as knowledge sources, the third tier consists of sources that are not directly related to a single company. At this tier we find fairs and conferences, magazines and books, and databases and the Internet.

2.2 Types of Knowledge

To identify differences in the KI process between various types of knowledge that SMEs use, we used a commonly made distinction between technological knowledge

(e.g. about materials or production processes), and customer/market knowledge (e.g. about demanded quality or functionality). We assumed and tested that our respondents could identify the KI process both types of knowledge.

2.3 External Knowledge Integration Process

As indicated, KI is defined as a process with three stages. The internal processes currently associated with knowledge management (KM) we call *knowledge utilization*. Since external knowledge needs to be acquired before it can be utilized, an essential preceding stage is *knowledge acquisition*. Similarly, before acquiring external knowledge it must first be identified. Acquisition is therefore preceded by a *knowledge identification* stage. Based on existing research, a number of subprocesses are identified within each stage and outlined below.

The identification stage consists of subprocesses involved in locating relevant knowledge outside the organization. Following literature on information seeking and environmental scanning, this stage is in a continuous interplay between knowledge seeker and source (Choo, 2001; Leckie, Pettigrew, & Sylvain, 1996), and eventually leading to a 'compromised knowledge need' between source and seeker (Taylor, 1968). Aguilar (1967), Daft & Weick (1984), and Choo (2001) identify the level of intrusiveness of the seeker as a distinguishing aspect of information seeking behavior. In his distinction between solicited and unsolicited information, Aguilar also deemed this aspect distinguishing for the information source. When the levels of intrusiveness of both source and seeker are seen as dichotomies, four identification subprocesses can be distinguished. The first subprocess - high intrusive seeker, low intrusive source - is *intentional search*. Aguilar refers to this as respectively formal or informal search. In this mode, the seeker actively seeks for knowledge outside the company, for example on the Internet, fairs, or in his personal network. The second subprocesses (low-high) is *unsolicited presentation* of knowledge by the source (cf. Aguilar, 1967). An example is the dissemination of information on new technologies by a source to potential partners. The third subprocess (low-low) is *accidental discovery* and occurs, for example, when the seeker browses the Internet without having a particular need for information. This subprocess is similar to what Aguilar has called undirected and conditioned viewing. The fourth theoretically possible subprocess (high-high) is believed to be not relevant within this study, because dependent on who is most intrusive, it will be similar to intentional search or unasked presentation from the

perspective of the seeker. For example, when the seeker is most intrusive (i.e. she finds the source), we expect that she will not be able to correctly establish whether the source has been intrusive or not. Therefore, this mode is left out for further consideration within this study.

In the acquisition stage, knowledge is transferred from a source to an organization. This transfer can take several forms, ranging from a document transfer (for explicit knowledge, cf. Nonaka, 1994) to interactive cooperation (for tacit knowledge) (Groen, De Weerd-Nederhof, Kerssens-van Drongelen, Badoux, & Olthuis, 2002). We base a more fine-grained distinction of acquisition subprocesses on several possible carriers of knowledge. Firstly, knowledge that is codifyable can be represented in *written form* and transferred in documents or files. Secondly, *physical objects* that contain knowledge can be transferred from the source to the recipient. An example in NPD is reverse engineering of a competitor's product (Becker & Zirpoli, 2003). Thirdly, the *people* that carry knowledge can be transferred by hiring or employing them. This is common practice in Japanese companies (Dyer & Nobeoka, 2000). Fourthly, people can also transfer their knowledge without necessarily being employed, for example in the form of *courses* (Devon & Bush, 1996). Fifthly, when knowledge is embedded in work processes, transfer of knowledge is possible by *cooperation* between the source and the recipient, for example by cooperative development. Finally, when knowledge is embedded in the source organization's structure or culture (cf. Walsh & Ungson, 1991), it can be acquired by *outsourcing* a problem to the source and staying in close contact with the source organization. Another option is acquiring the source organization itself or parts of it. However, since we expect this to be rare for SMEs because of their small scale, it is left out for further consideration.

The utilization stage consists of subprocesses in which obtained knowledge is made accessible, is applied, and is integrated in the organization. Each of these three subprocesses can take place as a one-time-only static process, or as an ongoing dynamic process, which suggests six subprocesses within this stage. Providing access on a one-time-only basis, is done by *storing* knowledge somewhere in the organization, for example in archives or individual people. The corresponding dynamic subprocess is that of *diffusion*. Using the image of a jigsaw puzzle, Galunic & Rodan distinguish two forms of diffusion: distribution and dispersion. "A picture on a jigsaw puzzle is distributed when each person receives a photocopy of the picture. The same image would only be dispersed when each of the pieces is given to a different person" (1998: 1198). One-time *application* of knowledge is the process of putting the obtained

knowledge to use in the situation it was needed for. Ongoing application can be referred to as knowledge reuse (Markus, 2001) or *exploitation* (March, 1991). The integration of knowledge on a one-time-only basis is what Grant (1996) has called *direction*: codifying tacit knowledge into explicit rules and instructions so that it can be communicated at low cost throughout the organization (Grant, 1996: 379). The second form of integration that Grant discusses is *routinization*. An organizational *routine* is "(…) a set of activities (…) routinized to the extent that choice has been simplified by the development of a fixed response to defined stimuli" (March & Simon, 1958: 142). The three stages and their subprocesses are depicted in Figure 3.

