Natural frequencies in medical risk communication:
Applications of a simple mental tool to improve statistical thinking in physicians and patients

Dipl.-Psych. Stephanie Kurzenhäuser

Dissertation
zur Erlangung des akademischen Grades
Doktor der Philosophie (Dr. phil.)

Erstgutachter: Prof. Dr. Gerd Gigerenzer
Max-Planck-Institut für Bildungsforschung, Berlin

Zweitgutachter: Prof. Dr. Ralf Schwarzer
Freie Universität Berlin

Datum der Disputation: 24.11.2003
# Contents

Abstract .............................................................................................................................................. iv

Chapter 1: Introduction: What are natural frequencies, and why are they relevant for physicians and patients? ........................................................................................................... 1

  What are natural frequencies? ........................................................................................................ 4
  Natural frequencies in the medical context .................................................................................... 9

Chapter 2: Applying natural frequencies to teach medical students how to interpret diagnostic test results ......................................................................................................................... 11

  Study 1: Evaluation of a classroom tutorial on Bayesian reasoning for medical students .......... 14
    Method ........................................................................................................................................... 14
    Results .......................................................................................................................................... 17
    Discussion ...................................................................................................................................... 20

Chapter 3: How exactly do natural frequencies facilitate the interpretation of statistical information? Implications for the application of natural frequencies outside the text problem paradigm ................................................................................... 23

  What is a “short information menu”? ............................................................................................ 25
  Previous comparisons of short frequency and short probability problems .................................. 27
  Comparison of performance measures and task wordings ........................................................... 29

  Study 2 .......................................................................................................................................... 33
    Method ........................................................................................................................................... 35
    Results .......................................................................................................................................... 36
    Summary ....................................................................................................................................... 37

  Study 3 .......................................................................................................................................... 37
    Method ........................................................................................................................................... 38
    Results .......................................................................................................................................... 38
    Summary ....................................................................................................................................... 40

  Summary and discussion .................................................................................................................. 40

Chapter 4: How is statistical information typically represented in medical risk communication? The case of mammography pamphlets ........................................................................... 43

  Facts about mammography screening ......................................................................................... 44
  Misperceptions about mammography screening .......................................................................... 46
  Why do these misperceptions occur? ............................................................................................. 47

  Study 4: Analysis of German mammography pamphlets ............................................................ 49
    Method ........................................................................................................................................... 50
    Results .......................................................................................................................................... 51

  Summary and discussion: Guidelines for pamphlet design .......................................................... 54
Chapter 5: Can natural frequencies improve understanding of mammography pamphlets? The role of statistical formats in learning from health information pamphlets

Study 5: Evaluation of a model mammography pamphlet

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding vs. knowing risk information</td>
<td>59</td>
</tr>
<tr>
<td>Information demand</td>
<td>59</td>
</tr>
<tr>
<td>Intention to participate in mammography screening</td>
<td>61</td>
</tr>
<tr>
<td>Method</td>
<td>62</td>
</tr>
</tbody>
</table>

Results

<table>
<thead>
<tr>
<th>Result</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1. Results: Knowledge about benefits and test efficiency of mammography screening</td>
<td>68</td>
</tr>
<tr>
<td>R2. Evaluation of model pamphlets</td>
<td>78</td>
</tr>
<tr>
<td>R3. Information demand</td>
<td>80</td>
</tr>
<tr>
<td>R4. Participation intention</td>
<td>90</td>
</tr>
</tbody>
</table>

Discussion

Chapter 6: Concluding remarks

References

Appendix

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A: Materials for Chapter 2</td>
<td>110</td>
</tr>
<tr>
<td>Appendix B: Materials for Chapter 3</td>
<td>115</td>
</tr>
<tr>
<td>Appendix C: Materials for Chapter 5</td>
<td>117</td>
</tr>
</tbody>
</table>

Summary

Zusammenfassung

Danksagung

Appendix A: Materials for Chapter 2

Appendix B: Materials for Chapter 3

Appendix C: Materials for Chapter 5

Summary

Zusammenfassung

Danksagung
Abstract

The way in which statistical information is represented is an important determinant for people's ability to interpret and utilize it. More specifically, the so-called natural frequency format has repeatedly been shown to improve statistical thinking in a range of text problems. Natural frequencies are absolute frequencies resulting from sequentially observing and counting events in a natural environment. The goal of this dissertation was to explore how natural frequencies can be used to improve statistical thinking in physicians and patients.

Study 1 compared the effectiveness of two versions of a one-hour classroom tutorial for medical students on interpreting diagnostic test results with Bayesian reasoning. Two months after the training, the students who had learned how to translate probabilities into natural frequencies were more likely to solve Bayesian inference tasks correctly than those who had been instructed how to insert probabilities into Bayes' rule.

The following two studies looked more closely at one of the features of the natural frequency format that contributes to its facilitating effect. Study 2 found support for the hypothesis that cardinal numbers are easier to process than probabilities in Bayesian inference problems that are otherwise equivalent (i.e., even when the number of computations does not differ between the formats). However, as Study 3 showed, simply adding one cardinal number (here the total number of considered cases) cannot circumvent the disadvantage of representing numerical information as percentages or probabilities.

The remaining studies explored the use of natural frequencies to facilitate patients' understanding of medically diagnostic tests. Study 4 examined 27 German health pamphlets informing women of the risks and benefits associated with mammography screening for breast cancer. The results showed that the pamphlets typically did not provide a balanced picture of the benefits and risks and often presented statistical information in an ambiguous way.

In Study 5, two versions of a new pamphlet text were evaluated by a sample of women between 40 and 69 years, the main readership of mammography pamphlets. One version presented statistical information as natural frequencies, the other as percentages. The first goal of the study was to explore whether understanding of the pamphlet depended on the statistical format used, the second goal was to assess the information demand of the women concerning mammography screening. Overall, there was only a small effect of statistical format. Natural frequencies improved the understanding of specific topics only. Both versions of the pamphlet were evaluated positively, but one third of the women indicated a dislike for precise numerical information in mammography pamphlets, which could explain the overall low recall level in the study. The information demand of the participants was high, the women wanted to be informed especially about risks, error rates, procedural aspects, and benefits of screening. Several implications of these findings for medical risk communication and the design of health information pamphlets are discussed.