# Table of Contents

Chapter 1. Introduction .................................................................................................1  
  1.1. INTRODUCTION ...............................................................................................1  
  1.2. CONTEXT OF THE STUDY ...............................................................................2  
  1.3. RESEARCH QUESTIONS ...................................................................................4  
  1.4. OVERVIEW OF METHOD ...............................................................................4  
    1.4.1. Think-aloud Triage Studies .......................................................................5  
    1.4.2. Identification of Question Taxonomies ..................................................6  
    1.4.3. Classification Task ...................................................................................6  
  1.5. OVERVIEW OF FINDINGS ...............................................................................8  
    1.5.1. Think-aloud Triage Studies .......................................................................8  
    1.5.2. Classification Task ...................................................................................9  
  1.6. CONTRIBUTIONS OF THE STUDY ..................................................................9  
    1.6.1. Contribution to Theory ............................................................................9  
    1.6.2. Contribution to Practice ..........................................................................10  
  1.7. LIMITATIONS OF THE STUDY ......................................................................11  
    1.7.1. Focuses on Only One Step in the Process of Providing Digital Reference ...11  
    1.7.2. Not System-Building .................................................................................12  
  1.8. CHAPTER SUMMARY .....................................................................................12

Chapter 2. Literature Review .......................................................................................13  
  2.1. INTRODUCTION ...............................................................................................13  
  2.2. WHAT IS A QUESTION? ..................................................................................13  
    2.2.1. Questions from the Perspective of Erotetic Logic ..................................14  
    2.2.2. Questions from the Perspective of Speech Act Theory ..........................15  
    2.2.3. Questions from the Perspective of Discourse Analysis ...........................17  
    2.2.4. Questions from the Perspective of Information Needs and Uses ............20  
    2.2.5. Defining the Term “Question” ..................................................................22  
  2.3. REFERENCE ...................................................................................................24  
    2.3.1. Information Needs .....................................................................................26  
    2.3.2. The Reference Interview and Question Negotiation ...............................27  
  2.4. KNOWLEDGE-BASED SYSTEMS FOR REFERENCE ....................................28  
    2.4.1. What is a Knowledge-based System? .......................................................29  
