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The role of explicit and implicit knowledge in work performance[1]

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Abstract

The article aims at the question if performance advantages of experts do relate to certain properties of their implicit and explicit knowledge. An overview on features of explicit and implicit knowledge shows divergent results from different research perspectives. Moreover, current research paradigms do not allow a direct comparison of explicit and implicit knowledge in a real world domain. A new approach to facilitate such a comparison is presented. A sample of fifteen nurses completed an interview on explicit professional knowledge. These nurses had to act in a critical nursing situation and their action-guiding implicit knowledge was explicated. Groups of successful and unsuccessful performers were established. Results from the professional knowledge test and the method for explication were compared by means of the Formal Concept Analysis regarding content and structure of explicit and implicit knowledge in the two performance groups. Several differences between good and poor performers were found. For example, poor performers revealed more emotional contents in their explicit knowledge than good performers meanwhile good performers had more flexible implicit knowledge than poor performers. The results are discussed in relation to methodological issues and practical consequences for knowledge management.

Key words: implicit knowledge, explicit knowledge, performance, Formal Concept Analysis

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In day-to-day life as in scientific debate high performance is seen in close relation to knowledge. Approaches to pinpoint such special performance to explicit knowledge have not always been successful. Therefore, in the last years, implicit knowledge is becoming a focus of interest in the research of high performance. The phenomenon of implicit knowledge has been investigated from different angles like cognitive, work and educational psychology. Based on these different perspectives varying methods and approaches can be found. The experimental paradigms of cognitive psychology mostly contain tasks where the implicit learning of artificial rules is necessary (see Seger, 1994). These rules do not have any relation with knowledge from the "real" life in order to ensure comparability of the knowledge bases of the test persons. This advantage turns into a disadvantage if one wants to compare explicit and implicit knowledge in a certain domain e.g., in working. The limitation is problematic from a work psychology perspective since empirical research regarding high performance, expertise, and work experience indicates a close relation between explicitly learned, domain specific knowledge and diffuse, somehow difficult to verbalize knowledge that is acquired implicitly during working. This article describes an approach that tries to integrate different methods in a common framework and that compares explicit and implicit knowledge and its role in (high) work performance aiming at an analysis of the knowledge prerequisites for high performance in working.

Theory

Quite recently it became apparent that implicit knowledge may play an important role in expertise although the relation between experience and implicit knowledge was outlined by Polanyi as early as 1958. One reason for this might have been that a common definition of expertise is still lacking or, as Sloboda (1991) states, there is no consensus among experts on the issue of expertise. Although expertise is a quite heterogeneous concept, researchers agree that experts usually work faster, more precisely and efficiently than novices and need less resources (Sonnentag, 2000; Speelman, 1998). Usually, experts do not display higher expenditures or better physical abilities than novices do. Differences between novices and experts are found above all in qualitative aspects – in the organization of performance prerequisites for a flexible, situation- and goal-orientated use of resources as well as in meta-knowledge and strategies (Hacker, 1992). Therefore, the organization of knowledge and other qualitative aspects of knowledge seem to be the most important difference between high and low performers. Based on this assumption, some aspects of implicit and explicit knowledge will be outlined in order to compare them empirically.

Acquisition of implicit and explicit knowledge

In general, the acquisition of explicit knowledge occurs through explicit learning while implicit learning is acquired through implicit learning (O´Brien-Malone & Maybery, 1998)[3]. Implicit learning is characterized as a process in which implicit knowledge is acquired with-

[3] In this research we exclude implicit knowledge that was formerly learned explicitly and became implicit (see e.g., the ACT* model by Anderson, 1992)

out the conscious intent to learn (e.g., Jimenez, 2003; Madden, 1999) while explicit learning is assumed only if a person uses active and conscious strategies to detect rules or features of a task. From the perspective of work psychology implicit knowledge is an essential part of experiential knowledge and is individually acquired by a worker in the course of (holistic) working. That is, implicit knowledge is bound to a person and situation- or context-orientated ("experience-guided working" e.g., Carus, Nogala & Schulze, 1992). Therefore, an explicit communication of this knowledge is hardly possible.

Experience means the development of holistic and flexible anticipation characteristics (Rose, 1992), i.e., expectations and ideas how a situation should look like. Anticipation characteristics are based on similarity principles which allow mental simulations for situation with a multitude of influencing variables (e.g., Büssing, Herbig & Ewert, 2001). Experience also includes the ability to use certain action patterns without becoming aware of their individual parts. Therefore, experience is seen as a process that produces a new "Gestalt" at the moment of deviation between supposed and real conditions. This position highlights the active dealing of an individual with environmental conditions in the development of experience.

Similar to this description of the acquisition of implicit knowledge through the development of holistic anticipation characteristics, Polanyi (1966) conceptualizes sensual experience and the integration of different information as the basis for the acquisition of implicit knowledge. Starting with findings from Gestalt psychology he describes the Gestalt as a result of an active transformation of experience during the course of insight. To acquire implicit knowledge about the world persons have to empathize in the objects of the world, they must "take in" these objects. In order for a learner to be successful, he has to assume that the things to learn are meaningful even though they seem meaningless. Through different integration- and/or interpretation-efforts meaningless sensations are translated into meaningful ones and transformed into experience. Insofar, a meaningful relation between different aspects is developed during implicit learning. Polanyi (1966) designates this process as the understanding of complex entities. In contrast to the acquisition of explicit knowledge implicit knowledge is therefore developed from concrete action and an unselective perception and integration of different information. For successful performance, therefore persons have to have meaningful relations stored in implicit knowledge based on self-reference and sensual experience as stressed by the philosophical work of Polanyi (1958, 1966).

Facts and procedures

The distinction between declarative and procedural knowledge is one of the most common differentiations between knowledge types (Anderson, 1976). Declarative knowledge as knowledge about facts and procedural knowledge as knowledge about procedures are associated with the distinction between "knowing that" and "knowing how" made by Ryle (1993). It is assumed that growing expertise goes along with an increase in non-formal elements in work (e.g., Benner, 1984). Professional expertise includes „knowing how" and less the theoretical thus formalized „knowing that" (Sonnentag, 2000). A person with a great deal of professional „knowing how" may not be able to translate it into „knowing that" (Ryle, 1993). Nevertheless, even though "knowing that" or declarative knowledge may decrease during the acquisition of expertise, experimental findings (e.g., O´Brien-Malone & Maybery, 1998)

showed that, for example, rules – as prototypes of declarative knowledge - can be acquired implicitly. That is, declarative knowledge can also be part of implicit knowledge.

Conversely, declarative and procedural parts can also be found in explicit knowledge. Although the acquisition of procedural knowledge aims for routinization or automatization, which means mostly a dropping to an implicit level, there are procedures which are too complex or too seldom to allow for this. Therefore, probability is high that declarative and procedural knowledge can be found in implicit as well as in explicit knowledge.

