How Does Net-Based Interdisciplinary Collaboration Change with Growing Domain Expertise?

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Abstract: This study examined how growing domain expertise influences net-based interdisciplinary collaboration of persons with medical and psychological background. We compared the quality of the collaborative process and the joint solution of interdisciplinary dyads of different expertise levels (advanced students, trainees, and experts) working on a patient case. To assess the quality of the collaborative process, a rating scheme developed by Meier et al. (in press) was used. Additionally, process log files measuring individual and joint time and number of work phases were gathered, and joint solutions were analyzed. As had been assumed, the experts scored lower than the less experienced dyads in most measures of collaborative process. Looking in more detail at the less experienced dyads revealed that the trainee dyads outperformed the student dyads in most of the process variables. Analyses of process logfiles revealed the same pattern regarding the number of phases used. The predictions for the quality of the joint solution were more difficult and the results for these variables more mixed.

Introduction

Studies on expertise development in different domains have revealed how experts' knowledge and the ways they solve domain-specific problems differ from those of novices (Feltovich, Prietula, & Ericsson, 2006). Also, it was shown that expert knowledge and problem solving behaviour differ across domains. Against this background, one would expect that experts from different domains should also differ in their interdisciplinary *collaborative behaviour* from laypersons or intermediates when asked to solve complex problems in a team. But even though interdisciplinary collaboration among experienced professionals is increasingly becoming important for solving complex problems in society, economy, and science, studies investigating social and cognitive processes of interdisciplinary collaboration are rare (Bromme, 1999). Existing articles primarily describe informal studies on successful and unsuccessful aspects of interdisciplinary work observed in the field (e.g. Epstein, 2005) or propose models intended to enhance such collaboration (McDaniel, 1995). The central question of the present study was, how growing domain experience influences net-based interdisciplinary collaboration. Two strands of research have motivated this study. First, in the last six years our team has investigated the net-based interdisciplinary collaboration among students of psychology and of medicine (Hermann, Rummel, & Spada, 2001; Rummel & Spada, 2005; Rummel, Spada, & Hauser, 2006). A second focus of work in our team has been on the investigation of expertise in complex domains. Early studies examined expertise in the domain of physics (Lay & Spada, 2000; Plötzner & Spada, 1993), a recent study examined expertise development in the domain of clinical psychology (Hauser, Spada, & Rummel, 2006). Thus, our research has been influenced by the CSCL literature as well as by research in cognitive science on expertise development. In the following paragraphs we will describe these two areas of research in more detail in order to derive hypotheses for the actual study.

Net-Based Interdisciplinary Collaboration

Our research has focused on the question of how to support and improve net-based interdisciplinary collaboration by means of instruction. In particular, we have chosen to investigate the *interdisciplinary collaboration of persons with medical and psychological background*, because collaboration is essential in this area. Secondly, we have focused on a *net-based collaboration setting*, because innovative computer-mediated settings open up new opportunities for collaboration across distance and time. This is important for the practicability of interdisciplinary collaborations and thus for the practical relevance of our research, as many times experts from different domains will not be co-located and face to face meetings are very time consuming. In the context of joint medical diagnosis, video conferencing systems have been advocated as a particularly suitable solution (Köhler & Trimpop, 2004).

In our prior studies (Rummel & Spada, 2005; Rummel et al., 2006) advanced medical students and advanced students of psychology collaborated on complex patient cases via a videoconferencing system. In two experiments we tested the influence of instructional measures on collaboration. Our experiments consisted of two phases: In a first phase, the learning phase, participants were instructed how to collaborate effectively by a script or they observed a model collaboration. In the second phase, the test phase, collaboration partners collaborated without further instruction. In this phase the learning effects of script or model were assessed by analyzing the collaborative process and its outcome, the joint solution. Observing a model collaboration proved to be a particularly effective method to instruct collaboration, and even more so if it was augmented by additional elaboration support (Rummel et al., 2006). Learning from scripted collaboration yielded mixed results: positive ones in the first study and not so good ones in the second study (Rummel et al., 2006). The main result of both our studies was that good collaboration can be instructed. Another product of this research was the development of a rating scheme that allows assessing the quality of collaborative processes (Meier, Spada, & Rummel, in press). Based on an iterative cycle of extensive literature search and detailed qualitative analyses of successful and unsuccessful dyads' collaboration, we developed a rating scheme that assesses the quality of collaboration processes reliably and in an efficient way. This rating scheme comprises nine dimensions (a more detailed description is provided below) and evaluates aspects of the communication, joint information processing, coordination, interpersonal relationship, and motivational aspects.

One limitation on this research is that the findings that have resulted from studies with advanced students could not simply be generalized to the collaboration among more experienced persons. However, it is particularly the experts of different domains who are required to collaborate in order to solve complex problems occurring in the real world.