Identification	Acquisition	Utilization
	4. Written form	10. Application
	5. Physical objects	11. Exploitation
1. Accidental discovery	6. People transfer	12. Storage
2. Intentional search	7. Course	13. Diffusion
3. Unsolicited presentation	8. Cooperation	14. Direction
	9. Outsourcing	15. Routinization
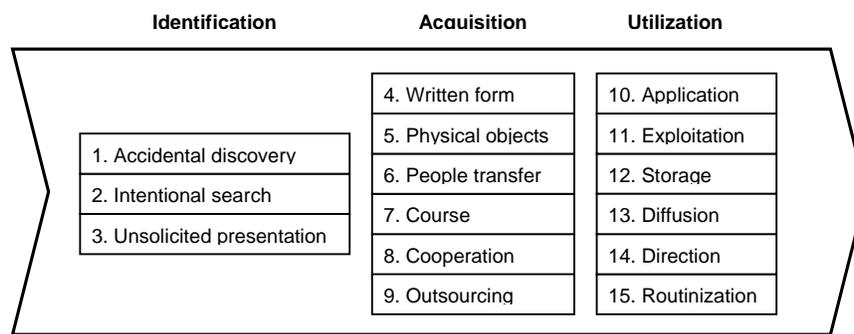
Fig. 3 Subprocesses of external knowledge integration

3. Research Method

In researching the framework described above, we conducted a large-scale self-administered questionnaire in Germany, Israel, Netherlands, and Spain as part of a larger European study on KI (EU project KINX, No. G1RD-CT-2002-00700). The authors were responsible for overall development, coordination, and analysis as well as for the data collection of the Dutch part of the study.

3.1 Sample

A major challenge was the selection of high-quality address databases for the questionnaire. Since we are not aware of any database that covers the four countries, we had to select four different databases that allowed selection on similar criteria. Because of their high-quality reputation and similarity, the following databases were selected: Hoppenstedt (Germany), D&A HiTech Information Ltd. (Israel), National Chamber of Commerce (Netherlands), and AXESOR (Spain). From these databases, we selected a stratified random sample of 1306 high-tech manufacturing SMEs. The

sample was stratified over country (Germany, Israel, Netherlands, and Spain), size (2-9, 10-49, 50-99, and 100-499 employees), and industry (industries 24 and 29-35 from the International Standard Industrial Classification). These companies were contacted by phone, were asked to identify a key informant, received a questionnaire, and were reminded twice if they did not respond. Although the validity of single-informants research has been debated, we agree with Kumar, Stern, & Anderson (1993) who state that informants are not selected to be representative of the members of a studied organization, but because they are supposedly knowledgeable and willing to communicate about the issue being researched. Because smaller companies are less likely to have such informants (Mitchell, 1994), we let companies decide themselves who was the most appropriate person to respond. Hereafter we label these respondents 'NPD managers'.

A total of 317 NPD managers responded, leading to a response rate of 24.3 %, which is considerably high for a randomized sample of SMEs (Raymond, Julien, & Ramangalahy, 2001). The response rates within each country were: Germany 21.7 %, Israel 20.9 %, Netherlands 38.2 %, and Spain 17.4 %. Since we followed the same procedures in each country, the high response rate in the Netherlands was surprising. One possible explanation is that Dutch governments pay relatively much attention in their policies to the acquisition and use of external knowledge by SMEs. During the interviews, the interest of NPD managers in our study also seemed higher in the Netherlands than in the other countries. The profile of the responding companies and individuals is given in Table 1. A comparison (t-test and Mann-Whitney test) of respondents with non-respondents showed no significant differences on industry. However, regarding company size, companies with 10-49 employees were relatively underrepresented in the response set, while companies with over 100 employees were relatively overrepresented. Moreover, younger companies were relatively underrepresented, while older companies were overrepresented. A comparison of early and late respondents on all variables in this study showed however no significant differences ($p < 0.05$). Thus, substantial non-response bias seems unlikely.

Table 1 Profile of respondents and their companies

Industry	%	Year of foundation	%
24 Chemicals & chemical products	10.7	Before 1965	13.1
29 Machinery & equipment n.e.c.	28.4	1966-1980	13.1
30 Office machinery & computers	11.7	1981-1990	18.0
31 Electrical machinery & apparatus n.e.c.	4.1	1991-1995	14.6
32 Radio, TV and communication equipment	19.9	1996-1998	15.5
33 Medical, precision & optical instruments	12.6	1999-2001	16.2
34 Motor vehicles, trailers & semi-trailers	5.0	Missing	9.5
35 Other transport equipment	3.2	(after 2001 excluded)	
Missing	4.4		

# of employees	Total	On R&D	Position of respondent	%
2-9	14.3 %	58.5 %	Director/general manager	29.9
10-49	28.7 %	23.2 %	Manager/head R&D	37.8
50-99	16.5 %	5.2 %	Manager/head marketing	14.3
>=100	35.1 %	3.4 %	Other	12.8
Missing	5.5 %	9.8 %	Missing	5.2
Mean	89.5	14.8		

