What Happens When Experts Over- or Underestimate a Layperson’s Knowledge in Communication? Effects on Learning and Question Asking

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Abstract
To communicate effectively with laypersons, experts must take into account the knowledge of their communication partner. Although prior research has shown that experts tend to over- or underestimate laypersons’ knowledge, little is known about the particular impact of such over- and underestimations on communication. Particularly, in computer-mediated communication where feedback is limited, experts’ false assumptions about a layperson’s knowledge might cause serious miscommunication. To address this issue, we conducted a dialogue experiment, in which we induced systematic over- and underestimations of laypersons’ knowledge and analyzed their influence on communication outcomes. Results showed that laypersons’ learning from experts’ explanations was impaired when experts had biased estimates of laypersons’ knowledge. Depending on whether laypersons were over- or underestimated, we found a differential impact on the kind of questions they asked. Laypersons whose knowledge was underestimated primarily asked for additional information previously not addressed in the experts’ explanations. Laypersons whose knowledge was overestimated more often asked comprehension questions. Although laypersons overall engaged in question asking, they could not compensate for the communication problems caused by experts’ miscalculations.

Keywords: computer-mediated communication; expert-layperson communication; instructional explanations; question-asking

Introduction
For communication to be effective, communicators must have quite a precise idea of what a particular conversational partner does and does not know (Nickerson, 1999). Only on the basis of an accurate mental model of the conversational partner can they provide intelligible information that meets the partner’s communicational needs (Fussell & Krauss, 1992). Consequently, miscommunication is likely to occur when speakers arrive at erroneous beliefs about their partner’s knowledge prerequisites. For example, including more elaborate content that may enrich the partner’s understanding.

In fact, there is empirical evidence that people are not very good at estimating others’ knowledge (see Nickerson, 1999, for an overview). They usually tend to view themselves as representative for other people (Ross, Greene, & House, 1977), and thus, impute their knowledge to others. This systematic bias in knowledge estimation may have only little impact on the effectiveness of communication when both partners have similar knowledge. However, it becomes increasingly more important the more the topical knowledge of the communication partners differs. Such a situation exists when experts communicate with laypersons (Bromme, Rambow, & Nückles, 2001). Because of the fundamental knowledge differences between experts and laypersons, false assumptions about a layperson’s knowledge are more likely to result in miscommunication. In computer-mediated communication (e.g., e-services for computer or medical advice), erroneous beliefs about the others’ knowledge might entail even more serious consequences because the possibilities to give a communication partner feedback are more restricted than in face-to-face communication (Clark & Brennan, 1991). Due to the limited feedback, less information is available which experts could use to form a model of their communication partner. Accordingly, they must rely more heavily on their prior assumptions about the layperson’s knowledge (Bromme et al., 2001). At the same time, however, biased assumptions about another person’s knowledge have lower chances of being recognized and corrected when feedback is more restricted.

Experts’ Estimations of Laypersons’ Knowledge
Research on expertise has provided evidence for both over- and underestimations of laypersons’ knowledge. According to people’s general bias to assume that others are similar to themselves (Ross et al., 1977), it might be expected that experts particularly are prone to overestimate a layperson’s knowledge. Their very expertise may make it difficult for experts to anticipate the limited domain knowledge of a layperson. Nathan and Koedinger (2000) found that high school teachers with advanced mathematics education overestimated the accessibility of symbol-based representations for students who were learning introductory algebra. Hinds (1999) had experts predict the time needed by novices to perform an unfamiliar complex task. In her study, experts systematically overestimated how quickly novices would be
able to complete the task. Hinds concluded that the ready availability (Tversky & Kahneman, 1974) and interconnectedness of the experts’ knowledge (Chi, Glaser, & Farr, 1988) may interfere with the task of taking into account the limited knowledge of a layperson.

