Chapter 6: Concluding remarks

In the present dissertation, I set out to explore how a simple mental tool, natural frequencies, could be used to improve statistical thinking in physicians and patients. I investigated two applications: The first used natural frequencies as a basis for teaching medical students how to interpret the results of a diagnostic test, and the second used natural frequencies in health information pamphlets that inform lay people about the risks and uncertainties associated with diagnostic tests.

In the first application (Study 1), I found a strong advantage of the representation-learning approach (that instructed how to translate probabilities into natural frequencies) over the rule-learning approach (that instructed how to insert probabilities into Bayes' rule). In the second application (Study 5), however, the effect of the statistical format on understanding of pamphlet information was slight, and natural frequencies had an advantage over percentages only for specific topics (e.g., the benefit of mammography screening).

One reason for these differential results could be that the tasks (or more specifically, the dependent measures for success of task completion) were so different. In Study 1, the effect of a natural frequency representation was assessed by using diagnostic inference tasks of the same type as in previous research on natural frequencies, and indeed the results of Study 1 were consistent with the predictions based on previous research. The main conclusion from Study 1 was that the advantage of the representation-learning approach to Bayesian reasoning seems to be stable over different instructional contexts, but that these contexts have an impact on the absolute level of performance after the training.

Study 5 did not use diagnostic inference problems, but instead tested whether the statistical format used in a health pamphlet had an impact on different knowledge and recall measures that served as indicators of basic "understanding" of the information given in the pamphlet. I spelled out in Chapter 3 why natural frequencies should facilitate understanding of statistical information in health pamphlets, as compared to percentages or probabilities. One explanation for the finding that women between 40 and 69 years profit only to a small extent from a mammography pamphlet with natural frequencies compared to one with percentages was that the effect of natural frequencies is influenced by moderating factors present in this specific applied context. That the effectiveness of a tool depends on the environment in which it is used is not a new insight, neither to the concept of natural frequencies with its foundation in ecological rationality (Gigerenzer, 1998), nor to applied cognitive psychology (Gillian & Schvaneveldt, 1999). It is important not to stop at this point, but to see the transfer of principles and empirical findings from basic research to the design of cognitive artifacts (e.g., health information pamphlets, tutorials) as a *first step* to answering the question of how the tool of natural frequencies can be used in medical risk communication. The next step is to take these first results concerning usability and effectiveness back to basic research and to identify relevant variables that allow to make theoretically informed predictions about how the tool will influence statistical thinking in different (and not only applied) contexts (Gillian & Schvaneveldt, 1999).

For instance, if future research should support the assumption that the facilitating effect of natural frequencies on understanding medical risk information in pamphlets depends on how carefully the information is read and elaborated, this result would lead to more precise predictions on how this effect transfers to other sources of medical risk information such as oral communication with the physician or health programs on TV (see also Fox & Irwin, 1998).

Finally, let me address another factor that appeared to be a crucial determinant of the effectiveness of natural frequencies in medical risk communication: the subjective attitude of the addressees concerning statistical information. People who hold attitudes such as “statistics are not relevant for me, because they say nothing about the single case” or “statistics are confusing” are likely to ignore health information materials that include a lot of numbers. Although Study 5 and previous research (e.g., Hallowell et al., 1997) suggest that the majority of medical lay people do not hold these attitudes and explicitly request precise numerical information, the problem nevertheless has to be addressed. The problem is of greater consequence for risk communicators, because many physicians also dislike statistics for similar reasons and thus prefer to use less precise verbal statements; the most frequent arguments against using numerical information in risk communication mentioned by physicians are that numbers are often unnaturally precise, easily misinterpreted by the patients, and that it is not clear how statistics could be applied to the single case (Fox & Irwin, 1998; Gigerenzer, 2002; Hamm, 1991; Heilbrun et al., 1999; Merz et al., 1991).

How can this general uneasiness with statistics be reduced? One way is to address the concerns directly, for instance by teaching physicians how to translate empirical results into predictions in single cases (Heilbrun et al., 1999). On a more general level, Gigerenzer (2002, p. 230) proposed to start a three-step educational campaign to teach all citizens, from school-children to professionals, how to reckon with risks: *“The first step is to teach people to recognize types of uncertainties, including uncertainties disguised as certainties. The second* *step is to teach turning uncertainty into risk – that is, estimating degrees of uncertainty. The third step is to teach people to experiment with representations so as to discover the most transparent way to communicate and reason with risks."* Translated into the context of medical risk communication, implementing these steps would mean educating people that no diagnostic technology is 100% foolproof, giving them the facts they need to quantify this uncertainty, and developing tutorials—not only for medical schools, but already in high schools—that show how uncertainty can be represented in an intuitive way.

Thus, in order to enable as many physicians and patients as possible to make truly informed medical decisions, not one, but two initiatives seem to be necessary. One is to develop simple tools such as natural frequencies to improve the comprehensiveness of medical risk communication and to investigate under what conditions these tools work most effectively. The other is to influence the environment in a way that ensures the effectiveness of these mind tools—here, this would mean working toward a more general acceptance of transparent risk communication by fostering statistical literacy. The latter idea is also the core of a famous visionary statement that has been attributed to H. G. Wells: *"Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write."*