The role of consciousness and awareness

An often-mentioned feature of implicit structures and processes is that they operate outside consciousness while explicit knowledge is always accessible to consciousness. However, this concept for contrasting the two modes of knowledge is problematic. As O´Brien-Malone and Maybery (1998) point out that the concept of consciousness is by far no homogenous or coherent whole. Two basically different point of views can be found regarding implicit knowledge and consciousness (e.g., Berry, 1997). Both positions assume that implicit learning is an unconscious process, i.e., there is neither an awareness of the learning process nor has the learner an intention to learn. The "no-access" position, e.g., Lewicki, Czyzewska, and Hill (1997), moreover claims that this unconsciously acquired knowledge remains inaccessible for consciousness. The "possible-access" position, e.g., Reber (1989), on the other side claims that implicitly learned knowledge not necessarily remains unconscious, i.e., implicit knowledge might be accessible. Evidence from cognitive research paradigms speaks against the "no-access" position (for an overview see Shanks & St. John, 1994) and for the appropriateness of the "possible-access" position.

Dienes and Berry (1997) argue differently but with similar results. They state that implicit knowledge works below a subjective threshold, i.e., implicit knowledge is not consciously perceived as guiding ones actions. The focus of this argumentation is therefore not the acquisition but the use of implicit knowledge and a more specific definition of the role of consciousness. The importance of implicit knowledge for the guidance of actions clearly does not prohibit the possibility of awareness of this knowledge at other times.

Related concepts to consciousness, which are also often used to differentiate between explicit and implicit knowledge, are awareness and intention. Implicit knowledge is believed to work without intention and awareness while explicit knowledge cannot be acquired or used without consciousness, awareness or intent. There seems to be little doubt that implicit knowledge may occur in the absence of conscious, reflective strategies to learn, i.e., that the acquisition of implicit knowledge can happen incidentally (e.g., Jiminez, 2003; Kelly, Burton, Kato, Akamatsu, 2001). Concepts from educational or work psychology also denote types of knowledge acquisition that operate independent of awareness or intention ("learning by osmosis" or "apprenticeship", e.g., Gelman, 1994).

As already stated the accessibility of explicit knowledge to consciousness is unquestionable. However, the related concept "availability" is not so clear for this knowledge type. As Renkl (1996) and Renkl, Mandl, and Gruber (1996) point out, there is a type of explicit knowledge that is for several reasons not put into action, like e.g., knowledge compartmentalization or deficiencies in meta-knowledge. This so-called "inert knowledge" is conscious but might not be available for action guidance.

Complexity and flexibility

For knowledge in order to be termed complex it has to comprise a great number of elements that have manifold connections among them. Undoubtedly, explicit knowledge can be complex in this way, but for implicit knowledge contradictory research results can be found. For example, on the one hand social cognition research shows that people are not able to name proportion rules for human faces but react even to slightest aberration from these complex rules (e.g., Lewicki, 1986). On the other hand, computer simulations of artificial grammar research imply that participants in this research did not always learn the complex rules but that results can also be explained by the learning of simple letter pairs (e.g., Ericsson & Smith, 1991). These examples show the difficulty to give a final evaluation on the potential complexity of implicit knowledge. Theoretically, implicit experiential knowledge seems to be more complex compared to the knowledge investigated in cognitive psychology (Mathews, 1997). Implicit knowledge acquired in the course of work experience contains holistic anticipation characteristics that comprise several different, diffuse and unclear information as well as sensual perceptions (e.g., Carus et al., 1992). Thus, this knowledge seems to be quite complex (e.g., Polanyi, 1958). And, it might be assumed, that more complex implicit knowledge can produce a performance advantage.

Flexibility of knowledge means not only to be able to transfer knowledge to different situations and areas but also to be able to newly combine and link different parts of knowledge. Both, complexity and flexibility are often viewed together. It is assumed that explicit knowledge is a precondition for flexibility respectively for the flexible use of knowledge (Browne, 1997). The inverse assumption is that implicit knowledge itself is not flexible. Holyoak and Spellman (1993) characterize implicit knowledge as a complex structure that is inflexible and therefore difficult to transfer. Gazzard (1994) names as a possible reason for this lack of flexibility the simultaneous, one-dimensional processing of stimuli. Explicit knowledge on the other side allows for a simultaneous, multidimensional processing which is more flexible (for supportive findings of this assumption see Willingham, Nissen & Bullemer, 1989). A transfer of implicit knowledge into an explicit mode might therefore be a necessary precondition for flexible use.

In contrast to cognitive psychology, work psychology seems to take a different perspective on flexibility. In the concept of experience it is assumed that implicit knowledge can be used very flexibly across new contexts and unexpected situations (e.g., Martin, 1995). Rose (1992) describes this process as a reaction to a deviation from stored anticipation characteristics. Two objections may be raised against this assumption of flexibility: First, reaction to a deviation from a stored image might in fact just be a phenomenon of memory and second, research results for this mostly stem from observation data which do not reveal much about underlying processes. In summary, it seems to be more likely that implicit knowledge is inflexible and becomes only flexible if or when it is transformed into explicit knowledge.

Erroneousness

Especially educational psychology gives some warnings regarding the appropriateness and correctness of implicit knowledge (e.g., Fischbein, 1994). From a constructivist viewpoint Gelman (1994) assumes that even in explicit learning environments (e.g., schools)

learners actively construct their knowledge representation; therefore, it is unpredictable what information is stored and used. How much more difficult is then the prediction of what is learned in unstructured, day-to-day situations or during normal working life? This point of view is supported by several findings. For example, Lewicki, Czyzewska and Hoffman (1987) demonstrated that complex procedural knowledge was implicitly acquired without the corresponding conditions of application. Consequently, it can be assumed, that in the course of growing work experience implicit knowledge is learned that is erroneous but is not questioned due to the lack of awareness.

Besides this incorrectly learned or used knowledge, naïve theories (also called intuitive or implicit theories) as contents of implicit knowledge may constitute a problem. The term naïve theories describes theories of the relation between human beings, their behavior and environment. They are mostly acquired through experience without any empirical testing. Naïve theories play an important role in the area of social cognition (e.g., Macrae & Bodenhausen, 2000) because they are an integral part of self- and other-related knowledge. Naïve theories help to orient oneself in the environment quickly and effectively. These theories become a problem if they are applied without adequate reflection or in inadequate situations. To sum up, it can be assumed that implicit knowledge may contain erroneous parts and that it might be necessary to explicate this knowledge in order to correct these erroneous contents (for more details see Herbig, 2001; Herbig & Büssing, 2003). Moreover, erroneous implicit knowledge and problematic naïve theories should hinder successful performance.

Research questions and propositions

As outlined above, in the last years high performance has been connected with implicit knowledge and differences in the organization of knowledge as performance prerequisites. As the results on implicit knowledge are quite heterogeneous no hypotheses will be posed, but the following research questions and propositions will be examined:

Research question 1: Are there differences in the availability of explicit knowledge between good and poor performers?