Expertise Development

But what exactly is expertise? Research in cognitive science has investigated this question from the pioneering work of de Groot (1965) on chess expertise to research in manifold domains today (for an overview, see Ericsson, Charness, Feltovich, & Hoffmann, 2006). As a background for the present study, research on expertise development in the domains of medicine (e.g. Boshuizen, 2003, 2004; Boshuizen & Schmidt, 1992) and clinical psychology (Hauser et al., 2006) is particularly relevant:

Medical expertise has attracted much research attention since the 1970s, resulting in a large body of literature (e.g. Boshuizen & Schmidt, 1992; Boshuizen, 2003; 2004; Elstein, Shulman, & Sprafka, 1978). To examine expertise development in the domain of medicine, researchers have usually constructed a text-based case study and have asked physicians and novices to think aloud while working on it (e. g. Boshuizen & Schmidt, 1992). After diagnosing the case, participants were asked to elaborate on their assessment of the signs and symptoms (post-hoc pathophysiological explanations). With this approach, novices, intermediate and advanced students of medicine, and expert physicians with an average of four years of work experience have been compared. Regarding the quality of diagnoses, an increase up to the level of expert physicians was found (Boshuizen, 2004; Rikers, Schmidt, & Boshuizen, 2002). Earlier studies on expertise had revealed that the amount and structure of knowledge is one main factor that separates novices from experts (Feltovich et al., 2006), Boshuizen and colleagues also investigated the development of knowledge with growing domain expertise. They postulated three steps in the development of a medical expert: First, medical students acquire large amounts of declarative knowledge about biomedical processes. The representation of this knowledge can be understood as a loosely connected semantic network. With some clinical experience, declarative knowledge is then proceduralized in a process of "knowledge encapsulation". Encapsulated knowledge pertains to higher-order concepts under which lower-order concepts are subsumed. In routine work, experts verbalize only higher-order concepts. Researchers can detect knowledge encapsulations by comparing the experts' post-hoc explanations with think-aloud protocols. The phenomena of knowledge encapsulation led to lower scores for the experts in the number of recalled case statements (e.g. Boshuizen & Schmidt, 1992). However, if asked to do so, or when problems arose, experts were able to verbalize lower-order concepts. Thus, Boshuizen and colleagues found a linear increase in the amount of post-hoc pathophysiological explanations. In a final step, the clinical experience helps the medical expert to develop illness scripts for each disease. An illness script consists of enabling conditions (conditions and constraints of a disease), the fault (major malfunctions in bodily processes), and consequences (signs and symptoms). To summarize the results on expertise development in medicine: Boshuizen and colleagues found an increase in the amount of clinical and pathophysiological knowledge as well as in the quality of diagnoses (Boshuizen & Schmidt, 1992; Boshuizen, 2003, 2004; Rikers et al., 2002).

In one of our own studies (Hauser et al., 2006) we examined whether *expertise in clinical psychology* develops similar to expertise in medicine. We compared psychologists at five different training levels: novice, intermediate and advanced students, graduated trainee therapists (at least in the second year of their obligatory therapeutic on-the-job-training) and expert psychotherapists at least ten years after graduation. All participants had to complete an instrument consisting of three parts: (1) A knowledge test measuring basic psychological knowledge (e.g. classic conditioning), the application of the basics to clinical psychology (e.g. Mowrers 2-factor theory of avoidance learning), and knowledge in the area of clinical psychology (e.g. Becks cognitive triad). (2) A set of open-format questions that asked participants to write down as much as they know about one basic concept (schedules of reinforcement) and one clinical concept (schizophrenia). (3) The main part of the instrument consisted of two text-based patient cases (e.g. describing a patient with a social phobia). Similar to the studies by Boshuizen and colleagues (e.g. Rikers, et al., 2002) participants had to skim the case, recall important information in writing, diagnose the described patient, and finally explain the signs and symptoms. Three result patterns were found: On all variables measuring basic principles of psychology, the scores were highest in the first years of university studies, then knowledge decreased. On the variables measuring clinical knowledge, we found an increase up to the level of trainee therapists, then, at the expert level, knowledge decreased again. Pattern three was only found in the two diagnoses; the quality of diagnoses rose at the level of the intermediate students and then levelled off. Comparing these results to the studies on expertise in medicine, we can conclude that similar to novice students in medicine novice students in psychology first acquire declarative knowledge about basic principles of psychology. With practical experience, clinical psychological knowledge is acquired. Clinical psychological knowledge increased up to the level of trainee therapists, but in contrast to studies in medicine, decreased at the level of expert therapists. At the level of the trainee therapists we found some indications of knowledge encapsulation. At the expert level, more than ten years after graduation, basic psychological and theoretical clinical psychological knowledge had decreased and we did not find a clear indication of knowledge encapsulations. This did, however, not impair their diagnostic abilities: experts scored as high as advanced students and trainee therapists on the diagnoses. A further study is planned to examine the existence of illness scripts.

Individual problem solving as investigated in studies on expertise development is only one aspect of experts' work life. However, often experts are required to solve complex problems in collaboration with others. In these cases they do not only collaborate with other experts from their own domain, but often in an interdisciplinary context. Knowledge encapsulation and even more the loss of basic knowledge, but also the formation of illness scripts of experts may complicate the development of common ground (Clark & Brennan, 1991) and therefore interdisciplinary collaboration.