Nevertheless, one may also picture situations in which experts are prone to underestimate laypersons’ knowledge. For example, when experts are aware of their status as an expert, they may perceive the exclusiveness of their knowledge as a feature that distinguishes them from the community of laypersons. Hence, experts may tend to underestimate the commonality of specialist knowledge among laypersons. In line with this assumption, Bromme et al. (2001) found that computer experts, as compared with laypersons, generally produced more cautious estimates concerning the commonality of specialist terms from the computer domain among laypersons. When specialist terms were considered that were known by the majority of laypersons, experts, in contrast to laypersons, clearly underestimated laypersons’ knowledgeability of these concepts.

Overall, the reported studies provide evidence that experts may be prone to over- as well as underestimations of laypersons’ knowledge. However, the particular consequences of such over- and underestimations for communication and learning have not yet been studied experimentally. Some studies identified problems regarding experts’ design of their explanations for laypersons. For example, in the experiment by Hinds, Patterson, and Pfeffer (2001), experts’ explanations addressed to a lay audience were more advanced, abstract, and less concrete than those provided by persons with less expertise. Alty and Coombs (1981) analyzed advisory dialogues of computer helpdesk services. They found that experts often included redundant information in their explanations, or paraphrased the same content several times without noticing that it was already understood by their recipient. These studies revealed weaknesses in experts’ message design. However, they do not allow for conclusions regarding the accuracy of experts’ beliefs about laypersons’ knowledge. For example, experts might deliberately express themselves in an incomprehensible manner to demonstrate the exclusiveness of their knowledge, or their rhetorical skills are insufficient for translating their writing plans into a well-designed text. Hence, in order to disentangle the effects of prior beliefs of others’ knowledge on communication, the nature of these beliefs must be established prior to message formation (Fussell & Krauss, 1992).

Therefore, in the present study, we manipulated experts’ assumptions about the layperson’s knowledge and observed the effects of experts’ over- and underestimations on communication outcomes. We used an asynchronous computer help-desk scenario where computer experts answered laypersons’ inquiries regarding diverse computer and Internet issues. The computer experts were provided with a so-called assessment tool, which displayed information about the layperson’s level of prior knowledge in the computer domain. The experts were told to use this information to adapt their explanations to the layperson’s knowledge level. In one experimental condition, the assessment tool displayed valid information about the layperson’s knowledge as measured by standardized knowledge tests prior to the communication phase. In the other two experimental conditions, the displayed information either overestimated or underestimated the layperson’s knowledge relatively to the layperson’s true knowledge level. We analyzed how the biased knowledge information affected laypersons’ learning from experts’ explanations and how laypersons engaged in question asking as a strategy to compensate for potential communication problems.

Predictions

Knowledge gain hypothesis Providing experts with biased information about the layperson’s knowledge should result in suboptimal explanations that were poorly adapted to the layperson’s knowledge level. Consequently, their learning should be affected regardless of whether the laypersons’ knowledge was over- or underestimated. Hence, it was predicted that laypersons should benefit less from the experts’ explanations, as compared with laypersons who received explanations from experts provided with valid information.

Question asking hypothesis At the same time, both over- and underestimated laypersons should experience a discrepancy between the information presented and their own communicational needs (cf. Graesser & McMahen, 1993). This should provoke them to write back to the expert and ask for clarifications or further information. In contrast, valid information about the layperson’s knowledge level should help the experts to better adapt their explanations to the layperson’s knowledge. Consequently, the layperson should be more contented and therefore return fewer questions to the expert. Accordingly, it was predicted that laypersons would ask substantially more questions when experts had biased information available, as compared with laypersons who were tutored by experts who had valid information.

Comprehension question hypothesis Depending on whether laypersons were over- or underestimated, they should ask different types of questions. Experts who were provided with information biased towards overestimation of the layperson’s knowledge should produce explanations that are too complex and difficult to understand. As a result, laypersons should have problems encoding unknown words or adequately representing the semantic structure of experts’ explanations in order to achieve a deep understanding (Otero & Graesser, 2001). Accordingly, it was predicted that laypersons whose prior knowledge level was overestimated would ask more comprehension questions that were specifically related to the words and statements produced by the experts, as compared with laypersons tutored by experts with valid information or information biased towards underestimation.