This research question relates to the concept of “inert knowledge” as outlined above (Renkl, 1996). It might be that poor performers do have the same amount of explicit knowledge, but that their knowledge is less available for action guidance.

Research question 2: Are there differences in the contents of implicit and explicit knowledge between good and poor performers?

Regarding the outlined features of the knowledge types the following differences in the contents of implicit and explicit knowledge are proposed:

Proposition 2a: Differences in the amount and/or distribution of declarative and procedural knowledge.

Proposition 2b: Differences in the amount and/or distribution of experience-related contents like self-referential knowledge or emotions.

Proposition 2c: Differences in the amount and/or distribution of naïve theories.

Besides the contents of the knowledge types research has been concerned with structural features of knowledge. Therefore, the following question is posed:

Research question 3: Are there differences in the structure of implicit and explicit knowledge between good and poor performers?

For this research question especially the features of complexity and flexibility are of interest:

Proposition 3a: Differences in the degree of complexity do exist.

Proposition 3b: Differences in the flexibility of the knowledge types can be found.

Moreover, based on research from Wolff and Gabler (1998) it is possible to investigate

Proposition 3c: There are differences in the structural equivalents of naïve theories.

As far as we know, up to now, no comprehensive approach to compare explicit and implicit knowledge with regard to performance in a real domain exists. Therefore, a number of different, newly developed or adapted methods have to be outlined first.

Methods

Investigation of implicit and explicit knowledge

Precondition and Procedure: In order to investigate implicit and explicit knowledge from a „real life“ perspective a situation had to be developed that allows for the use of explicit and implicit knowledge acquired through work experience. The working simulation stems from the domain of nursing. Following six criteria were considered in the process of developing the nursing simulation (for details see Herbig, Büssing & Ewert, 2001): First, the situation had to be of sufficient solvability. Second, the situation had to imply time and decision pressure in order to increase the probability for use of implicit knowledge. Third, the information participants were confronted with should be ambiguously and complex (e.g., Griffin, Schwartz & Sofronoff, 1998). Fourth, the effect of the actions should be directly observable. Fifth, the situation should enable nurses to make use of sensual information. Sixth, successful management of the situation should be possible with the help of only a few technical devices.

Using the Delphi-method (Linstone & Turoff, 1975) ten nursing experts (ward nurses, nursing teachers, director of nursing services) were asked to develop critical nursing situations on the basis of these criteria. A detailed script for the selected situation “hypoglycemia” was developed and students were intensively trained to act as patients and to react flexible on the grounds of their “problem”. The task to be performed by the participants is the dressing of a small wound with slight signs of infection. The wound results from an accident with a motor bike and a closed head trauma is suspected. Unknown to the nurse is that a not yet diagnosed diabetes exists. Difficulties arise from the fact that closed head trauma and hypoglycemia have several symptoms in common. Already from the beginning of the simulation the patient shows slight symptoms of hypoglycemia (e.g., weakness, perspiring, trembling, hunger) which increase quickly and eventually lead to a loss of consciousness if the nurse does not react appropriately.

The evaluation by the participants indicated that an ecologically valid working situation was created in the laboratory (items on the realism of the situation and the patient behavior: situation $M = 4.0$, $SD = 0.82$; patient $M = 4.56$, $SD = 0.51$ on a five point scale).

A performance score was created to measure the quality of the accomplishment of the situation. Based on evaluations of the nursing experts four central points were considered: Information of the physician (when and how), dressing of the wound (when did the nurse stop doing this task?), symptoms check for a closed head trauma, and hypoglycemia (“diagnosis” and measures). These points were differently weighted on grounds of their importance

judged by experts before computing them to an overall performance score. Two independent observers rated the videotaped performances of all participants along the criteria of this performance score. Disagreement occurred only for 13 out of 15 criteria because of inexact definition. By redefining the two criteria complete agreement could be reached. After assigning a performance value to each participant a theoretically driven cut-off point was used to group the persons into good and poor performers (i.e., successful and unsuccessful nurses). This cut-off point indicated a performance that neither endangered the patient nor implicated serious complications.

The simulation of the critical situation was embedded in two types of knowledge tests (see below). That is, the general *procedure* was as follows: On a first appointed date a test of professional explicit knowledge was conducted with the participants. Seven to fourteen days later the simulation of the critical situation took place. Directly after the simulation a method for the explication of implicit knowledge was employed and some supplementary questionnaires were given to the participants (e.g. regarding the ecological validity of the simulation).

Explicit knowledge: To be able to compare explicit and implicit knowledge, an independent test for explicit professional knowledge is necessary. The form of the test used here is a half-structured interview with questions that were generated on basis of relevant literature and with the help of experts. Questions covered all theoretical and practical aspects of relevance for the successful dealing with the nursing simulation. They ranged from very wide questions (e.g., How can diabetes manifests itself?) to quite concrete ones (e.g., What do you do with a hyperglycemic coma?).

Besides the nursing topics of primary interest in regard to the nursing simulation additional topics were asked to avoid priming effects. The interviewer read the questions in standardized format and asked participants to recall all information, which spontaneously came to their mind when hearing the question. Moreover, nurses were asked to remember situations with the topic in question and to answer the questions from this perspective. This should ensure that every type of relevant explicit knowledge was obtained (like e.g., feelings/ emotions or highly idiosyncratic knowledge contents) so that comparability between explicit and implicit knowledge would be given.

The verbal responses were recorded on tape without time limit. The approximate length of the interview was one hour. The form of a half-standardized interview was deliberately preferred against a fully standardized interview. A completely standardized test can hinder that idiosyncratic explicit knowledge is detected and can also imply that nurses realize knowledge gaps causing a Zeigarnik effect. To further lower the possibility of priming effects to a minimum and to minimize the probability that events interfere that could lead to an examination of explicit knowledge, a time span of 7-14 days between the knowledge test and the laboratory session was chosen.

The test of explicit professional knowledge allows also for an estimation of the availability of the knowledge. The questions were asked in a hierarchical order from very wide ones to very specific ones that contained certain key words. Three levels of specificity were developed for each knowledge area. In order to define these levels as exactly as possible, the degrees of freedom for answering each question were used as a criterion. Questions on level one give the highest degree of freedom for answering (e.g., “How can diabetes manifest itself?”) meanwhile questions on level three give only a limited answering latitude to the participants (e.g., “What do you do with a hypoglycemic shock?”). Therefore, the question

level, to which a certain explicit knowledge part can be allotted, gives an impression on the availability of this specific knowledge.