The present study aimed at overcoming the shortcomings of both the studies on computer-supported collaboration and the research on expertise development discussed above. In addition to our previous studies with students, we wanted to investigate net-based interdisciplinary collaboration across different levels of expertise. Thus, not only students at different stages of their education, but also job beginners and experienced professionals took part in this study. Also, building on studies of expertise development in individuals, we wanted to examine the collaboration of people with growing expertise and from different domains.

Hypotheses

The main goal of our study was to examine how growing domain experience influences collaborative process and outcome in an interdisciplinary, net-based setting. In our scenario a physician and a psychotherapist, or students from these disciplines, collaborated on solving a complex case study using a desktop videoconferencing system. Specifically, we investigated collaboration at three levels of expertise: student, trainee and expert. At all three levels dyads consisting of one partner from each of the two domains collaborated. At the *student level,* medical students who were at least in their third clinical semester (forth year of study) collaborated with students of psychology who had completed their specialization in clinical psychology (also in the forth year). At the *trainee level,* residents who had been working in a hospital for at least one year after graduation collaborated with trainee therapists who were at least in the second year of their on-the-job training after graduation. In Germany, medical doctors and psychologists have to complete postgraduate professional training in order to become a medical specialist or a psychotherapist. They are only allowed to establish an own practice after this training. And finally at the *expert-level,* physicians working as general practitioners collaborated with psychotherapists. All experts had worked in patient care for at least 10 years. It should be noted, however, that the expert psychotherapists, in contrast to the psychological trainee therapists, had not engaged in a certified postgraduate training at their time because this was not obligatory until 1998 in Germany. Collaborating partners did not know each other before taking part in the study. We carefully chose the degree of specialization of the two partners in order to model a collaborative scenario as authentic as possible. For example, one can easily think of a scenario where a patient consults his general practitioner because of a chronic disease, the general practitioner then notices that his patient also shows symptoms of a mental disease and consults with a psychotherapist. Most studies on expertise development in medicine were, however, conducted not with general practitioners but with even more specialized physicians, for example, cardiologists. Thus, predictions from this research could only be made with care. For the psychological participants, in contrast, our predictions were more straightforward because these were mainly the same participants who also took part in our study on expertise development in clinical psychology (Hauser et al., 2006).

We assumed that the growing domain expertise could have various positive but also negative effects on their collaboration: Hinds (1999) labeled the difficulties of experts to take the perspective of a layperson and design their communication accordingly “the curse of expertise”. Interdisciplinary communication can be characterized as mutual expert-layperson communication (Bromme, Jucks, & Rambow, 2004; Rummel & Spada, 2005): each partner is expert in his own domain, but (at least relatively) novice in the other’s domain. On the basis of this literature we can, for example, assume that experts will give highly abstract explanations that might not be understood by their partner from the other domain (Hinds, Patterson, & Pfeffer, 2001). Given the above research on expertise development, experts could also have forgotten some basic knowledge (Hauser et al., 2006) and thus could not be able to exchange as much information as students or trainees (or at least not as easily if knowledge encapsulation as described by Boshuizen and Schmidt, 1992, is the case). Moreover, experts could see less need to exchange domain specific information than participants with less experience, because they might implicitly feel the sole responsibility for their own domain part (Bromme & Nückles, 1998). Consequently, collaborating experts might arrive at a joint solution rather intuitively (Dreyfus & Dreyfus, 1986) not discussing their arguments with their partner. A precondition for discussion is awareness of the partner’s knowledge and expertise. However, Bromme & Nückles, 1998, found that physicians seldom took notice of the difference between their own perspective of a patient and the perspective of nurses. In their study physicians were thus not likely to profit from the nurses’ knowledge. In turn, novices might be more willing to take up alternative perspectives offered by a partner as they are less sure about their abilities to solve the case at hand. In the terminology of Heckhausen and Gollwitzer (1987), novices could be characterized as being in a motivational state of mind, whereas experts could be described as being in a volitional state of mind. In a motivational state of mind, people actively search for information and consider alternatives. They have not yet decided for a specific action and are trying to incorporate any relevant information in their decision making. In contrast, in a volitional state of mind, people focus on following through with an already made action plan. Thus, they lock themselves up to any new incoming information and centre their attention on the one alternative. Perhaps experts’ interaction is in general less reciprocal than the interaction of persons with less experience because experts are used to adopting the leadership in their team. This could also affect dimensions like dialogue management (e.g., turn taking) and task management negatively.