3.2 Questionnaire

For operationalization it is important to regard validity, reliability, and practicality, of which the concerns "(…)a wide range of factors of economy, convenience, and interpretability" (Cooper & Schindler, 1998: 166). In particular in SMEs, practicality is important, because managers are usually overloaded with their daily survival and have little time to fill out questionnaires (cf. Scarborough & Zimmerer, 2000). Illustrative is a remark of one participant of our study: he at times receives up to ten questionnaires a week, of which some are obligatory. For the development of the questionnaire we preferred using existing scales because of their proven validity and reliability. However, a search in 500+ relevant journal articles and the ISWorld MIS Survey Instruments database yielded no scales that concern KI processes. What we found, were, for example, scales on capabilities and outcomes (e.g. Lee, 2001; Szulanski, 1996), on IT support (Ruggles, 1998), on learning (Lyles & Salk, 1996), or on institutionalization of knowledge transfer activities (Santoro & Gopalakrishnan, 2000). Moreover, the scales we found were rather lengthy lists of items, limiting the practicality of the questionnaire. Therefore, as an alternative approach, we developed a new questionnaire in close interaction with respondents. Based on earlier interviews about the KI process, a draft English questionnaire was developed and discussed in an expert panel of fifteen academics and practitioners. Consequently, the clarity and validity of this draft questionnaire was tested with three to four potential respondents in each country. After improving the questionnaire it was tested again in a similar way before it was double blindly translated in the four national languages. The translated versions were also tested and transformed into an online questionnaire, which was finally tested again.

The pretests of the questionnaire showed the need for simplifications. Regarding the acquisition stage, we initially also included 'talking to the source' as a means of acquisition. However, this was seen as so obvious that it even annoyed some respondents. The difference between direction and routinization and between direction and diffusion in the utilization stage was not clear to the respondents. Also after an explanation of the difference, they indicated that this difference was too subtle. Moreover, it turned out that explanations and instruction within the questionnaire were simply not read. Consequently, direction and routinization were combined in one subprocess: internalization. A final modification was the replacement of the term 'diffusion' by 'dissemination' because respondents were more familiar with this second term.

The final English questionnaire is included in the Appendix. The question numbers correspond to the subprocess numbers in Figure 3 (with the exception that subprocess 14 in the Appendix refers to subprocesses 14 and 15 in Figure 3 because of the changes made based on the pre-test). For each of the subprocesses respondents were asked about the frequency of executing that subprocess for technological as well as for customer/market knowledge. We did not ask the process questions for each source but only once for both types of knowledge. Consequently, we are only able to find general patterns like 'NPD-managers using source X execute process Y more often than NPD-managers not using source X'. If we would have asked these questions for each source separately, this would imply 2x9x14=252 similar questions (types x sources x subprocesses), which is unacceptable for any respondent.

3.3 Analysis

For each process-source combination and for both types of knowledge, we compared respondents using a source with respondents not using it. For example, we compared the mean score of the respondents that did use customers as a source of technological knowledge with the respondents that did not use it as a source of technological knowledge. To this end, we conducted a t-test for two independent samples in which equal variances were assumed (given that Levene's test had shown that for virtually all F-values $p > .05$). We left the category 'other sources' out of the analysis because it was very small ($N1 = 18$ and 9) and diverse.

4. Results

Tables 2 and 3 provide the differences in mean scores for each combination of source and process for respectively technological and customer/market knowledge. For example, Table 2 indicates that the mean difference between companies that used research institutes as a source of technological knowledge and companies that did not use this source for technological knowledge is .32. Because of the exploratory nature of this study, we marked all differences in means that were significant at .1 level. Both tables should be interpreted carefully, because of the risk of overfitting.

Table 2 Differences in mean scores of respondents that used a certain source (N1) and that did not use a certain source (N0) for technological knowledge

	N	Mean	SD	CUSTOMER N0=129 N1=136	SUPPLIER N0=95 N1=172	OTHERCOM N0=190 N1=78	RES_INST N0=165 N1=104	BRAN_ORG N0=233 N1=37	FAIR N0=116 N1=152	MAGAZINE N0=134 N1=135	DATA_INT N0=137 N1=131	OTHER N0=251 N1=18
DISCOVER	270	2.47	.82	.00	-.04	.22**	.03	.04	.22**	.14	-.03	.07
SEARCH	272	4.02	.85	.01	-.16	.11	.32***	.28*	.07	-.03	.05	-.09
PRESENT	269	2.55	.92	-.20*	.22*	.22*	.10	.28*	.18	.08	-.17	-.15
WRITTEN	265	3.32	.98	.03	.16	.11	.11	.36**	-.07	-.12	.11	-.05
PHYSICAL	269	3.36	1.02	-.02	.21	.30**	.25**	.31*	.23*	-.08	.06	-.16
PEOPLE	263	2.07	1.11	-.01	-.02	.01	.15	-.10	-.08	-.32**	.02	.14
COURSE	268	2.74	1.08	-.02	.21	.31**	.24*	.43**	.49***	.25*	.03	.16
COOPERAT	266	2.77	1.16	.25*	.19	-.01	.31**	.22	.02	.04	.19	.29
OURSOURC	267	2.29	1.08	.08	-.07	.16	.44***	.01	-.07	-.06	.22	.69***
APPLICAT	270	3.92	.82	.01	-.09	.02	.07	-.00	-.02	-.01	.19*	.45**
EXPLOIT	262	2.73	.94	.06	.11	.08	.05	-.21	-.07	-.05	.15	.12
STORAGE	267	3.40	1.17	.14	.06	.25	.03	.00	-.01	.03	.02	.04
DIFFUSIO	264	3.18	1.29	-.22	.02	.40**	.29*	.12	.26	-.13	.29*	.23
INTERNAL	264	3.25	1.11	.13	.00	.17	.29**	.01	.08	.47***	.49***	.21