Implicit knowledge: While explicit knowledge should be detectable by verbalization, it is assumed that implicit knowledge can only be found in a practical context, in which direct action has to be taken. This is analogous to the mode of acquisition of implicit knowledge – here the direct experience with the patient. Thus, performing a nursing simulation before the explication of implicit knowledge should help the participants to recall action-guiding implicit knowledge (see also Büssing, Herbig & Latzel, 2004). Knowledge explication was done in form of a repertory grid-interview (Kelly, 1955) on the basis of the elements nurses mentioned as action guiding. This technique is suited for studying implicit knowledge based on experience because of its proximity to constructivism - Kelly's hypothesis that a person subjectively construes his or her world and that these constructs are not easily to access inter-individually. Every construct consists of a dichotic reference axis, which has both differentiating and integrating functions during the construction of the "world". For example, a nurse may have the construct "symptom" consisting of the construct poles "specific for a certain illness" and "unspecific alarm signal" so that a differentiation between illnesses as well as an integration that something has to be done can take place.

The elements of the repertory grids are generated by means of a half-structured interview with the leading questions "what was important for you in the situation?" and "what led you to the different actions?". This is supported by the videotape of the performance. After generating the elements participants are asked to decide if they – from their own subjective point of view - perceive each of two action-guiding elements as similar or different and are asked to describe the difference or similarity. At the end of this differentiating process participants have generated idiosyncratic constructs of importance for their just performed action. Moreover, they have rated each element on each construct, meaning they have judged to what construct pole of each construct every element belonged (six point scale, e.g. 0 = element has nothing to do with this construct, 1 = element belongs completely to 1st construct pole, 3 = element belongs to both poles, 5 = element belongs completely to 2nd pole; see table 1a). Büssing, Herbig, and Ewert (2002) and Büssing and Herbig (2003a) were able to show that by means of this procedure it was indeed possible to explicate action-guiding implicit knowledge.

Comparison of explicit and implicit knowledge – Formal Concept Analysis

The methods presented above provide the basis for the comparison of content and structure of implicit and explicit knowledge. The test of professional knowledge results in qualitative data on explicit knowledge. The method for explication results in data on action-guiding implicit knowledge in form of repertory grids, i.e., graded similarity measures between elements and constructs. To integrate these two types of data the method of Formal Concept Analysis (FCA; Wille, 1982) was used (see also Herbig, 2001; Herbig & Büssing, 2003). This method allows for an investigation and interpretation of the data on a common theoretical ground.

Similar to the constructivist approach by Kelly (1955) the basis of the FCA is the notion that the informal understanding of a concept can vary significantly between different persons and different contexts. In order to make the meaning of a concept inter-individually accessi-

ble the formal representation of its context as well as its extent and content (i.e., intent) is necessary. The extent covers all objects (or entities) belonging to the concept while the intent comprises all attributes (or properties) valid for all its objects (e.g., Wolff & Gabler, 1998). The first step to make a concept inter-individually accessible is then to define a so-called incidence relation “an object has the attribute” (see Wolff, 1994) which can be used for the mathematical definition of a formal context and is denoted in a “cross-table” (for an example see table 1b). This incidence relation is one of the simplest verbal expressions and for this reason asks little of the data level. Therefore, in order to compare the different data from the test of professional knowledge and the method for explication they have to be transformed into incidence relations. The resulting “cross-tables” form so-called mono-valued contexts, i.e., an object has or has not an attribute. Naturally, the provision of mono-valued contexts is different for qualitative data (test of professional knowledge) and similarity measures (method for explication), which represent many-valued contexts.

The method used here for the transformation of a many-valued context, i.e. the repertory grids developed in the assessment of the implicit knowledge (see table 1a), into a mono-valued one is called “limits scaling” (Spangenberg & Wolff, 1993). Thereby, the elements of the repertory grids are handled as objects, and the constructs as attributes. Since each construct consists of two distinct construct poles each pole is defined as an attribute in the FCA. In a second step, the graded similarity measures of the repertory grid have to be transformed into "yes/no" evaluations. This is executed by defining certain values in the repertory grids, for which the existence of an attribute for an object is assumed (values one and two in the repertory grid – attribute is first construct pole in the formal context; values four and five – attribute is second pole). Values zero and three in the repertory grids are excluded (object does not have an attribute, no cross in the "cross-table") because participants did not give a clear judgement or named a clear non-relation. Tables 1a and 1b show data matrices before and after the “limits scaling”. As Spangenberg and Wolff (1993) demonstrated the information loss through this scaling type is low. Above all, no attributes are lost that contribute to the differentiation or combination of objects, thus, to the conceptual structure.

For the transformation of qualitative data, i.e. the explicit professional knowledge, into a mono-valued context another method is necessary: First, the selection of the relevant sections from the test and second the actual transformation. Relevant sections were selected first of all by the questions and answers relating to the mastering of the critical nursing situation (“dressing of wounds” and “diabetes”). Then similar contents in both knowledge types were searched for by identifying all mentions of elements and constructs (and their synonyms) in the test of professional knowledge that were also named in the repertory grids. In a last selection step units had to be defined in which, finally, was searched for incidence relations. This could be the complete answer to a question or (if an obvious change in content was found in one answer) only the section with the content of interest.

The actual transformation of the selection into a formal context was conducted in the following way: Common elements and construct poles (objects and attributes) were placed in a cross-table. Starting with the common elements (objects; in the example below an element also found in the repertory grid of the person was "expectation attitude") it was searched for attributes that described the element in the participant’s answer. Analogously, it was searched for objects that had been described by common construct poles (attributes; in the example below a construct pole also found in the repertory grid was "important"). New objects and attributes identified by this procedure were also placed in the cross-table. Similar to the rep-

ertory grid method, for every new coding section these new objects and attributes were carried along and every incidence relation was marked by a cross (for details see Herbig & Büssing, 2003). In this way the following verbal unit was transformed into the formal context denoted in table 2: "Eventually if the wound looks differently as if expected, that I'm prepared for it and then can fetch someone, e.g. a physician that he also looks at it, e.g. that is also important."

As a comparison between explicit and implicit knowledge is the research aim, a further step is necessary to try to ensure the "purity" of the knowledge types, i.e., the two knowledge types should be clearly separated. It is reasonable to assume that the method for explication also contains some explicit knowledge relevant for dealing with the situation. Therefore,

Table 1a:
Extract from the repertory grid of a participant
(many-valued context)

	elements			
1st construct pole	degree of consciousness	trembling	perspiring	2nd construct pole
emotional expression	1	1	2	control
personal communication	3	2	0	seclusion
emotional	4	1	1	rational

Table 1b:
Extract from the repertory grid of a participant after the "limit scaling"
(mono-valued context)*

attributes / objects	emotional expression	control	personal communication	seclusion	emotional	rational
degree of consciousness	X					X
trembling	X		X		X	
perspiring	X				X	

** rows and columns are switched in line with FCA conventions*

Table 2:
Transformation of data from the professional knowledge test into a formal context

attributes / objects	unexpected	being prepared	important	call the physician
expectation attitude	X	X	X	

wound situation	X	X	X

only knowledge that was not already mentioned in the test of professional knowledge is entered in the analyses. This was executed by deleting all objects and attributes (rows and columns) from the formal context of the method of explication that were also named in the test of professional knowledge. This procedure provides a conservative estimation of the implicit knowledge because some parts of this knowledge might get lost (e.g., if an explicit object is described by an implicit attribute). However, it has the advantage, to separate implicit and explicit knowledge as clearly as possible.