Predictions for the *outcome* of the collaboration, the joint solution, were more difficult. Studies on expertise development in both domains have revealed that experts’ diagnoses are as good as or better than those of advanced students. Consequently, we hypothesized that expert dyads, based on their large clinical experience, would score equally high or higher than less experienced dyads on the diagnoses. On the other hand, our case study was designed in such a way that a combination of medical and psychotherapeutic knowledge was required to come to a good solution. Therefore, not only the individual knowledge of the interacting partners, but also the quality of the collaboration during which the knowledge resources are combined plays an important role. If the partners do not pool their knowledge, they might fail to arrive at a good solution even if they would have the prerequisites. With regard to therapy planning: Research on expertise development in the medical domain has so far concentrated on measuring diagnostic skills and neglected the investigation of the development of therapeutic skills (Norman, Eva, Brooks, & Hamstra, 2006). In clinical psychology such research is also rare. In one of the few existing studies Caspar (1993) showed that during intake interviews inexperienced therapists verbalized more contents related to their own thinking. In contrast, experts information processing was more selective, automated, and complex. As they were less preoccupied with self-monitoring, experienced therapists had more cognitive resources available for the planning of therapy steps. Thus, we assumed that the more experienced participants would score as high as or even higher than less experienced dyads regarding the quality of their therapy plan.

Method

Sample and Design

Twenty-seven dyads (54 participants) took part in the study. Three expertise levels were implemented: student, trainee, and expert. Participants collaborated in dyads within their particular level of expertise. Dyads each consisted of one partner from the field of psychology and one from the field of medicine. Eleven advanced student dyads (*students*), ten intermediate dyads (*trainees*), and six expert dyads (*experts*) were composed (see Table 1).

Table 1: Sample and design of the study

Student Level: *Advanced medical students collaborating with advanced students of psychology*	*Trainee Level:* *Physicians in their residency collaborating with postgraduate trainee therapists*	*Expert Level:* *General practitioners collaborating with psychotherapists, (both at least ten years after graduation)*
n (dyads) = 11	*n* (dyads) = 10	*n* (dyads) = 6

Procedure

After an initial introduction, the two partners of each dyad were seated in different rooms and received training with the computer-mediated setting. In this training, all technical skills needed to complete the tasks were taught. Participants learned to work with the desktop videoconference system, and with the shared and individual editors. After the technical training they received a text-based case study (752 words) describing a woman suffering from physiological and psychological symptoms, and some domain-specific physiological and psychological literature. Participants were given 15 minutes to read the case study and to skim the text material. During this individual preparation phase they were not allowed to speak to each other. Next, participants collaborated on a threefold task: (1) They were asked to diagnose the case (multiple sclerosis and major depression), (2) state differential diagnoses (for example borreliosis, adjustment disorder), and (3) plan medical and psychological therapy steps for the main diagnoses. The time to complete these tasks was limited to 60 minutes. During the collaboration phase, participants communicated via a desktop videoconference system with the audio-video connection, individual text editors to take notes, and a shared text editor to compile the joint solution. Finally, each participant individually filled out a post-test measuring knowledge about important aspects of collaborating well in an interdisciplinary, net-based setting, and a questionnaire asking for the perceived helpfulness of such collaboration.

Dependent Variables

Dependent variables on the collaborative process and on the joint solution were assessed. To analyze the quality of *collaborative process* we applied a rating scheme that allows assessing collaboration quality by comparing a dyad's interaction with a pre-defined standard (Meier et al., in press). The rating scheme had been developed in two previous studies that had tested the effects of instructional measures on a subsequent unsupported collaboration (Rummel & Spada, 2005; Rummel et al., 2006). Based on qualitative analyses of transcribed collaboration dialogue from the first study, and theoretical concepts from the relevant literature, nine dimensions of successful collaboration had been defined. Then, the rating scheme had been applied to data from the second study, where it had helped detecting effects of instruction on the subsequent collaboration and had proven to be a valid and reliable assessment method (Meier et al., in press). The rating scheme comprises the following nine dimensions: (1) *Sustaining mutual understanding* measures the extent to which participants express themselves intelligibly, e.g. whether they explain technical terms when using them or whether they tailor their contributions to the knowledge of their partner. (2) *Dialogue management* assesses turn taking and other aspects of communicative process coordination. (3) *Information Pooling* denotes the extent to which the partners take responsibility for their own domain, whether they see the partner as resource to gather information from the other domain, and the extent to which information from both domains is referenced in the solution. (4) *Reaching consensus* evaluates the decision making process, for instance, whether the partners critically discuss and mutually evaluate their arguments before coming to a decision. (5) *Task division* measures the extent to which the participants plan their solution process and divide the task in meaningful subtasks that are solved individually or in collaboration. (6) *Time management* assesses how participants deal with the time available for solving the task. (7) *Technical coordination* assesses whether technical resources such as the individual editors and the shared editor are used effectively and how participants deal with technical problems arising. (8) *Reciprocal interaction* examines whether the interaction is symmetrical, respectful, and whether both partners can contribute to their joint solution in equal shares. (9) *Individual task orientation* (psych. or med.) is a dimension relating to motivational aspects in the behaviour of the partners. Task orientation is the commitment of each partner to work towards solving the task, his or her willingness to put effort in the collaboration, and the extent to which volitional strategies are used. In contrast to all other dimensions, we assessed this dimension on the level of the individual rather than the dyad. Thus, effectively ten variables resulted from the process ratings. Each variable was rated on a five-point rating scale ranging from 0 (very bad) to 4 (very good). The ratings were made as the rater watched the videotaped collaboration of a dyad. In order to reduce cognitive load on the raters, each dyad's videotape was segmented into three parts. The three parts were consecutively rated on the ten variables of the rating scheme. Finally the three ratings for each variable were aggregated. These aggregated values are reported in the results section below. In addition to applying the rating scheme to assess the quality of the collaborative process, we gathered process data from logfiles. Our earlier studies have revealed that working *also* individually is essential for the quality of collaborative solutions because participants need this individual time to reflect their joint considerations on the background of their own domain knowledge (Hermann et al., 2001; Rummel & Spada, 2005). But, individual work is often neglected in computer-mediated collaboration (Hermann et al., 2001). Thus, we measured the amount of individual or joint work, and the number and length of work phases from the logfiles. To asses the quality of the *joint solution*, the solutions of all dyads were blind rated by a medical and a psychotherapeutic expert. Each expert rated the quality of the diagnoses, differential diagnoses and therapy steps for her domain (medicine and clinical psychology) on a six-point scale (1 = very bad to 6 = very good).