    2.4.2. The Functionality of Knowledge-based Systems for Reference ...............30  
    2.4.3. The Failure of Knowledge-based Systems for Reference .......................32  
  2.5. DIGITAL REFERENCE ....................................................................................33  
    2.5.1. A Model of Digital Reference .................................................................36
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5.2. The Triage Process</td>
<td>37</td>
</tr>
<tr>
<td>2.5.2.1. Variations on the Triage Process</td>
<td>40</td>
</tr>
<tr>
<td>2.5.2.2. Triage in Real-Time Services</td>
<td>41</td>
</tr>
<tr>
<td>2.5.3. The Opening Question in Digital Reference</td>
<td>42</td>
</tr>
<tr>
<td>2.5.4. Digital Reference vs. Knowledge-based Systems for Reference</td>
<td>44</td>
</tr>
<tr>
<td>2.6. QUESTION ANSWERING SYSTEMS</td>
<td>46</td>
</tr>
<tr>
<td>2.6.1. QUALM</td>
<td>46</td>
</tr>
<tr>
<td>2.6.2. The TREC Question Answering Track</td>
<td>47</td>
</tr>
<tr>
<td>2.6.3. The Possible Future of Question Answering Systems</td>
<td>50</td>
</tr>
<tr>
<td>2.7. CLASSIFICATION</td>
<td>53</td>
</tr>
<tr>
<td>2.7.1. Classification and Categorization</td>
<td>53</td>
</tr>
<tr>
<td>2.7.2. Classification of Intellectual Entities</td>
<td>54</td>
</tr>
<tr>
<td>2.7.3. Mutual Exclusivity</td>
<td>54</td>
</tr>
<tr>
<td>2.7.4. Automatic Classification and Automatic Indexing</td>
<td>55</td>
</tr>
<tr>
<td>2.7.5. Faceted Classification Schemes</td>
<td>57</td>
</tr>
<tr>
<td>2.7.6. Evaluation of Classification Schemes</td>
<td>59</td>
</tr>
<tr>
<td>2.8. SURVEY OF EXISTING QUESTION TAXONOMIES</td>
<td>62</td>
</tr>
<tr>
<td>2.8.1. Subjects of Questions</td>
<td>64</td>
</tr>
<tr>
<td>2.8.2. Wh- Words</td>
<td>66</td>
</tr>
<tr>
<td>2.8.3. The Functions of Expected Answers</td>
<td>68</td>
</tr>
<tr>
<td>2.8.4. The Forms of Expected Answers</td>
<td>71</td>
</tr>
<tr>
<td>2.8.4.1. The Subject of the Question</td>
<td>71</td>
</tr>
<tr>
<td>2.8.4.2. Types of Sources from Which the Answer May Be Drawn</td>
<td>72</td>
</tr>
<tr>
<td>2.8.4.3. The Forms of Expected Answers</td>
<td>73</td>
</tr>
<tr>
<td>2.8.5. Linguistic Analysis</td>
<td>76</td>
</tr>
<tr>
<td>2.9. CHAPTER SUMMARY</td>
<td>77</td>
</tr>
<tr>
<td>Chapter 3. Methodology</td>
<td>79</td>
</tr>
<tr>
<td>3.1. INTRODUCTION</td>
<td>79</td>
</tr>
<tr>
<td>3.1.1. Research Questions</td>
<td>80</td>
</tr>
<tr>
<td>3.1.2. Research Design</td>
<td>81</td>
</tr>
<tr>
<td>3.2. PHASE 1: TRIAGE THINK-ALOUD STUDIES</td>
<td>85</td>
</tr>
<tr>
<td>3.2.1. The Think-aloud Method</td>
<td>85</td>
</tr>
<tr>
<td>3.2.2. The Constant Comparative Method</td>
<td>89</td>
</tr>
<tr>
<td>3.2.3. Selection of Digital Reference Services</td>
<td>91</td>
</tr>
<tr>
<td>3.2.4. Solicitation of Respondents</td>
<td>95</td>
</tr>
<tr>
<td>3.2.5. Think-aloud Task</td>
<td>96</td>
</tr>
<tr>
<td>3.2.5.1. Prompts and Probes</td>
<td>97</td>
</tr>
<tr>
<td>3.2.5.2. Content Analysis and the Unit of Analysis</td>
<td>99</td>
</tr>
<tr>
<td>3.2.6. Post-Think-aloud Survey</td>
<td>102</td>
</tr>
<tr>
<td>3.2.7. Coding of Reasons for Triage Decisions</td>
<td>103</td>
</tr>
</tbody>
</table>
3.2.8. Member Check ................................................................................................................................. 104