As a result of these transformations two formal contexts and two line diagrams (see below) for each participant are available for analysis - the formal context of relevant explicit knowledge, the formal context of implicit action-guiding knowledge and their respective visualizations in line diagrams. Based on these contexts a comparison between explicit and implicit knowledge could be conducted regarding content and structure of the different knowledge types.

Coding procedures

For the investigation of the three research questions several coding strategies had to be developed. For research question 1 regarding differences in the availability of explicit knowledge all mentions in the formal context of the test of professional knowledge were coded with a further attribute that consisted of the question level, on which the phrase was mentioned first.

In order to compare the contents of implicit and explicit knowledge as posed in research question 2 an aggregation of the data is necessary. Dichotic categories were developed (as in content analysis procedures, e.g., Miles & Huberman, 1984) that allow for a theoretically driven aggregation of the objects and attributes of the formal contexts.

To analyze the differences in declarative and procedural knowledge (proposition 2a) the first dichotic categorization deals with “action-orientated versus non action-orientated” phrases. Although it is assumed that not all procedural knowledge can be verbalized, at least references to this kind of knowledge should be found. Therefore, verbalizations that point to medical care skills as well as other actions are named action-orientated. All other mentions are coded as non action-orientated (e.g., non-deliberate reactions, facts or states).

Proposition 2b deals with differences that are related to the acquisition of implicit knowledge through concrete experience. Therefore, as a second dichotic categorization “nurse-related versus patient-related” and a third categorization “fact-orientated versus emotion-orientated” are employed. The second categorization is operationalized as follows: For action-orientated codes the actor is named in this category (nurse versus patient), the mentioning of symptoms or illnesses is always coded as patient-related, and unspecific objects or attributes (e.g., problem) are coded regarding their context. For the third categorization the following rules are used: The category emotion-orientated is coded for concretely named emotions (e.g., “fear”), for phrases hinting to underlying emotions (e.g., “Something is very wrong”), and for terms that describe emotions in general (e.g., “emotional expression”). All other objects and attributes are coded as fact-orientated.

For proposition 2c on naïve theories a fourth categorization “medical care versus not medical care” was developed. It is assumed that naïve theories manifest themselves more

likely in global statements over different areas as in specific work-related terms. Therefore symptoms, illnesses and medical or care-related activities are coded as medical-care while all other expressions without references to this area are coded as non medical-care.

For the investigation of research question 2 all objects and attributes of the participants were coded in the way outlined above, i.e., every expression was assigned one category for each dichotic categorization. Since the number of expressions varied greatly the absolute number in the explicit and implicit context was standardized.

In order to compare the structure of explicit and implicit knowledge (research question 3) indicators for complexity (proposition 3a) and flexibility (proposition 3b) in the formal contexts had to be found.

As described, something is not only complex because it has a large number of different parts but also because these parts are structured and have an inner organization of linking with each other. Linkage of different knowledge parts is therefore one aspect of complexity and can be used as an indicator for the complexity of implicit and explicit knowledge. The number of incidence relations in the formal contexts can objectively measure the degree of linkage of different knowledge parts.

Flexibility of knowledge means that it can be employed in different situations or different tasks. Moreover, flexibility states the ability to newly combine different knowledge parts. The transfer of knowledge to different situations cannot be tested in our design but the FCA supplies a measure for the new combination of different knowledge parts – the number of composed concepts. In FCA data are visualized in form of line diagrams that present all objects and attributes as so-called Hasse points (e.g., Davey & Priestley, 1990). In these line diagrams unnamed Hasse points can be found that are neither object nor attribute concepts but comprise both. These composed concepts can be regarded as an indicator for flexibility because they are evidence for a new combination of already existing knowledge parts. They can be directly taken from the FCA line diagrams.

In proposition 3c it was stated that a comparative investigation of structural equivalents of naïve theories is possible. These are the so-called super-concepts that can also be derived directly from the FCA. Super-concepts are defined as attributes having all objects in their extent or objects having all attributes in their intent (Wolff & Gabler, 1998). Usually, the existence of such concepts is assumed to be related with an undifferentiated assessment (e.g., a nurse who first and foremost evaluates all symptoms of a patient with the attributes “real” or “play acting”) and dominating naïve theories (e.g., “patient cannot be trusted”).

Sample

Fifteen registered nurses (11 female, 4 male) from three different hospitals participated in the laboratory study. Average job tenure was 14 years and 9 months. Age varied between 23-49 years (average age: 34 years). The participants worked on thirteen different wards. The vast majority of participants (87.5%) had completed secondary education. Current work positions were: Five nurses, eight assistant ward nurses, one ward nurse, and one nursing advisor. The experiments were conducted during leisure time; participation was voluntary and additionally paid for.

Results

In the following section group comparisons between participants that performed well in the simulated nursing situation (successful nurses: $N = 9$) and those who performed poorly (unsuccessful nurses: $N = 6$) are presented. Because of the small sample size exact statistical test procedures were employed. Exact tests prove to be asymptotically more efficient under small sample sizes than comparable parametric test procedures (see Edgington, 1995). Therefore, their use is advisable and appropriate in case of costly and time-consuming experiments in applied research as this study[4]. Moreover, for the comparisons regarding the structural features complexity and flexibility the absolute size of the formal contexts was kept constant by studentized residues. All testing results are calculated against an error rate of α=.10 since the detection of relevant effects in the sense of an explorative data analysis was the main interest.

In order to ensure that the differences in performance do not merely depend on differences in the amount of explicit knowledge successful and unsuccessful nurses were compared regarding their scores in the relevant areas of the knowledge test, diabetes and wound dressing. For both areas no significant differences were found (diabetes: $M_{\text{successful}} = 46.17$; $M_{\text{unsuccessful}} = 57.92$; wound dressing: $M_{\text{successful}} = 65.33$; $M_{\text{unsuccessful}} = 67.09$).

First research question: Availability of explicit knowledge

As both groups do have the same amount of explicit knowledge, performance differences might also be related to the availability of this explicit knowledge. Therefore, availability was tested along the dimension of recall and recognition. Comparisons of the amount of explicit knowledge on the different question levels in the formal contexts of the knowledge test were conducted.

For answers on the highest level of availability (recall) no differences between both groups ($M_{\text{successful}} = .23$; $M_{\text{unsuccessful}} = -.34$) exist. There are also no differences on a medium level of availability ($M_{\text{successful}} = .05$; $M_{\text{unsuccessful}} = -.16$). However, a significant difference occurs in the amount of only difficult available knowledge (recognition) ($M_{\text{successful}} = -.26$; $M_{\text{unsuccessful}} = .43$, exact p-value = .036). That is, unsuccessful nurses do have more only difficult available knowledge than successful ones; meanwhile both groups have about the same amount of easily available knowledge.