Results and Discussion

Collaborative Process

We had hypothesized that experts would score lower than advanced students and trainees with regard to particular aspects of the collaborative process. In terms of the dimensions of the rating scheme the following variables could be affected: dialogue management, information pooling, reaching consensus, reciprocal interaction, task division. Table 2 gives an overview of the means and standard deviations of the *ratings of the collaborative processes*. A multivariate analysis of variance (MANOVA) of the ten process variables revealed a marginally significant overall effect for the expertise level (F (2, 24) = 1.9, p = .05, η^2 = .62). Subsequent ANOVAs showed that the trainee dyads scored best followed by the students and the experts formed the taillight. Altogether, eight out of ten dimensions showed this pattern. Consistent with our assumptions we found substantial group differences on the following dimensions: *information pooling* (F (2, 24) = 3.34, p = 0.05, η^2 = 0.22), *technical coordination* (F (2, 24) = 6.39, p = 0.01, η^2 = 0.35), and *reciprocal interaction* (F (2, 24) = 4.46, p = 0.02, η^2 = 0.27). Figure 1 illustrates this pattern by showing the means for the dimension *reciprocal interaction*. On five other variables the same pattern was found (*sustaining mutual understanding, dialogue management, reaching consensus, task division, task orientation psychological participant*), however, the group differences did not reach the significance level. Other patterns were found only for the variables *time management* and *task orientation medical participants*. However, the differences were small and did not reach the significance level.

Table 2: Means and standard deviations (in parentheses) for the ratings of collaboration quality.[+]

	Students	*Trainees*	*Experts*
Sustaining mutual understanding	2.88 (0.73)	2.93 (0.78)	2.72 (0.90)
Dialogue management	2.58 (1.03)	2.97 (0.90)	1.94 (0.93)
Information Pooling*	2.42 (0.79)	3.17 (0.79)	2.22 (0.86)
Reaching Consensus	2.58 (0.92)	2.78 (1.26)	2.17 (0.69)
Task Division	2.02 (1.01)	2.60 (1.07)	1.33 (0.60)
Time Management	0.88(1.11)	0.63 (0.60)	0.94 (0.71)
Technical Coordination*	2.79 (0.83)	3.18 (0.85)	1.64 (0.87)
Reciprocal Interaction*	2.64 (1.18)	3.27 (0.56)	1.83 (0.91)
Individual task orientation (med.)	3.33 (0.49)	2.87 (0.89)	2.83 (1.01)
Individual task orientation (psych.)	2.85 (0.58)	3.10 (0.97)	2.56 (0.62)

[+]Scores range from 0 = very bad to 4 = very good, *p ≤ .05

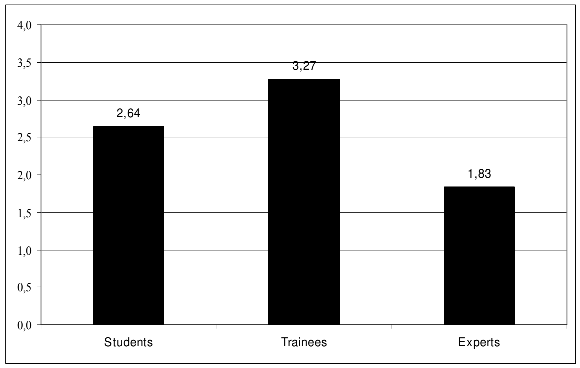

Figure 1: Results for the process dimension reciprocal interaction

Table 3 shows the results of the *logfile analysis*. Overall, participants spent more than twice as much time on collaborative work than on individual work. The time spent working individually decreased with growing expertise. Given the small sample and the relatively high variances within the expertise levels, the group differences did, however, not reach the significance level (amount of collaborative work: F (2, 24) = 1.41, p = 0.26, η^2 = 0.11; individual work: F (2, 24) = 1.57, p = .23, η^2 = 0.12). As former studies (Hermann et al., 2001; Rummel & Spada, 2005) have revealed, individual work is positively related to the joint outcome. In accordance with these findings, the average correlation of the amount of individual work with the variables of the quality of the joint solution (see Table 4) was r = .30. Concerning the number of phases, the expertise levels differed significantly (F (2, 24) = 5.26, p = .01, η^2 = .30). Students alternated more often between joint and individual work than trainees and experts. For this variable, the average correlation with the outcome variables was r = .26.