3.3. PHASE 2: IDENTIFICATION OF QUESTION TAXONOMIES ................................................................. 105
   3.3.1. Selection of a Digital Reference Service .......................................................................................... 106
   3.3.2. Sampling .......................................................................................................................................... 108
   3.3.3. Classification of Questions ............................................................................................................... 109
   3.3.4. Intercoder Reliability Testing ........................................................................................................... 109
   3.3.5. Evaluation of Question Taxonomies ............................................................................................... 111
   3.3.6. Modification of Question Taxonomies ............................................................................................ 112

3.4. PHASE 3: CLASSIFICATION TASK ........................................................................................................ 113
   3.4.1. Inter-indexer Reliability Studies ........................................................................................................ 114
   3.4.2. Solicitation of Coders ...................................................................................................................... 115
   3.4.3. Sampling .......................................................................................................................................... 115
   3.4.4. Classification Task ......................................................................................................................... 117
   3.4.5. Computation of Intercoder Reliability Statistics ............................................................................ 120
   3.4.6. Computation of Strength of Correlation ...................................................................................... 120

3.5. CHAPTER SUMMARY ............................................................................................................................ 122

Chapter 4. Findings ....................................................................................................................................... 124

4.1. INTRODUCTION ........................................................................................................................................ 124

4.2. PHASE 1: THINK-ALOUD STUDIES ...................................................................................................... 125
   4.2.1. Participating Digital Reference Services and Triagers ..................................................................... 126
      4.2.1.1. Reasons for Services’ Non-Participation in this Study ............................................................... 127
      4.2.1.2. Representativeness of the Sample .............................................................................................. 133
   4.2.2. Think-aloud Task ............................................................................................................................. 136
      4.2.2.1. Achieving Saturation .................................................................................................................. 136
      4.2.2.2. Volume of Questions Received .................................................................................................. 137
      4.2.2.3. Factors in Triage Decision-making ............................................................................................ 140
      4.2.2.4. Distribution of Triage Factors .................................................................................................... 146
         4.2.2.4.1. Comparison with Pomerantz, Nicholson, and Lankes (2003) .................................................. 153
         4.2.2.4.2. Subject ................................................................................................................................. 157
         4.2.2.4.3. Language .............................................................................................................................. 158
      4.2.2.5. Origins of Questions ................................................................................................................. 159
      4.2.2.6. Destinations of Questions ......................................................................................................... 160
         4.2.2.6.1. Destinations of Questions According to the Volume of the Service .................................... 162
         4.2.2.6.2. Destinations of Questions According to the Type of the Service ....................................... 163
         4.2.2.6.3. Attributes that Affect the Destinations of Questions ............................................................ 165
   4.2.3. Post-Think-aloud Survey ................................................................................................................ 168
   4.2.4. Zooming In on the Triage Process ................................................................................................... 170

4.3. PHASE 2: IDENTIFICATION OF QUESTION TAXONOMIES ................................................................. 174
   4.3.1. Classification of Questions ............................................................................................................... 175
4.3.1.1. Taxonomy of Wh- Words ......................................................... 175
4.3.1.1.1. Intersection of the Taxonomies of Wh- Words and Functions of Expected Answers ........................................ 177
4.3.1.1.2. Intersection of the Taxonomies of Wh- Words and Forms of Expected Answers ........................................ 178
4.3.1.2. Taxonomy of Functions of Expected Answers ......................... 179
4.3.1.2.1. Intersection of the Taxonomies of Functions of Expected Answers and Wh- Words .................................. 181
4.3.1.3. Taxonomy of Forms of Expected Answers .............................. 182
4.3.1.3.1. Intersection of the Taxonomies of Forms of Expected Answers and Wh- Words ........................................ 184
4.3.1.3.2. Intersection of the Taxonomies of Forms of Expected Answers and Functions of Expected Answers ........ 185
4.3.1.4. The Intersection of All Three Taxonomies ............................... 186
4.3.2. Intercoder Reliability .............................................................. 187
4.3.3. Evaluation of Question Taxonomies ....................................... 190
4.3.3.1. Evaluation of the Taxonomy of Wh- Words ............................. 190
4.3.3.2. Evaluation of the Taxonomy of Functions of Expected Answers ................................................................................. 192
4.3.3.3. Evaluation of the Taxonomy of Forms of Expected Answers ................................................................................. 193
4.3.3.4. Summary of the Evaluation ..................................................... 194
4.3.4. Modification of Question Taxonomies .................................... 196
4.3.4.1. Modifications to the Taxonomy of Wh- Words ......................... 196
4.3.4.2. Modifications to the Taxonomy of Functions of Expected Answers ................................................................................. 197
4.3.4.3. Modifications to the Taxonomy of Forms of Expected Answers ................................................................................. 199
4.4. PHASE 3: CLASSIFICATION TASK ............................................. 200
4.4.1. Classification of Questions ..................................................... 200
4.4.1.1. Taxonomy of Wh- Words ......................................................... 201
4.4.1.2. Taxonomy of Functions of Expected Answers ......................... 203
4.4.1.3. Taxonomy of Forms of Expected Answers .............................. 205
4.4.2. Unclassifiable Questions ........................................................ 206
4.4.3. Questions on which Coders Disagreed ................................ 208
4.4.3.1. Taxonomy of Wh- Words ......................................................... 209
4.4.3.2. Taxonomy of Functions of Expected Answers ......................... 210
4.4.3.3. Taxonomy of Forms of Expected Answers .............................. 210
4.4.4. Intercoder Reliability .............................................................. 212
4.4.5. Correlation between Question Type and Triage Action ...... 213
4.5. CHAPTER SUMMARY .............................................................. 220