*significant at .1 level (2-tailed); **significant at .05 level (2-tailed); ***significant at .01 level (2-tailed)

Table 3 Differences in mean scores of respondents that used a certain source (N1) and that did not use a certain source (N0) for customer/market knowledge

	N	Mean	SD	CUSTOMER N0=22 N1=200	SUPPLIER N0=127 N1=95	OTHERCOM N0=157 N1=65	RES_INST N0=177 N1=44	BRAN_ORG N0=183 N1=40	FAIR N0=82 N1=139	MAGAZINE N0=131 N1=90	DATA_INT N0=117 N1=103	OTHER N0=215 N1=9
DISCOVER	230	2.83	.90	.26	-.16	-.13	.07	-.13	-.02	-.05	-.04	-.03
SEARCH	230	3.90	.90	-.05	-.11	-.03	.11	-.11	.00	-.07	.29**	.46
PRESENT	226	2.53	.94	.43*	.15	.14	.46***	-.18	.08	.00	.14	.27
WRITTEN	223	3.11	.98	.24	.09	.10	.13	.28	-.12	-.15	.24*	-.10
PHYSICAL	225	3.13	1.11	.47	.11	.20	.16	.18	.29*	.03	.13	.10
PEOPLE	220	1.95	1.06	.21	.04	.17	.28	-.12	.37**	-.04	-.08	.29
COURSE	223	2.33	1.09	.29	.16	.03	.34*	.38**	.29*	.01	.21	-.11
COOPERAT	222	2.58	1.14	.34	.13	.05	.37*	.03	.06	-.10	.03	.32
OURSOURC	221	2.11	.99	.27	.09	.12	.23	.04	.25*	.03	.05	.69**
APPLICAT	220	3.75	.87	.52**	.13	-.06	-.08	-.01	-.07	-.38***	.13	.26
EXPLOIT	215	2.60	.85	.21	.01	-.07	.25*	-.02	.02	-.07	.18	.55*
STORAGE	215	3.26	1.09	.77***	-.02	.15	.08	.26	.01	-.04	.10	.78**
DIFFUSIO	216	3.00	1.23	.55*	-.20	.05	.19	.06	.24	-.28	.24	.93**
INTERNAL	215	3.06	1.08	.85***	-.06	.09	.22	.32*	.12	.18	.59***	.86**

*significant at .1 level (2-tailed); **significant at .05 level (2-tailed); ***significant at .01 level (2-tailed)