Table 3: Means and standard deviations (in parentheses) for the logfile data

	Students	*Trainees*	*Experts*
Collaborative Time (minutes)	41.91 (9.67)	47.10 (8.13)	49.00 (10.16)
Individual Time (minutes)	17.45 (9.65)	12.90 (8.13)	9.83 (8.52)
Number of Phases*	10.82 (4.45)	7.10 (2.56)	5.83 (1.94)

*$p \leq .05$

Joint Solutions

The ratings of the joint solutions are shown in Table 4. The medical ratings were given by a medical expert, the psychological ratings by a psychotherapeutic expert. On the medical ratings no significant differences were found between expertise levels; neither for the diagnoses, nor for the differential diagnoses, nor for the planned therapy steps. Multiple sclerosis is a rather uncommon diagnose for general practitioners. Perhaps we asked too much of them when presenting them with this complex disease. On the psychological ratings a significant difference between expertise levels was found regarding the differential diagnoses The trainee dyads scored best, followed by the student dyads and, finally the expert dyads (F (2, 24) = 4.63, p = .02, η^2 = 0.28). Although not significant (F (2, 24) = 1.78, p = 0.19, η^2 = 0.13), the same descriptive pattern could be found in the diagnoses. This result contradicts assumptions we had derived from experts' performance in diagnosing in the Hauser at al. (2006) study. Contrary to the present study, expert psychotherapists had scored as high as less experienced psychologists on the diagnoses.

Table 4: Means and standard deviations (in Parentheses) for the expert ratings of the joint solutions.[+]

	Students	*Trainees*	*Experts*
Medical Ratings			
Diagnoses	4.00 (1.84)	3.40 (1.51)	3.50 (1.38)
Differential Diagnoses	4.18 (0.87)	4.50 (0.71)	3.67 (0.82)
Therapy Steps	3.82 (1.60)	3.10 (1.29)	2.33 (1.21)
Psychological Ratings			
Diagnoses	4.55 (1.37)	4.90 (0.99)	3.67 (1.51)
Differential Diagnoses*	2.73 (1.42)	3.70 (1.16)	1.83 (0.75)
Therapy Steps	4.73 (1.01)	4.60 (1.17)	5.00 (1.67)

[+]Scores range from 1 = very bad to 6 = very good, *$p \leq .05$

General Discussion and Outlook

The main goal of the present study was to examine how growing domain expertise influences net-based interdisciplinary collaboration of persons with medical and psychological background. Consequently, process and outcome of collaborations at different expertise levels were compared. Advanced students of medicine and clinical psychology collaborated with each other, physicians in their residency collaborated with postgraduate trainee therapists, and experienced general practitioners collaborated with experienced psychotherapists. In our collaborative setting participants did not meet in person but collaborated via a videoconferencing system with individual text editors and a shared one. Their joint task was to diagnose a complex case study, state differential diagnoses, and plan therapy steps. As the patient showed symptoms of a medical disease (multiple sclerosis) as well as a mental disease (major depression), the task could only be solved with interdisciplinary effort. The collaborations of all 27 dyads were video-recorded. To assess the quality of the collaborative processes a rating scheme developed by Meier et al. (in press) was applied. This rating scheme consisted of the nine dimensions: sustaining mutual understanding, dialogue management, information pooling, reaching consensus, task division, time management, technical coordination, reciprocal interaction, and individual task orientation. In addition to the process ratings, log files were analyzed for individual and joint time, and the number of work phases. Also, the joint solutions of the case were analyzed.

As we had hypothesized, expert dyads scored lowest on most variables of the *collaborative process ratings*. We also found that trainee dyads outperformed student dyads on most of these variables. Particularly clear results were found for information pooling, reciprocal interaction, and technical coordination. For the variables mutual understanding, dialogue management, task coordination, and individual task orientation the same pattern resulted, but the differences did not yield statistical significance. Analyses of *process logfiles* revealed that experts spent more time working collaboratively and less time working individually than trainees and students, although this result did not become statistically significant. Also they alternated less frequently between the two modes. As had been found in former studies (Hermann et al., 2001; Rummel & Spada, 2005), the amount of individual work was positively correlated with the quality of the joint outcome. Also, a higher number of work phases correlated positively with a better solution. We can conclude that a more balanced collaboration, with a greater proportion of individual work and a more frequent alternation between modes of interaction, could have improved the outcome of the more experienced dyads. In interpreting the results let us go back to the studies on expertise development in medicine and clinical psychology cited in the introduction (e.g. Boshuizen, 2004; Hauser et al., 2006). Based on the findings regarding knowledge encapsulations, decrease in theoretical knowledge, and the formation of illness scripts, we assumed that large practical experience would affect the exchange of information on the case. Together with potentially arising social processes such experts taking over leadership and responsibility for the own domain, this might explain the findings on the collaborative process in the present study. However, the situation is not as negative at it may seem. In the present study we only looked at unsupported collaboration. From our earlier studies (Rummel & Spada, 2005; Rummel et al., 2006) we know effective methods for enhancing collaboration that could be tailored to support particularly collaborating experts.