Chapter 5. Discussion ...................................................................... 222
5.1. INTRODUCTION ......................................................................... 222
5.1.1. Defining the Term “Question” for Triage ................................. 223
5.2. THE UTILITY OF QUESTION TAXONOMIES ........................................ 224
  5.2.1. Linguistic Analysis ................................................................. 225
  5.2.2. Question Answering ............................................................. 226
  5.2.3. Digital Reference ................................................................. 227
  5.2.4. Faceted Classification .......................................................... 228
  5.2.5. Other Possible Taxonomies .................................................. 229
5.3. ATTRIBUTES THAT AFFECT THE TRIAGE PROCESS ............... 232
  5.3.1. Training for Digital Reference Triagers .................................. 232
  5.3.2. Machine-Assisted Triage ...................................................... 234
  5.3.3. Grammars of Actions ........................................................... 238
  5.3.4. The Equivalence of Triage and Answer Formulation ............... 239
  5.3.5. Correctness of the Triage Decision ........................................ 241
  5.3.6. The Zipfian Distribution ....................................................... 243
5.4. THE UNIQUENESS OF THE TRIAGE PROCESS ......................... 246
5.5. TRIAGE IS DEAD, LONG LIVE TRIAGE .................................. 248
5.6. THE QUESTION INTERCHANGE PROFILE (QUIP) ...................... 251
5.7. REAL-TIME REFERENCE .......................................................... 252
5.8. CHAPTER SUMMARY ............................................................... 254

Appendix A: Solicitation Email Messages ....................................... 261
Appendix B: Think-Aloud Instructions ............................................. 265
Appendix C: Taxonomies, Scope Notes, and Coder
  Instructions Utilized in Phase 2 ................................................... 267
Appendix D: Taxonomies, Scope Notes, and Coder
  Instructions Utilized in Phase 3 ................................................... 274
Appendix E: Questions Coded in Phase 3 ........................................ 284
Bibliography ................................................................................... 286
Table of Tables

Table 2-1: An Overview of Perspectives on Questions.................................................. 22
Table 2-2: Types of Systems and Their Approach to Question Answering.............. 52
Table 2-3: Thirteen Criteria for the Evaluation of Classification Schemes ...... 61
Table 2-4: The Taxonomy of Functions of Expected Answers ............................... 69
Table 2-5: The Taxonomy of Forms of Expected Answers ..................................... 75
Table 2-6: Levels of Linguistic Analysis of Question Taxonomies .......................... 77

Table 3-1: Steps in the Phase 1 Methodology: Think-aloud Triage Studies ......... 82
Table 3-2: Steps in the Phase 2 Methodology: Identification of Question Taxonomies ........................................................................................................ 83
Table 3-3: Steps in the Phase 3 Methodology: Classification Task ....................... 84
Table 3-4: Thirteen Criteria for the Evaluation of Classification Schemes ............ 112
Table 3-5: Classification of Sets of Questions among Groups of Coders .......... 118

Table 4-1: Reasons for Services’ Not Participating in the Study......................... 128
Table 4-2: Number of Think-aloud Questions Received on the Day the Think-aloud Study was Performed.................................................. 138
Table 4-3: Categories and Attributes That Affect Triagers’ Decisions ................. 141
Table 4-4: Attributes that Affect Triage Decisions.................................................... 148
Table 4-5: Questions Triaged by Attribute Category ............................................. 152
Table 4-6: Break-down of Triage Destinations of Questions from High- and Low-Volume Services .......................................................................... 162
Table 4-7: Break-down of Triage Destinations of Questions from High- and Low-Volume Services ........................................................................ 164
Table 4-8: Post-Think-aloud Survey Results ......................................................... 169
Table 4-9: Questions Classified According to the Taxonomy of Wh- Words .... 176
Table 4-10: Questions Classified According to the Taxonomy of Functions of Expected Answers ............................................................... 179
Table 4-11: Questions Classified According to the Taxonomy of Forms of Expected Answers ........................................................................... 182
Table 4-12: Phase 2 Intercoder Reliability Kappa Values..................................... 188
Table 4-13: Thirteen Criteria for the Evaluation of Classification Schemes ...... 195
Table 4-14: Questions Classified According to the Taxonomy of Wh- Words .. 201
Table 4-15: Questions Classified According to the Taxonomy of Functions of Expected Answers ............................................................... 203
Table 4-16: Questions Classified According to the Taxonomy of Forms of Expected Answers ........................................................................... 205
Table 4-17: Phase 3 Intercoder Reliability Kappa Values..................................... 213
Table 4-18: Values of Cramér’s V for the Correlation between Question Taxonomies and Question Attributes.................................................. 214
Table 4-19: Values of Cramér’s V for the Correlation between Question Taxonomies and Triage Action ......................................................... 215
Table 4-20: Values of Cramér’s V for the Correlation between Question Taxonomies and Triage Action, in the Four Highest-volume Services