Although there are a number of significant relationships, Tables 2 and 3 show no unambiguous relationship between sources and KI processes. To enable a further exploration of the results, we have converted both tables into graphs. Figures 4-9 depict the mean scores for KI processes for respectively the identification stage (Figures 4 and 5), acquisition stage (Figures 6 and 7) and utilization stage (Figures 8 and 9). The lines 'process1' represent the means of the respondents that did use a particular source; the lines 'process0' represent the means of the respondents that did not use that source.
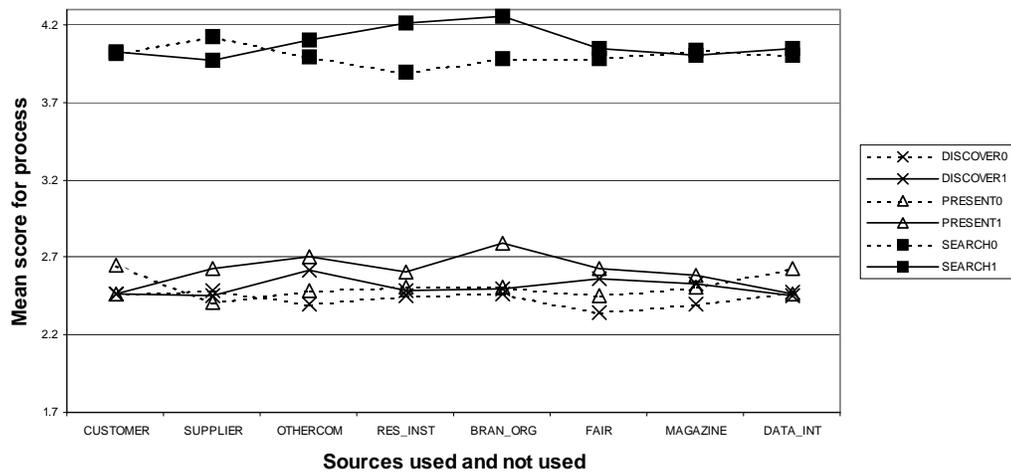
Fig. 4 Identification processes for technological knowledge
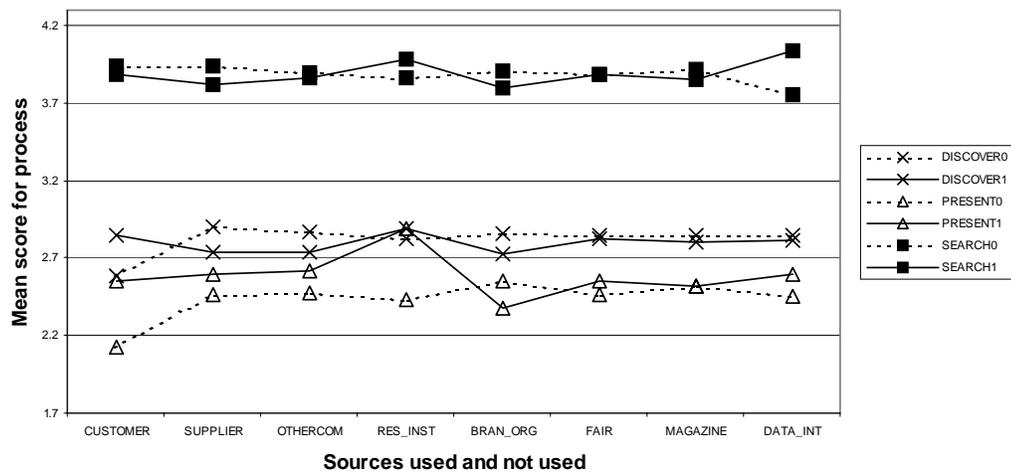
Fig. 5 Identification processes for customer/market knowledge
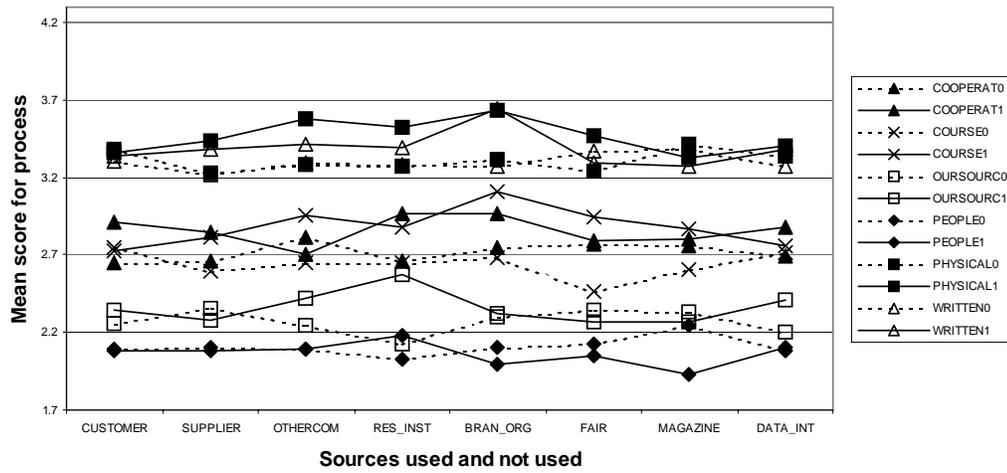
**Fig. 6** Acquisition processes for technological knowledge
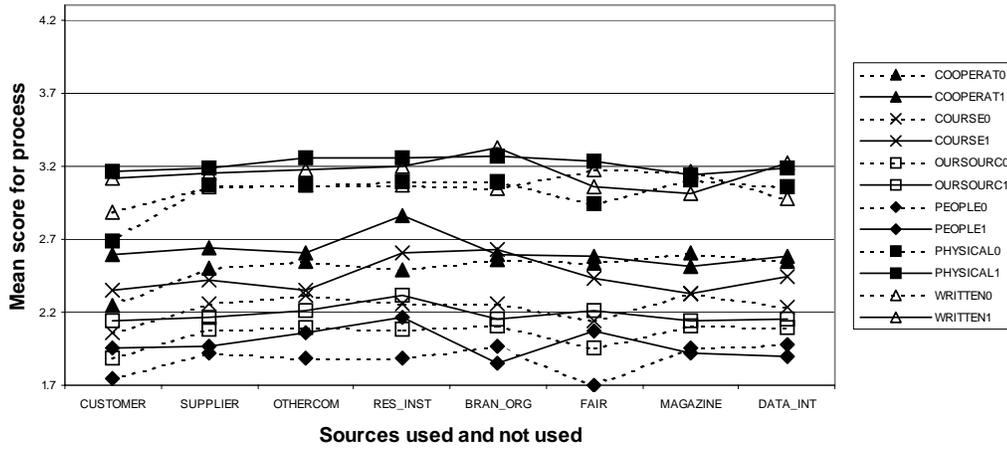
**Fig. 7** Acquisition processes for customer/market knowledge
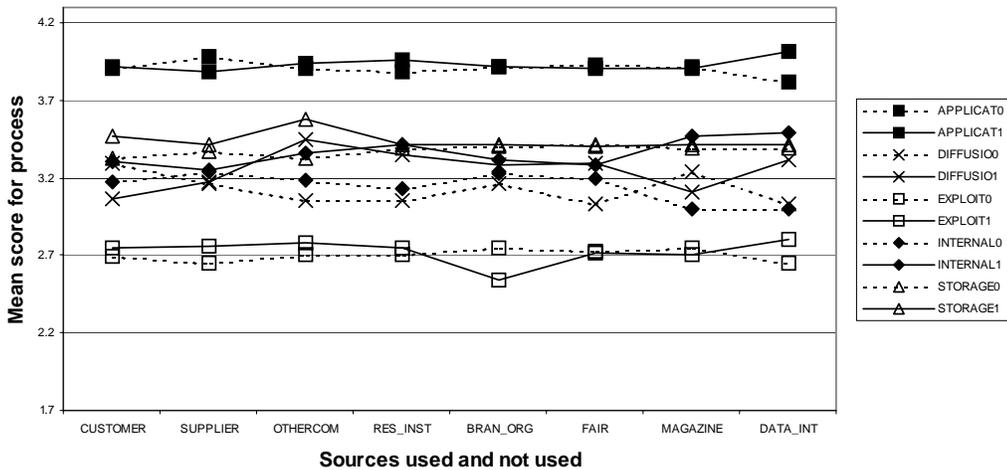
**Fig. 8** Utilization processes for technological knowledge
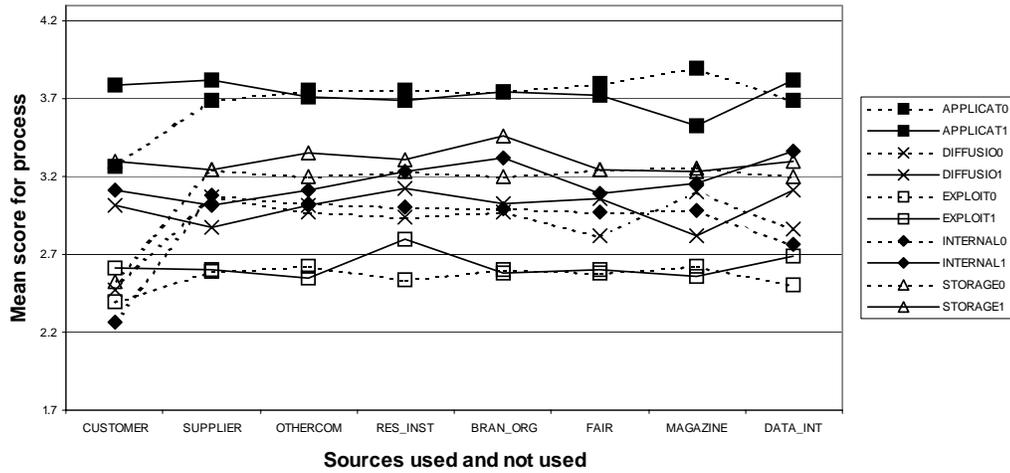
Fig. 9 Utilization processes for customer/market knowledge