Information-seeking question hypothesis In contrast, providing experts with underestimations of a layperson’s knowledge should result in rather simple explanations which are not very informative to the layperson. The laypersons might have little problem comprehending the content of these explanations. On the other hand, they would offer the laypersons little opportunity to deepen and extend their understanding, that is, to enrich their situation model (Otero
& Graesser, 2001) with new information. Hence, laypersons whose knowledge was underestimated should ask more often for additional information not previously stated in the explanations (information-seeking questions), as compared with laypersons who received explanations from experts with valid information or information biased towards overestimation.

**Method**

**Participants**

Forty-five computer experts and 45 laypersons participated in the experiment. Computer experts were recruited among advanced students of computer science. In regards to the question as to how often they usually advise computer users (1 = very rarely, 5 = very often), the experts’ mean response was 3.68 (SD = 0.83). Hence, the participants serving as computer experts were rather experienced in advising other computer users although they had no formal training in advisory skills. The participants serving as laypersons were recruited among students of psychology and of the humanities. It was ensured that all laypersons had a moderately low level of prior knowledge in the computer and Internet domain. This was necessary in order to establish systematic over- and underestimations of the laypersons’ knowledge. Moreover, the preselection of laypersons allowed us to control for potential effects of prior knowledge on question asking. Research has shown that the amount and the quality of the questions people ask typically depend on the knowledge they have in a certain domain (e.g., Otero & Graesser, 2001). Therefore, to determine the laypersons’ prior knowledge in the computer and Internet domain, a standardized knowledge test was administered. This test was based on a multiple-choice test by Richter, Naumann, and Groeben (2000) that was specifically constructed to differentiate among people who are laypersons in this domain. Thus, even someone with high scores on this knowledge test would still have substantially less knowledge than a computer expert. The test consisted of 24 multiple choice items, with 12 items representing the computer knowledge scale and 12 items representing the Internet knowledge scale. Only those laypersons participated in the experiment who correctly solved at least 5 but no more than 8 items on each scale. This range of solved items on each scale was defined as a layperson’s medium knowledge level. Students whose number of correctly solved items was outside this range were not eligible to participate. Accordingly, there were no significant differences in laypersons’ computer and Internet knowledge between the experimental conditions, $F(2, 42) = 1.76$, ns (computer knowledge); $F(2, 42) = 1.72$, ns (Internet knowledge).

**Design**

In the experiment, computer experts and laypersons were combined into pairs that were randomly assigned to the experimental conditions. A one-factorial between-subjects design was used consisting of three different conditions: communication with an assessment tool (a) displaying valid information about the layperson’s knowledge (in the following labeled valid data condition), (b) displaying information that was biased towards overestimation of the layperson’s knowledge (overestimation condition), and (c) displaying information that was biased towards underestimation of the layperson’s knowledge (underestimation condition).

**Materials**

**The assessment tool** The assessment tool provided the computer experts both with ratings of the laypersons’ general computer knowledge and their Internet knowledge (see Figure 1). For each rating, laypersons’ individual knowledge was displayed on a 6-point scale in the assessment tool, ranging from a very low to a very high knowledge level. The values displayed in the assessment tool were determined through the computer and Internet knowledge test mentioned before (see participants section).

In the valid data condition, the number of items that a layperson solved correctly in the general computer knowledge subtest and in the Internet knowledge subtest was translated into values on the scales in the assessment tool. This was done by dividing the raw score a layperson achieved in each subtest by 2 and indicating the resulting score on the corresponding scale in the assessment tool. For example, if a layperson solved 6 out of the 12 items of the Internet knowledge subtest this was indicated as a rather low Internet knowledge level.

In the biased estimation conditions, over- and underestimations were produced by adding or subtracting, respectively, 2 points on each scale from the laypersons’ actual knowledge level. For example, if a layperson actually had a rather low knowledge level on the computer knowledge scale, this was indicated as a very low knowledge level in the underestimation condition, and as a high knowledge level in the overestimation condition.