The results on the solution quality were mixed. In the *medical ratings*, contrary to our assumptions, no significant differences could be found. However, as was noted, the medical disease described in the patient case (multiple sclerosis) is a rather uncommon disease for general practitioners. One could imagine that when confronted with such a complex symptom pattern in their daily work they would consult with a more specialized physician for further steps. However, at least in Germany general practitioners usually are the first physician patients consult and thus these physicians should be able to cope with complex and rare diseases at least in the beginning. Then, the results for the planning of therapy steps might be explained by the fact that multiple sclerosis is an uncommon disease, but not experts' low performance on the diagnoses and differential diagnoses. On these variables they should have scored higher than student dyads and trainee dyads as diagnosing is an important competence for general practitioners in order to find the right specialist to consult. As an additional explanation of the results, consider that in most studies on expertise in medicine experts were less experienced than the expert physicians examined in our study. In the study of Boshuizen and Schmidt (1992) experts had worked four years after graduation on average, while in our physicians had worked at least ten years after graduation. Perhaps, the longer time span after graduation also causes experts from the medical domain to forget theoretical clinical knowledge as it was found in our study on clinical psychology (Hauser et al., 2006). In general, therapy planning has been neglected in the existing research on expertise in medicine (Norman et al., 2006) and should be focused on in future studies.

The results on the *psychological ratings* of the joint solutions were surprising. Contrary to our study in expertise development, the experts formed the taillight regarding psychological diagnoses, and differential diagnoses. We had assumed that experts would be able to compensate for potential difficulties in their communication through their high experience with patient cases. But this hypothesis was not supported by our results. Also in the planning of therapy steps, contrary to our assumptions no substantial differences between the levels could be found. In interpreting these results we would like to emphasize once more that the expert psychotherapists participating in the present study have not undergone a postgraduate professional training comparable to the one trainee therapists engage in today, because this was not obligatory until 1998 in Germany. In other words, the above results might in part be due to our cross sectional design, i.e. an effect of differences among cohorts.

In explaining the results on the quality of the joint solution at large let us consider a thought we already brought up in the introduction. Our case study was designed in such a way that combining medical and psychotherapeutic knowledge was required to come to a good solution. Therefore, not only the individual knowledge and abilities of the interacting partners, but also the quality of their collaboration, during which knowledge resources were to be combined, played an important role. If the partners failed to pool their knowledge, they could have arrived at poor solution even if they had had the prerequisites to do better.

To sum up, our study showed that growing domain expertise can have negative effects on the net-based collaboration among persons from different, yet related domains. For the outcome (the joint solution) the results were mixed. As the outcome was influenced not only by the individual expertise of the collaborating partners, but also by the quality of their collaboration, providing support for the collaborative process could lead to better collaborative solutions. Further studies should work towards developing collaboration support tailored to the specific problems encountered at the expert level.

In concluding, we would like to emphasize that in contrast to previous case studies on interdisciplinary collaboration, with the present study we attempted to systematically test hypotheses derived from research on expertise development and computer-supported collaboration. Although net-based interdisciplinary collaboration is a very complex area of research with many interwoven aspects, we are confident that further systematic empirical research following this idea will yield more insights in this interesting and relevant field.

References

Boshuizen, H. (2003). *Expertise development: how to bridge the gap between school and work*. Den Haag: Cip-gegevens Koninklijke Bibliotheek.

Boshuizen, H. (2004). Does practice make perfect? In H. Boshuizen, R. Bromme & H. Gruber (Eds.), *Professional learning: gaps and transitions on the way from novice to expert* (pp. 73-93). Dordrecht: Kluwer.

Boshuizen, H., & Schmidt, H. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates and novices. *Cognitive Science, 16*(2), 153-184.

Bromme, R. (1999). Beyond one's own perspective: The psychology of cognitive interdisciplinarity. In P. Weingart & N. Stehr (Eds.), *Practising interdisciplinarity* (pp. 115-133). Toronto: Toronto University Press.

Bromme, R., Jucks, R., & Rambow, R. (2004). Experten-Laien-Kommunikation im Wissensmanagement. In G. Reinmann & H. Mandl (Eds.), *Psychologie des Wissensmanagements* (pp. 176-188). Göttingen: Hogrefe.

Bromme, R., & Nückles, M. (1998). Perspective-taking between medical doctors and nurses. A study on multiple representations of different experts with common tasks. In M. W. van Someren, H. Boshuizen, T. de Jong & P. Reimann (Eds.), *Learning with multiple representations* (pp. 175-196). Oxford: Elsevier.

Caspar, F. (1993). *Information processing in intake interviews: Interpretive and intuitive processes of cognitive-behaviorally and psychodynamically oriented therapists.* Paper presented at the Annual Meeting of the Society for Psychotherapy Research, Pittsburgh, Penns.