Table 4-21: Very Strong Correlations between Intersections of Question Types and Triage Action

Table 5-1: Question Taxonomies and Levels of Linguistic Analysis

Table 5-2: Categories and Attributes That Affect Triagers’ Decisions

Table 5-3: Very Strong Correlations between Intersections of Question Types and Triage Action
## Table of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>General Digital Reference Model</td>
<td>3</td>
</tr>
<tr>
<td>1-2</td>
<td>Research Methodology</td>
<td>5</td>
</tr>
<tr>
<td>2-1</td>
<td>The Process of Semantic Collaboration (Roberts and Bavelas, 1996, p. 143)</td>
<td>19</td>
</tr>
<tr>
<td>2-2</td>
<td>Steps in the Triage Process</td>
<td>40</td>
</tr>
<tr>
<td>3-1</td>
<td>Research Methodology</td>
<td>81</td>
</tr>
<tr>
<td>4-1</td>
<td>Research Methodology</td>
<td>125</td>
</tr>
<tr>
<td>4-2</td>
<td>Distribution of Number of Questions Received by Participating Services on the Day the Think-aloud Study was Performed</td>
<td>139</td>
</tr>
<tr>
<td>4-3</td>
<td>Distribution of Question Attributes that Affect Triage Decisions</td>
<td>150</td>
</tr>
<tr>
<td>4-4</td>
<td>Distribution of all Attributes that Affect Triage Decisions</td>
<td>151</td>
</tr>
<tr>
<td>4-5</td>
<td>Distribution of Questions Triaged by Attribute Category</td>
<td>152</td>
</tr>
<tr>
<td>4-6</td>
<td>Distribution of all Attributes that Affect Triage Decisions, with the 15 Factors from Pomerantz, Nicholson, and Lankes (2003) Highlighted</td>
<td>156</td>
</tr>
<tr>
<td>4-7A</td>
<td>Distribution of Question Attributes that Affect Triage Decisions, in total</td>
<td>166</td>
</tr>
<tr>
<td>4-7B</td>
<td>Distribution of Question Attributes that Affect Triage Decisions, in total</td>
<td>167</td>
</tr>
<tr>
<td>4-7C</td>
<td>Distribution of Question Attributes that Affect Triage Decisions, in total</td>
<td>168</td>
</tr>
<tr>
<td>4-8</td>
<td>General Model of the Triage Process</td>
<td>172</td>
</tr>
<tr>
<td>4-9</td>
<td>Distribution of Questions Classified According to the Taxonomy of Wh- Words</td>
<td>176</td>
</tr>
<tr>
<td>4-10</td>
<td>Distribution of Questions Classified According to the Taxonomy of Functions of Expected Answers</td>
<td>180</td>
</tr>
<tr>
<td>4-11</td>
<td>Distribution of Questions Classified According to the Taxonomy of Forms of Expected Answers</td>
<td>183</td>
</tr>
<tr>
<td>4-12</td>
<td>Distribution of Questions Classified According to the Taxonomy of Wh- Words</td>
<td>202</td>
</tr>
<tr>
<td>4-13</td>
<td>Distribution of Questions Classified According to the Taxonomy of Functions of Expected Answers</td>
<td>204</td>
</tr>
<tr>
<td>4-14</td>
<td>Distribution of Questions Classified According to the Taxonomy of Forms of Expected Answers</td>
<td>206</td>
</tr>
<tr>
<td>4-15</td>
<td>Taxonomy Space Defined by the Three Taxonomies</td>
<td>217</td>
</tr>
</tbody>
</table>
Figure 5-1: Taxonomy Space as the Basis for Machine-Assisted Triage .......... 236
Figure 5-2: Screenshot of the Triage Area for a Digital Reference Service
Using the QABuilder Software .......................................................... 249