**Laypersons’ inquiries** The laypersons received six prepared inquiries they directed one after another to the experts. The inquiries demanded explanations of relevant Internet topics and problems. Three inquiries required the
computer expert to explain a technical concept. The other three were more complex. They asked the expert to instruct the layperson how to solve a problem and, additionally, to provide an explanation why the problem occurred in order to help the layperson understand the nature of the problem (e.g., ‘Whenever I try to print a website consisting of several frames, my printer only prints out one frame. I would like to understand why this happens and what I can do so that the frames are printed out all at once’).

Increase in knowledge about inquiries The laypersons’ knowledge about the inquiries discussed in the communication phase was assessed using a written description measure. Laypersons were asked to try to answer each of the six inquiries before and after the communication phase. Their written answers were scored for correctness and completeness on a 4-point scale, ranging from 0 to 3 points. All points achieved were summed up across the answers to the six inquiries. The maximum score to be attained was 18 points. Generally, laypersons had no substantial knowledge about the inquiries prior to the communication phase. On average, they only obtained 0.97 out of 18 points ($SD = 1.59$). There were no significant differences between the experimental conditions, $F(2, 42) = 1.29, ns$.

Procedure

The experiment lasted about two and a half hours and was divided into three sessions. In the pretest session, laypersons were asked to complete the computer and Internet knowledge test and to write down their answers to the inquiries to be discussed in the communication phase. After completion, the experimenters analyzed the computer and Internet knowledge test in a separate room, where they subsequently entered the results into the assessment tool form. In the communication phase, the expert and layperson sat in different rooms and communicated through a text-based interface. In all three experimental conditions, the assessment tool with information about the layperson’s knowledge was incorporated into the interface and visible on the expert’s screen. The experts were informed that the layperson’s knowledge had been determined in advance and that they should try to bear in mind this information when answering the layperson’s inquiries. The layperson’s task was to sequentially direct each one of the prepared six inquiries verbatim to the expert by typing the prepared wording of the inquiry into the text form of the interface. The expert was asked to answer each inquiry as well as possible. The laypersons were free to write back and ask as many follow-up questions as needed. After the communication phase, the laypersons were again asked to write down their knowledge about each of the six inquiries.

Analysis and Coding of Laypersons’ Questions

The recorded dialogues between experts and laypersons were analyzed for all follow-up questions laypersons asked in response to an expert’s explanation. The questions were assigned to one of the following two question categories:

Comprehension questions. This category was scored when the question addressed comprehension problems specifically related to particular words or statements produced by the experts. For example, an expert explained the technical concept ‘Secure Shell’ and used the terms ‘command line’ and ‘UNIX’ for an illustration. The layperson asked in response to the expert’s explanation: ‘What does it mean to execute a command line in UNIX?’. Hence, these questions sought information necessary to develop an adequate text-base or situation model from the expert’s explanations (cf. Otero & Graesser, 2001).

Information-seeking questions. This category refers to questions that required experts to provide laypersons with additional or new information that was not previously stated in the experts’ explanations. For example, an expert explained the basic differences between the Internet protocols HTTP and FTP. The layperson expressed the need for further information by asking: ‘What are the advantages of FTP over HTTP?’. Thus, these questions aimed at adding new or more elaborate information to the layperson’s already existing situation model (cf. Otero & Graesser, 2001).

Two independent judges coded all questions. Interrater agreement was very good ($κ = 0.91$).

Results

In this study, an alpha level of .05 was used for all statistical tests.