Clark, H. H., & Brennan, S., E. (1991). Grounding in Communication. In L. B. Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perpectives in socially shared cognition* (pp. 127-149). Washington, DC: American Psychological Association.

Dreyfus, H., & Dreyfus, S. (1986). *Mind over maschine. The power of human intuition and expertise in the era of the computer*. New York: Free Press.

DeGroot, A.D. (1965). *Thought and choice in chess*. The Hague: Mouton.

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical Problem Solving - An Analysis of Clinical Reasoning*. Cambridge MA: Harvard University Press.

Epstein, S. L. (2005). Making interdisciplinary collaboration work. In S. J. Derry, C. D. Schunn & M. A. Gernsbacher (Eds.), *Interdisciplinary collaboration: an emerging cognitive science*. Mahwah, NJ: Erlbaum.
Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (2006). *The Cambridge handbook of expertise and expert performance.* New York: Cambridge University Press.
Feltovich, P. J., Prietula, M. J., & Ericsson, K. A. (2006). Studies of expertise from psychological perspectives. In K. A. Ericsson, N. Charness, P. J. Feltovich, R. R. Hoffman (Eds). *The Cambridge handbook of expertise and expert performance.* (p. 41-67). New York: Cambridge University Press.
Hauser, S., Spada, H., Rummel, N., & Meier, A. (2006). Expertise development in clinical psychology. In R. Sun, N. Miyake & C. D. Schunn (Eds.), *Proceedings of the 28th Annual Conference of the Cognitive Science Society.* (pp. 1458-1463). Mahwah: Erlbaum.
Heckhausen, H., & Gollwitzer, P.M. (1987). Thought contents and cognitive functioning in motivational vs. volitional states of mind. *Motivation & Emotion, 11*, 101-120.
Hermann, F., Rummel, N., & Spada, H. (2001). Solving the case together: The challenge of net-based interdisciplinary collaboration. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *Proceedings of the First European Conference on Computer-Supported Collaborative Learning.* (pp. 293-300). Maastricht: McLuhan Institute.
Hinds, P. J. (1999). The curse of expertise: The effects of expertise and debiasing methods on prediction of novice performance. *Journal of Experimental Psychology: Applied, 5*(2), 205-221.
Hinds, P. J., Patterson, M., & Pfeffer, J. (2001). Bothered by abstraction: The effect of expertise on knowledge transfer and subsequent novice performance. *Journal of Applied Psychology, 86*(6), 1232-1243.
Lay, K., & Spada, H. (2000). Erwerb und Anwendung domänenspezifischen Wissens: Eine psychologische Perspektive. In R. Duit & C. v. Rhöneck (Eds.), *Ergebnisse fachdidaktischer und psychologischer Lehr-Lernforschung. Beiträge zu einem Workshop an der Pädagogischen Hochschule Ludwigsburg* (pp. 17-34). Kiel: IPN-Schriftenreihe.
Köhler, T., & Trimpop, R. (2004). Sehen und gesehen werden: Teleradiologie mittels Desktop- Videoconferencing. In W. Bungard, B. Koop & C. Liebig (Eds.), *Proceedings zur 3. Tagung der Fachgruppe Arbeits- und Organisationspsychologie*. München: Rainer Hampp.
McDaniel, S. H. (1995). Collaboration between psychologists and family physicians: Implementing the biopsychosocial model. *Professional Psychology: Research and Practice, 26*(2), 117-122.
Meier, A., Spada, H., & Rummel, N. (in press). A rating scheme for assessing the quality of computer-supported collaboration processes. *International Journal of Computer-Supported Collaborative Learning*.
Norman, G., Eva, K., Brooks, L. R., & Hamstra, S. (2006). Expertise in medicine and surgery. In K. A. Ericsson, N. Charness, P. J. Feltovich & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 339-353). New York: Cambridge University Press.
Ploetzner, R., & Spada, H. (1993). Multiple mental representations of information in physics problem solving. In G. Strube & K. F. Wender (Eds.), *The cognitive psychology of knowledge* (pp. 285-312). Amsterdam: Elsevier Science Publishers.
Rikers, R. M. J. P., Schmidt, H. G., & Boshuizen, H. P. A. (2002). On the Constraints of Encapsulated Knowledge: Clinical Case Representations by Medical Experts and Subexperts. *Cognition and Instruction, 20*(1), 27-45.
Rummel, N., & Spada, H. (2005). Learning to Collaborate: An Instructional Approach to Promoting Collaborative Problem Solving in Computer-Mediated Settings. *Journal of the Learning Sciences, 14*(2), 201-241.
Rummel, N., Spada, H., & Hauser, S. (2006). Learning to collaborate in a computer-mediated setting: Observing a model beats learning from being scripted. In S. A. Barab, K. E. Hay & D. T. Hickey (Eds.), *Proceedings of the Seventh International Conference of the Learning Sciences* (pp. 634-640). Mahwah, NJ: Lawrence Erlbaum Associates.

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