[4] Exact tests for univariate and multivariate data analysis were developed by Willmes (1987). Two sample tests for main effects and simple main effects are computed on the basis of Pitman's statistics. Tests for interaction employed split-plot designs. Exact permutation testing can do without the normality and homogeneity of variance assumptions. However, both - exact and parametric - testing procedures are asymptotically equivalent under conditions of normality and homogeneity of variance (see Pyhel, 1980).

Second research question: Contents of explicit and implicit knowledge

To compare the contents of explicit and implicit knowledge in the groups of successful and unsuccessful performers the described categories are used. As these categories are dichotic only one pole of each category is presented in the following. Table 3 summarizes the results.

For proposition 2a regarding declarative and procedural knowledge the action-orientated mentions of the first category are compared. No significant interaction between knowledge type and success can be found for this category. Also, no main effect of success results. However, a significant main effect for knowledge type occurs, i.e., the portions of action-orientated mentions in explicit and implicit knowledge differ significantly in both groups (exact p-value ≈ 0). That is, successful (exact p-value = .008) and unsuccessful persons (exact p-value = .031) do have more action-orientated mentions in their explicit than in implicit knowledge. Therefore, no differences between the groups can be found regarding declarative and procedural knowledge and the distribution of these knowledge contents in explicit and implicit knowledge within the groups is similar.

Proposition 2b deals with features of implicit knowledge that base on its acquisition through experience. Here, the nurse-related, i.e., self-referential, mentions are tested for the second content category, and the emotion-orientated mentions for the third content category. For the nurse-related mentions no significant interaction between knowledge type and success can be found nor are there main effect of success or knowledge type (see table 3). Since an overall analysis between explicit and implicit knowledge revealed a difference in self-referential knowledge regarding the attributes of the formal contexts a further analysis of these attributes was conducted. No differences between explicit and implicit self-referential attributes are found. However, a difference in the distribution can be detected. For the successful nurses a significant difference can be found (exact p-value = .059) in the direction that the implicit knowledge of successful nurses contains more self-referential attributes than the explicit knowledge. However, no such difference can be found for the unsuccessful nurses (exact p-value = .72), i.e., their implicit and explicit knowledge contains about the same amount of nurse-related attributes.

For the emotion-orientated mentions the following results are found: No significant interaction between knowledge type and success exists for this category. However, both main effects are significant (success: exact p-value = .096; knowledge type: exact p-value ≈ 0). That is, implicit knowledge contains significantly more emotion-orientated mentions than explicit knowledge for both groups and unsuccessful persons do have more emotion-orientated mentions than successful ones. The latter is mainly caused by differences in the explicit knowledge (exact p-value = .049), i.e., unsuccessful nurses do have more emotion-orientated explicit knowledge than successful nurses. This tendency remains stable for a separated analysis of emotion-orientated objects and attributes.

Proposition 2c deals with naïve theories. Therefore, the non medical-care mentions of the fourth content category are presented. Here, a tendency for an interaction effect can be stated (exact p-value = .10). Main effects and simple main effects allow to describe this tendency further: Successful as well as unsuccessful nurses have significantly more naïve theories in their implicit than in their explicit knowledge (exact p-value ≈ 0). The groups do not differ regarding naïve theories in implicit knowledge. However, the non medical-care mentions in

explicit knowledge do differ significantly: Unsuccessful nurses have more naïve theories in their explicit knowledge than successful nurses (exact p-value = .092).

Table 3:
Comparison of explicit and implicit knowledge contents in successful and unsuccessful performance

	Factor 1 - success	Factor 2 - knowledge		Factor 1		Factor 2		Interaction
Dependent variable		Explicit (1) *M* (*SD*)	Implicit (2) *M* (*SD*)	p-value**		p-value**		p-value
Action-orientated	successful (s)*	.33 (.14)	.06 (.05)	ME:	.75	ME:	.000	.97
	unsuccessful (u)	.33 (.11)	.05 (.05)	SME 1:	.88	SME s:	.008	
				SME 2:	.50	SME u:	.031	
Nurse-related	successful (s)	.39 (.19)	.51 (.20)	ME:	.61	ME:	.24	.36
	unsuccessful (u)	.40 (.12)	.40 (.16)	SME 1:	.93	SME s:	.20	
				SME 2:	.31	SME u:	.97	
Emotion-orientated	successful (s)	.03 (.05)	.27 (.15)	ME:	.096	ME:	.000	.35
	unsuccessful (u)	.08 (.05)	.23 (.15)	SME 1:	.049	SME s:	.008	
				SME 2:	.66	SME u:	.063	
Not medical-care	successful (s)	.20 (.08)	.81 (.15)	ME:	.13	ME:	.000	.10
	unsuccessful (u)	.30 (.14)	.77 (.23)	SME 1:	.092	SME s:	.004	
				SME 2:	.65	SME u:	.031	

*Notes: * successful n = 9 and unsuccessful n = 6; ** ME: main effect, SME: simple main effect*

Table 4:
Comparison of structural features of explicit and implicit knowledge in successful and unsuccessful performance

	Factor 1 - success	Factor 2 - knowledge		Factor 1		Factor 2		Interaction
Dependent variable		Explicit (1) *M* (*SD*)	Implicit (2) *M* (*SD*)	p-value**		p-value**		p-value
Degree of linkage (index for complexity)	successful (s)*	.25 (.05)	.34 (.05)	ME:	.16	ME:	.000	.043
	unsuccessful (u)	.19 (.05)	.39 (.08)	SME 1:	.049	SME s:	.027	
				SME 2:	.16	SME u:	.031	
Number of composed concepts (index for flexibility)	successful (s)	.31 (.68)	.37 (.91)	ME:	.22	ME:	.83	.60
	unsuccessful (u)	-.40 (1.67)	-.62 (1.03)	SME 1:	.28	SME s:	.85	
				SME 2:	.073	SME u:	.66	
Number of super-concepts	successful (s)	0	3	/		/		/
	unsuccessful (u)	0	1***					

*Notes: * successful n = 9 and unsuccessful n = 6; ** ME: main effect, SME: simple main effect; *** Differences in the number of super-concepts: McNemar-Test, $p < .07$*

Third research question: Structural features of explicit and implicit knowledge

In order to compare structural features of the knowledge (research question 3) of successful and unsuccessful performers the indicators "degree of linkage" for complexity (proposition 3a), "number of composed concepts" for flexibility (proposition 3b), and the "number of super-concepts" (proposition 3c) as the structural equivalent of naïve theories are employed (see table 4).