Laypersons’ Knowledge Gain

In order to examine laypersons’ learning from the experts’ explanations, the laypersons’ knowledge increase was analyzed. To this purpose, the mean scores of their answers to the six inquiries prior to the communication phase were subtracted from the corresponding mean scores after the communication phase. Following the knowledge gain hypothesis, in those conditions where the experts were presented biased information, the laypersons should acquire less knowledge than the laypersons in the valid data condition. This prediction was represented by the following contrast: valid data condition: 1, overestimation condition: –0.5, underestimation condition: –0.5. The results of the contrast analysis supported this prediction, $F(1, 42) = 4.83, p = .03$, $η^2 = .10$ (medium to strong effect). Table 1 shows the mean values of the laypersons’ increase in knowledge. As predicted, the largest knowledge gain occurred in the valid data condition, whereas in both conditions in which the laypersons’ knowledge was over- or underestimated, laypersons’ knowledge acquisition was impaired.

Laypersons’ Questions

To analyze how the biased information about the laypersons’ knowledge level affected their question asking, the total number of follow-up questions a layperson produced in response to the expert’s explanations was counted. Following the question asking hypothesis, laypersons should ask more questions in response to an expert’s explanation if the expert had biased information about the layperson’s knowledge level than if the information was valid. This prediction was represented by the following contrast: valid data condition: 1, overestimation condition: –0.5, underestimation condition: –0.5. The results confirmed the question asking
hypothesis, \( F(1, 42) = 5.86, p = 0.02, \eta^2 = .12 \) (strong effect). As Table 1 shows, laypersons directed significantly more questions to the experts when their knowledge was over- or underestimated compared with the number of laypersons’ questions in the valid data condition.

Table 1: Means and standard deviations (in parentheses) of the dependent variables of the experiment.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Experimental Condition</th>
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<tbody>
<tr>
<td></td>
<td>Valid Data</td>
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<tr>
<td>Mean difference of laypersons’ increase in knowledge</td>
<td>8.47 (3.54)</td>
</tr>
<tr>
<td>Total number of follow-up questions per expert-layperson exchange</td>
<td>1.40 (1.12)</td>
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<tr>
<td>Number of comprehension questions per expert-layperson exchange</td>
<td>0.67 (0.82)</td>
</tr>
<tr>
<td>Number of information-seeking questions per expert-layperson exchange</td>
<td>0.73 (0.88)</td>
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</tbody>
</table>

To examine the differential effects on question asking as a result of the over- or underestimation of laypersons’ knowledge, we distinguished between comprehension questions and information-seeking questions. Following the comprehension question hypothesis, laypersons whose knowledge was overestimated should ask more comprehension questions than the laypersons in the valid data condition or underestimation condition. This prediction was represented by the following contrast: valid data condition: \( -0.5 \), overestimation condition: \( -0.5 \). The results of the contrast analysis clearly supported this prediction, \( F(1, 42) = 9.77, p = .003 \), \( \eta^2 = .19 \) (strong effect). Laypersons in the overestimation condition produced more than twice as many comprehension questions as laypersons in the other experimental conditions (see Table 1).

Following the information-seeking question hypothesis, laypersons whose knowledge level was underestimated should produce more information-seeking questions, that is, questions that demanded additional information, than laypersons in the valid data condition or overestimation condition. Accordingly, a planned contrast with the following weights was computed: valid data condition: \( -0.5 \), overestimation condition: \( -0.5 \), underestimation condition: \( 1 \). This contrast, however, just failed statistical significance, \( F(1, 42) = 3.20, p = .08, \eta^2 = .07 \) (medium effect). Table 1 shows that – as predicted – information-seeking questions occurred most frequently in the underestimation condition. However, despite their comprehension problems, laypersons whose knowledge was overestimated also asked experts for further information.

Discussion

This study showed that the accuracy of information about a layperson’s knowledge was important for communication to be effective. When experts had valid information about laypersons’ domain knowledge, laypersons asked the fewest questions and acquired the most knowledge. In contrast, when experts were provided with biased information, the laypersons profited less from the explanations. Regardless of whether the laypersons were over- or underestimated, their knowledge acquisition was impaired to a similar extent, and they asked significantly more questions. This predicted pattern of results was obtained although the induced estimation biases were rather discreet in order to prevent the experts from becoming suspicious.