In order to answer the four research questions we discuss the results of Tables 2 and 3, and Figures 4-9 below by research question.

RQ 1: Is the use of various sources associated with different ways of identifying, acquiring, or utilizing knowledge?

To answer RQ1, we looked mainly whether the ranking (order) of the KI processes varied or remained constant for the various sources. Figures 4 and 5 show that intentionally searching for knowledge (SEARCH) is clearly the most used way of identification for both types of knowledge, irrespective of the sources that are used. Similarly, Figures 6 and 7 indicate that acquisition of knowledge by means of documents (WRITTEN) and physical products (PHYSICAL) are most important compared to the other ways of acquisition, irrespective the sources that are used. Additionally, Figures 8 and 9 indicate that application of knowledge for the purpose for which it was acquired for (APPLICAT) is the most common way of utilizing knowledge, irrespective of source of knowledge. Thus, despite of the variation of mean scores for all processes between the several types of sources, there seem to be a primary KI process that is performed irrespectively of source of knowledge. This primary KI process is characterized by a goal-oriented search for external knowledge that is acquired by documents and physical products and applied for some particular purpose. When we look in Figures 4-9 at the remaining ten KI processes, there seem to be a number of groups of KI processes. Within these groups the ranking of KI processes

changes dependent on the sources that are used, but between the groups the order remains the same. For both types of knowledge we seem to identify the following five groups of KI processes: (DISCOVER, PRESENT), (COOPERAT, COURSE), (OUTSOURCE, PEOPLE), (STORE, INTERNAL, DIFFUSE), (EXPLOIT). The stable ranking of these groups seems to imply that the use of various sources of knowledge hardly influences the way knowledge is identified, acquired, and utilized. Considering the differences between the three tiers of sources we did not expect this. A final remarkable result within this stage is that the use of databases and the Internet (DATA_INT) is positively associated with the internalization process (INTERNAL) for both types of knowledge. Moreover, for technological knowledge this relationship also holds for another impersonal source of knowledge: magazines. This seems to imply that SMEs that use impersonal sources as magazines and the Internet are more likely to make sure that they have similar knowledge internally available next time.

Considering these results, the answer to RQ1 seems to be negative: the use of various sources of knowledge is, in general, hardly associated with the way knowledge is identified, acquired, and utilized.

RQ 2: Are some sources affecting KI processes more than other sources?

To answer the second research question, we looked in Tables 2 and 3 whether particular sources show more significant effects on KI processes than other sources. The sources that show most significant effects on KI processes are research institutes (RES_INST) for technological knowledge and customers (CUSTOMER) for customer/market knowledge. It is also interesting to see that the effects of using these sources are not only largest; they all are also positive (with the exception of -.05 for searching customer/market knowledge). Table 2 shows that, although not all significant, using research institutes (RES_INST) as sources of technological knowledge is associated with higher mean scores for all KI processes. This seems to imply that SMEs that make use of research institutes as sources of technological knowledge are more active in KI than other SMEs. This also applies – but to a lesser degree – to the use of other companies (OTHERCOM) as sources of technological knowledge, where the only negative effect (-.01) is insignificant and equal to the smallest positive effect (.01). Table 3 and Figure 9 indicate that, although rare (N0 = 22), not using customers as a source of customer/market knowledge seem to have a

strong negative effect on all KI processes, mainly in the utilization stage. This seems to indicate that SMEs that do not use their customers for customer/market knowledge are less active in KI than other SMEs.