For the complexity indicator (proposition 3a) an interaction between success and knowledge type occurs (exact p-value = .043). Simple main effects show the direction of this effect: Means for the complexity indicator "degree of linkage" in the explicit knowledge are for the group of successful nurses .25 and for the unsuccessful ones .19. This difference is significant (exact p-value = .049), i.e., the explicit knowledge of successful persons has a higher degree of linkage than the explicit knowledge of unsuccessful persons. Means for this indicator in implicit knowledge are .34 for the successful group and .39 for the unsuccessful group. This difference is not significant. Comparisons between explicit and implicit knowledge on the degree of linkage show significant differences in both groups, i.e., for successful as well as for unsuccessful nurses implicit knowledge has a higher degree of linkage as explicit knowledge (exact $p\text{-value}_{successful} = .027$; exact $p\text{-value}_{unsuccessful} = .031$).

For the "number of composed concepts" as an indicator of flexibility (proposition 3b) the following results are found. No significant interaction between success and knowledge type or main effects of the two factors occur for this indicator. However, a simple main effect between the groups in implicit knowledge can be found (exact p-value = .073). That is, successful persons possess more composed concepts in their implicit knowledge than unsuccessful ones.

For the number of super-concepts (proposition 3c) a McNemar test only for implicit knowledge is performed since no super-concepts can be found in the explicit knowledge of both groups. Three out of nine successful nurses had super-concepts in their implicit knowledge meanwhile in one out of six unsuccessful nurses such a concept could be identified. This difference is significant (exact p-value = .063).

Discussion

The aim of the here reported research was an analysis of the knowledge prerequisites for high performance in working. Therefore, the availability of explicit knowledge, important content categories and indicators for flexibility and complexity in explicit and implicit knowledge of successful and unsuccessful nurses as well as the distribution of these categories and indicators were investigated.

For the first research question on the availability of explicit knowledge an interesting difference between the performance groups occurred. Successful as well as unsuccessful persons had a similar amount of well or medium available explicit knowledge but, moreover, the unsuccessful participants had a significantly bigger amount of knowledge that was only available with difficulty. Performance advantages can therefore not be attributed to more well available knowledge. Conversely, it might be asked if the performance disadvantages of the unsuccessful persons are related to too much difficult available explicit knowledge or as Renkl (1996) phrases it "inert" knowledge. A possible explanation, which unfortunately

cannot be tested within the design of this study, might be that this “inert” knowledge hinders the correction of inadequate implicit knowledge and therefore remains an obstacle for successful performance in critical situations that require fast action.

The second research question dealt with possible differences in the knowledge contents of good and poor performers. It was proposed (2a) that differences in declarative and procedural knowledge between these performance groups might occur. However, no differences in the action-orientated mentions of successful and unsuccessful persons were found. That is, the performance advantage of successful nurses can neither be attributed to a bigger amount of implicit procedural knowledge nor to a higher action orientation in explicit knowledge in general.

In a second part of research question two (2b) it was proposed that differences might be found in experience-related contents, like self-referential knowledge and emotions. No such differences between the groups were found regarding the nurse-related, i.e. self-referential mentions. However, if the mentions are divided in objects and attributes, a difference in the distribution of this knowledge content could be observed. Implicit attributes of the successful performers contained more of this self-referential knowledge than their explicit attributes meanwhile no such distribution difference was found for unsuccessful performers. The differentiation in objects and attributes in the FCA can – contentwise - be regarded as the differentiation in the object and subject of experience. According to Polanyi (1958) an integration of experience-object and -subject is a necessary precondition for a fruitful use of experience. He describes two ways for such an integration. For once, the immediate “unification” of subject and object in the action process. And, an explicit differentiation and analysis of the object in order to reach an implicit integration on a higher level. Especially the second way is important to process experiences and to use them in a fruitful way. Against this background, a relation between the different distributions of self-referential attributes in both performance groups and therefore the “subject of experience” seems obvious. It might be assumed that the equal distribution of these attributes in the group of unsuccessful persons points at a lacking integration, that is a missing relation between work experience and ones own person; or that such a relation has not been reestablished (reintegrated) after a phase of differentiation. Meanwhile, the higher amount of self-referential attributes in the implicit knowledge of successful persons might imply well-integrated experience, which in turn might lead to better performance. Moreover, it is possible, that the cognitive load for an integration of object and subject in explicit knowledge is quite high and thus withdraws capacities needed for the successful dealing with a critical situation (e.g., Broughton, 1998; Pendry & Macrae, 1999) meanwhile this integration is a “natural” process in implicit knowledge (Polanyi, 1958).

For the content category “emotion” in proposition 2b it was found that unsuccessful performers had more mentions of this category in their explicit knowledge than successful ones. In implicit knowledge no such differences were found although the general distribution of these categories shows that emotion-orientated mentions are more frequently in the implicit than in the explicit knowledge of both groups. It can be argued that the latter difference might be due to the kind of assessment method used for the two knowledge types. However, as measures were taken to ensure that all possible types of knowledge contents were also asked for in the test of professional knowledge and the difference in the category "emotion" occurred in the explicit knowledge, an interpretation of this difference is possible similarly to the interpretation for the self-referential mentions. The explicit processing of emotions may increase the cognitive load and therefore resources are withdrawn that would have been nec-

essary to deal with the situation. On the other hand, the integration of emotions in implicit knowledge, that is, without the necessity of attention, might preserve the information content of emotions - as postulated in the concept of experience – without impairing the accomplishment of the situation.

The third proposition of research question two (2c) dealt with the question of differences in the amount and/or distribution of naïve theories. Here, a further difference between successful and unsuccessful nurses was found regarding the content category “non medical-care” mentions. Unsuccessful performers had more of these mentions in their explicit knowledge than successful ones. Again, no differences were found in implicit knowledge. Against the background that both groups hold the same amount of professional explicit knowledge the interpretation of this result is difficult. The content category was introduced because it should be – at least theoretically – an important aspect of implicit knowledge whereby non medical-care mentions should hint at the possible negative aspect of naïve theories. The results suggest, that naïve theories may cause problems in performance even though adequate professional knowledge exists, i.e., that a more general explicit knowledge superimposes the use of correct professional knowledge.

For the third research question on the structural features of implicit and explicit knowledge some distinct differences between the successful and unsuccessful persons were found. The first difference occurred regarding the complexity indicator “degree of linkage” (proposition 3a). The explicit knowledge of successful performers showed a higher degree of linkage than that of unsuccessful performers whereby for both groups implicit knowledge showed a higher linkage than explicit knowledge. A higher degree of linkage means that a better access from single knowledge parts to other knowledge contents is possible. Therefore, it can be assumed that although the unsuccessful nurses did have all the relevant professional knowledge a lack of linkage hindered the access of important information while dealing with the situation. This might have had a special impact in the employed critical situation since the patient displayed unspecific symptoms, which made a search in different areas of information necessary in order to find the essential knowledge. Under these circumstances a higher interlinked explicit knowledge conveys clear performance advantages. The high degree of linkage in the implicit knowledge of both groups plays no important role in this context insofar as implicit knowledge in general contained only small amounts of professional knowledge (medical-care mentions).