The present study further demonstrated differences in laypersons’ question-asking behavior, depending on whether laypersons’ knowledge was over- or underestimated. When the laypersons’ knowledge was overestimated, the experts’ explanations substantially raised the number of comprehension questions asked. Conversely, laypersons whose computer knowledge was underestimated asked very few comprehension questions, indicating that the explanations they received from the experts apparently caused very little trouble in understanding. At the same time, the number of information-seeking questions was highest in the underestimation condition. This suggests that the experts’ explanations were apparently less than optimally informative for the laypersons in this condition. However, with regard to laypersons’ information seeking, our empirical results are less clear, because contrary to our expectations there were also a substantial number of information-seeking questions in the overestimation condition. Obviously, laypersons whose knowledge was overestimated not only sought to resolve their comprehension problems but also demanded additional information to enrich and extend their understanding of the topic. One may speculate that non-cognitive variables played an important role in the laypersons’ behavior. It is possible that laypersons in the overestimation condition received slightly too complex and demanding explanations causing comprehension problems. On the other hand, the laypersons nevertheless might have perceived these explanations as stimulating which could explain the higher number of information-seeking questions as compared with the valid data condition. Further research is needed to clarify this issue.

Preliminary linguistic analyses of the experts’ explanations indicate that the use of specialist terms and domain specific instantiations (e.g., ‘a common browser software is Mozilla’) indeed was highest in the overestimation condition and lowest in the underestimation condition, \( F(1, 42) = 4.40, p = .03 \). Such analyses that relate the type of questions asked by the laypersons to the linguistic features and semantic content of the experts’ explanations could further help to clarify the relationship between experts’ message design and laypersons’ communicational needs.

Nonetheless, although the laypersons in the biased estimation conditions obviously experienced different communication problems and engaged in different types of questions to compensate for these problems, they were not fully able to overcome their perceived difficulties. Despite the increased
incidence of laypersons’ questions in the biased estimation conditions, they acquired less knowledge than the laypersons in the valid data condition. Different factors could contribute to explaining this result. Given the overall low frequency of questions asked by laypersons, one might assume that laypersons did not sufficiently engage in question asking behavior to compensate for their knowledge deficits. Remember that the laypersons were free to ask follow-up questions and not instructed to do so. Under these self-regulated conditions, combined with the high costs of message production in net-based settings, that is, typing the questions on a keyboard (Clark & Brennan, 1991), laypersons might have put generally less effort in question asking, although this would have been beneficial to them (cf. Graesser & McMahen, 1993). Additionally, it is possible that laypersons exhibited rather poor metacognitive behavior and settled for monitoring only the surface code of the experts’ explanations (e.g., the technical terms used; Otero & Graesser, 2001). To address these issues, further studies are needed in which laypersons’ comprehension processes are explored in more detail through think-aloud protocols.

More broadly, the findings of the current study could also be suggestive for other instructional settings where people greatly differ in the extent to which they have knowledge about a domain. For example, in human tutoring, there is evidence that tutor-generated explanations often do not support students’ learning (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). One might speculate that the students’ problems in learning from tutor explanations also result from tutors’ miscalculations of what a student actually knows (Chi, Siler, & Jeong, 2004). Like the computer experts in the present study, tutors often do not have formal training in tutoring skills and thus might lack the ability to flexibly adapt to a learner’s needs. On the other hand, people with extensive didactic expertise should be less prone to over- or underestimate a learner’s prior knowledge. Thus, it would be interesting to investigate whether tutors with little didactic expertise differ from tutors with extensive didactic expertise in their ability to adjust their instructional explanations to a learner’s knowledge.

Finally, the results of the present study suggest that, at least in computer-mediated contexts, the negative effects of instructional explanations that are not adapted to a learner’s knowledge do persist even when students take an active role in self-regulating their learning, for example, through question asking. Therefore, it is important to support online-tutors’ adaptation to the learner by providing them with accurate information about the learner’s knowledge level (Wittwer, Nückles, & Renkl, 2004).

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