On the other hand, there are also a number of sources that show virtually no significant effect on any of the KI processes. For technological knowledge, these are two of the most used sources: customers and suppliers. Our first interpretation was that since these sources are used so much the additional effect of using them is only minor. That is, these are source that they use anyway. However, when we look at Table 2 we see that there is a substantial group of SMEs that does not use these sources for technological knowledge (129 for CUSTOMER and 95 for SUPPLIER). This implies that this interpretation is wrong. We suspect that when analyzing this in more detail we will find that for these SMEs customers and suppliers are for some reason not relevant as sources of technological knowledge. This is obviously the case, for example, when customers and suppliers have no expertise of the particular technological niche of a certain SME. For customer/market knowledge the use of SUPPLIER and OTHERCOM show no significant effects on any of the KI processes. Since also here the number of SMEs that use and that not use these sources is substantial we believe the same interpretation applies as for technological knowledge. When we generalize these findings across both types of knowledge it seems that mainly the use of first tier sources of knowledge shows little effect on KI processes.

In sum we observe that the effect of various sources of knowledge on KI processes is clearly different. While some sources show positive effects for all KI processes, other sources show no significant effect at all. Thus, the answer to RQ2 is confirmative.

RQ 3: Are some KI processes more source-sensitive than other processes?

To answer RQ3, we first looked in Tables 2 and 3 whether particular KI processes show more significant effects than other processes. For technological knowledge we observe no KI processes that show substantially more significant effects than other processes, with the possible exception of following courses (COURSE). This is also shown in Figure 6 by the relatively large distance between the solid and the dotted line for this process. As also remarked when answering RQ1, this seems to make sense since courses are usually given by organizations that are somewhat more at a distance than customers and suppliers. In Table 2 we see that EXPLOIT and STORAGE show

no significant effects at all and that APPLICAT shows hardly significant effects. Currently, we do not know how to interpret this. For customer/market knowledge we also find no KI process that shows substantially more significant effects than the other processes. The only possible exception is the internalization of knowledge (INTERNAL), for which the difference in means is most significant and positive (the only negative effect (-.06) is insignificant and smaller than the smallest positive effect (.09). This seems to apply that 'making sure to have knowledge available internally next time' is positively affected by the use of all sources. There are also a relatively large number of processes that show virtually no significant effects: DISCOVER, WRITTEN, PHYSICAL, COOPERAT, OUTSOURCE, EXPLOIT, and DIFFUSIO. We did not find an explanation for this yet. However, in answer to RQ3 we can conclude that some KI processes are more source-sensitive than others. Thus the answer to RQ3 is confirmative.

RQ 4: Is this different for various types of knowledge?

When answering the first three research questions we already have given a number of examples of how the relationship between the use of sources and KI processes is different for the two types of knowledge. For example, we have seen that the use of customers as a source significantly affects the utilization of customer/market knowledge but not the utilization of technological knowledge (RQ2). Conversely, the use of research institutes as a source significantly affects the acquisition of technological knowledge, but not the acquisition of customer/market knowledge (RQ2).

When we further focus on the differences between the types of knowledge we find a number of additional remarkable results. In the identification stage we see that the use of research institutes (RES_INST) is associated with a substantial increase of the mean score for intentional search (SEARCH) for technological knowledge (+ .32, Table 2) and for unasked presentation (PRESENT) of customer/market knowledge (+ .46, Table 3). This seems to imply that SMEs that use research institutes as external sources of knowledge are particularly active in searching for technological knowledge and particularly receptive to customer/market knowledge. Within this stage we also find that using customers as a source is associated with a small but significant decrease of PRESENT for technological knowledge (- .20, Table 2) and an increase for customer/market knowledge (+ .43, Table 3). This can imply that SMEs that use customers as a source are relatively less receptive to technological knowledge and

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more receptive to customer/market knowledge. In the acquisition stage we find that mainly the use of personal sources of knowledge at a distance (OTHERCOM, RES_INST, BRAN_ORG, FAIR) is associated with a higher use of courses as a means of acquisition of technological knowledge (+ .31, + .24, + .43, and + .49, Table 2). This makes sense when we consider that courses are usually given by personal sources at a distance (for example branch organizations). In the utilization stage we find that not using customers for customer/market knowledge substantially decreases the mean scores for all utilization processes (Figure 9). This seems to imply that SMEs that do not use customers as a source of customer/market knowledge do substantially less with customer/market knowledge.

Also when we look at the mean scores for both types of knowledge there are differences. All scores for technological knowledge are higher with the exception of DISCOVER. Also the difference for PRESENT is only minor (2.55 vs. 2.53). Since these two processes are more reactive than the other processes, this seems to imply that SMEs are more active in integrating technological knowledge than integrating customer/market knowledge. Considering the technological roots of many SMEs this is not surprising. In sum we can conclude that the answer to RQ4 is confirmative.

5. Conclusion and Discussion

After having answered the four research questions we can conclude that the answer to the question in the title should be confirmative: knowledge sources do matter. However, we can add to this that the way they matter is not straightforward and deserves much further investigation. Also, the current study has a number of limitations that make that we have to be careful with this conclusion. The first limitation relates to the development of the questionnaire. Since we found no existing instruments that measured KI processes, we had to develop a new questionnaire. Moreover, we had to limit the length of the questionnaire because of the time that SME's NPD managers were willing to spend on it. We have tried to address this limitation to the best possible extent with our pre-test procedures. A second limitation relates to the indirect way we related knowledge sources to KI processes. Because we did not ask the respondents to answer the 'process questions' for each source, we were not able to establish a direct connection between sources and processes. However, since the alternative would have resulted in 252 similar questions we think this limitation was unavoidable for an exploratory study like this. A third limitation is the limited domain in which the

research has taken place. Although NPD in SMEs is an appropriate domain to investigate KI processes it is certainly not the only domain in which KI processes are relevant. Based on the results of this study we cannot generalize our findings to these other domains or to other types of organizations in the public and private sector. Finally, the results of this study are far from conclusive. We did not establish incontestable relationships between sources and processes. This is, however, inherent to exploratory studies.