A further structural difference was found regarding the number of composed concepts that should indicate flexibility (proposition 3b). Successful persons had more composed concepts in their implicit knowledge than unsuccessful persons, i.e., the implicit knowledge of good performers seems to be more flexible than that of poor ones. Therefore, the general assumption that implicit knowledge is inflexible has to be altered insofar that implicit knowledge can be flexible and that this flexible knowledge can bring about a performance advantage in working. Unfortunately, the presented study allows no insight into the question how flexible implicit knowledge is acquired or why implicit knowledge is not with all people sufficiently flexible. Possible explanations may reach from person variables (e.g., rigidity) to very specific situation variables (e.g., the presence or absence of feedback on the used knowledge).

Proposition 3c dealt with the question of structural equivalents of naïve theories. Because of the small occurrence of these super-concepts in the sample under study it can only be stated that possibly more super-concepts can be found in the implicit knowledge of success-

ful persons than in the implicit knowledge of unsuccessful ones. Super-concepts point to the existence of global naïve theories that in turn may be a way of reducing complexity. However, as successful persons displayed more of these naïve theories it is necessary to take a closer look at the adequacy of the super-concepts for performance. For the poor performers one super-concept named "emotional expression" was found meanwhile for the successful group three super-concepts named "observation criteria", "important aspect in nursing" and "time for the patient" could be identified. The contents of these concepts seem to be on different levels. For the unsuccessful nurse the super-concept clearly poses a reduction to a naïve theory, namely everything is primarily evaluated as an expression of emotions. Such a reduction to one dimension of evaluation cannot be found in the super-concepts of successful nurses. It seems to be more like an expansion in the sense that everything is potentially important and worthy of observation. That is, both "types" of super-concepts reduce complexity but meanwhile the unsuccessful nurse used a naïve theory that was inadequate in the concrete situation, the successful nurses might just have reduced their cognitive load by sparing themselves the effort to sort their perceptions regarding importance.

To sum up, regarding the question if differences in the knowledge contents and structure of unsuccessful and successful persons exist the results are quite clear. Such differences do exist and some specific distinguishing features could be found for good and poor performers. However, these differences are not solely restricted to implicit knowledge but display a complex interaction between explicit and implicit knowledge.

The presented study aimed at a comparison of explicit and implicit knowledge prerequisites for performance from a "real life" perspective. Most previous studies on implicit knowledge use artificial tasks where new implicit knowledge is learned and thus no equivalent explicit knowledge can be found. Therefore, with this type of research it is neither possible to investigate implicit knowledge acquired through experience nor is a direct comparison between explicit and implicit knowledge possible. Considerations from research in expertise (e.g., Sonnentag, 2000) show that such a comparison is necessary in order to gain some insight into the question why and how some people perform superior in certain work tasks while others do not. However, in work psychology most investigations are observation studies that only allow for indirect conclusions about implicit knowledge.

The design of the presented study tries to circumvent these problems. Basing on an ecological valid simulation of a work situation that actualizes implicit knowledge and provides data on performance, implicit knowledge was explicated in form of repertory grids (Büssing et al., 2002). Additionally, a test of professional knowledge provided data on explicit knowledge. For the comparison of both knowledge types the Formal Concept Analysis (Wille, 1982) was employed. This procedure has advantages over other methods for the visualization of categorical data since no loss of data or distortions happen (e.g., Blasius & Greenacre, 1998). However, the data reduction necessary to gain a formal context is to be seen more critically. Especially the described transformation of explicit knowledge into a formal context shows that only a small amount of explicit knowledge entered the comparison. On one hand, this necessary data reduction might have led to the problem that not all performance relevant explicit knowledge was considered. On the other hand, the conscientious selection along the explicated implicit knowledge ensures that the comparisons are meaningful as they are anchored in knowledge contents similar to both knowledge types.

Another methodical problem has to be discussed, namely the adequacy of the used content categorizations. Experiential knowledge should be quite idiosyncratic basing on the

different experiences and histories of people. Is then a meaningful aggregation possible at all? The answer might be “yes and no”. “No” in the sense that concrete summaries of content might be impossible without loss of data. And “yes” in the sense that general classes of contents can be defined and compared. The categorizations used in this study were based on the theoretical assumptions on properties of explicit and implicit knowledge in which differences may occur without dealing with concrete contents. Therefore, they do have the limitation that no statements can be made about e.g., the kind of emotions or the mentioned procedures. That means also, concrete relations between the individual knowledge and performance cannot be stated. However, there is no reason to assume such an idiosyncratic influence of experience on the structural features of knowledge like complexity or flexibility.

Besides these methodical considerations the results show some distinct differences in the knowledge structure and contents of good and poor performers which suggest some consequences for dealing with knowledge in organizations. Expertise and implicit knowledge are of great concern for organizations especially since these human resources are grounded in experience, bound to a person and therefore not easily to transfer (Johannessen, Olaisen & Olsen, 2001). The results of the study give some cautions regarding the question of transfer of knowledge from one person to another. As shown for the knowledge contents of self-reference and emotion the explicit transfer of knowledge that refers to the subject of experience might cause problems for the receiver of this knowledge. That is, if the receiver has no possibility to integrate the knowledge through experience in his/her implicit knowledge a cognitive “overload” of the explicit system can lead to a decreased instead of an increased performance. Within knowledge management it is therefore necessary to offer occasions where newly acquired knowledge can be used and experienced. Moreover, as it seems that the complexity of explicit knowledge is important for a successful performance, the representation of knowledge, e.g., via data base technology, should support a linkage of knowledge parts. The development of interlinked explicit knowledge can also be enhanced by metacognitive strategies which help to consciously build up complex knowledge and to use technological aids in a fruitful way (e.g., Hacker, Dunlosky & Graesser, 1998). Another result shows the importance of the flexibility of implicit knowledge. Good performers displayed a high flexibility as proposed for implicit experiential knowledge in work psychology (Carus et al., 1992; Martin, 1995). In order to gain this flexibility a use of knowledge in many different contexts seems to be necessary. A consequence of this assumption for organizational knowledge management is that members of the organization should get enough opportunities to use their knowledge in different areas and to experience the consequences of their actions. As implicit knowledge is not always adequate (although all participants of our study were experienced nurses dysfunctional naïve theories could be identified), the risk of inadequate action in a real context can be too high. Therefore, in order to manage implicit knowledge on the level of use, methods like planning games or simulations might be useful, as they allow people to benefit from the experience without possible risks and costs for the organization (for a more detailed discussion of knowledge management see Büssing & Herbig, 2003b).

To sum up, the results of this study show that explicit and implicit knowledge have to be considered quite differentially when it comes to the enhancement of performance. The two knowledge types pose different demands on the management of knowledge. Meanwhile the positive aspects of explicit knowledge for performance can be explicitly taught and learned, a correction of inadequate implicit knowledge has to start with an explication of this knowl-

edge. The positive aspects of implicit knowledge for performance have to be strengthened through opportunities to use and experience this knowledge.

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