Yet, this study has implications for research on KI processes. Firstly, even on the aggregated level of analysis in this study, our observations support our initial assumption that sources and KI processes are related. Although this seems not to apply to all processes and sources to the same extent, this indicates that research on KI processes should not abstract from the sources of knowledge. Rather, knowledge sources should be taken into account as a separate variable in research on KI processes. Secondly, the differences between the two types of knowledge indicate that also the type of knowledge substantially influences the sources that are used and the way KI processes are performed. This seems to imply that research projects on KI processes should either include the type of knowledge as variable in the research or control for it.

In addition to these implications for research and more important for exploratory research, we identify three main directions for further research on KI processes and sources. The first type of research concerns further descriptive research. The current study researched KI in the NPD process of SMEs. Future research should investigate what the relationship between knowledge sources is for KI:

a) In other domains and types of organizations. Examples are strategic management and finance in large companies and public organizations. This type of research allows for a horizontal comparison of findings across domains and organizations.

b) On the more specific level of individual NPD projects. While the current study analysed the NPD process in general, we expect to find a more detailed description of the relationship between sources and KI processes when we investigate individual NPD processes. This type of research allows for a vertical comparison of findings on different levels of analysis. Since the results within the current study are already substantially aggregated, we believe that KI

research on a more generic level of organizations as a whole does not add to our current understanding of KI processes anymore.

The second type of research concerns further explanatory research. Although we have suggested a few possible explanations, the current study has focused on the mere description of relationships between sources and KI processes. Hence, future research should also aim at the explanation of these relationships. We suggest doing so by analysing KI:

c) In more detail by relating the current results to the profiles of the individual companies and/or clusters of companies. While the current study has aggregated the results of all respondents, we expect that a more detailed analysis and clustering of the type of companies will point at explanations for the current results. For example, we found that customers and suppliers are used by many SMEs as sources of knowledge and not by many other SMEs but that the use of these sources does not seem to affect KI processes. An analysis of the type of companies that use and do not use these sources might provide an explanation for this result.

d) In less detail by clustering certain sources and KI processes. While the current study has concentrated on particular types of sources and KI processes we expect that an analysis on a higher level of aggregation of sources and processes will provide additional explanations. Examples of an analysis on this higher level of aggregation could be the first, second, and third tier sources and the three KI stages.

A final direction for further research concerns prescriptive research. Although a description and explanation of how and why organizations use certain sources and KI processes provides a better understanding of KI, it is also useful for managers to know how this relates to performance. Hence we promote further research that:

e) Investigates how the use of sources and KI processes relates to organizational performance. While the observation that certain sources and KI processes are performed more often in practice than others is probably one indicator of their success, it is certainly not the only one: many people smoke cigarettes during coffee breaks, but smoking is certainly not a successful strategy for a long and healthy life. Thus, we need to investigate whether there is a relationship between the use of certain sources and KI processes KI and organizational

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performance. In doing so we suggest using the 'spatial model of effectiveness criteria of Quinn & Rohrbaugh (1983) because it provides a differentiated view of organizational effectiveness.

f) Leads to guidelines for the improvement of the KI process in practice. Although knowledge about what is effective and what is not is needed to manage KI processes, it is not sufficient. Managers also need to know how to move from the current situation to a more effective situation. To generate this type of knowledge further research is needed on the design of KI processes and (information) systems that are to support these processes. Designing such system for KI requires an 'KI kernel-theory' to derive requirements from (Markus et al., 2002). The current study provides the first steps towards such kernel theory of KI.

Appendix: Questionnaire

Knowledge can come from several external sources. Check the sources that are most important for your company (multiple answers)	
Customer	Fair / conference
Supplier	Magazine / book
Other company than customer or supplier	Database / Internet
Research institute / university	Other (please specify)
Branch organization / center for innovation	

Nr.	Item	Question (5-point Likert-type, ranging from never (1) to always (5))
		There are several ways to find external knowledge. How often do the following ways occur in your company?
1	DISCOVER	We come across knowledge without really looking for it
2	SEARCH	We intentionally search for knowledge
3	PRESENT	Another organization presents knowledge unasked
		There are many ways to obtain knowledge if its source its known. How often do the following ways occur in your company?
4	WRITTEN	We receive documents or files from a source
5	PHYSICAL	We analyze products from a source
6	PEOPLE	We hire or employ persons from a source
7	COURSE	We attend a course given by a source
8	COOPERAT	We develop a product together with a source
9	OUTSOURC	We outsource a problem to a source
		Obtained knowledge can be used in several ways. How often do the following ways occur in your company?
10	APPLICAT	We use it for the goal we acquired it for
11	EXPLOIT	We use it for other goals than we acquired it for
12	STORAGE	We store it for potential later use
13	DIFFUSIO	We disseminate it to everybody concerned
14	INTERNAL	We make sure that we have similar knowledge internally available next time

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