

# Contents

Preface to second edition .....	xiii
Preface to first edition .....	xv

<b>CHAPTER 1 Historical context .....</b>	<b>1</b>
1.1 Background .....	2
1.2 Vannevar Bush’s “As We May Think” (1945) .....	3
1.3 Ivan Sutherland’s Sketchpad (1962) .....	5
1.4 Invention of the Mouse (1963) .....	6
1.5 Xerox Star (1981) .....	11
1.6 Birth of HCI – 1983 .....	15
1.6.1 First ACM SIGCHI Conference (1983) .....	15
1.6.2 The Psychology of Human-Computer Interaction (1983) .....	17
1.6.3 Launch of the Apple Macintosh (1984, January) .....	22
1.7 Growth of HCI and graphical user interfaces .....	24
1.8 Empirical research in HCI .....	25
1.8.1 Conferences – the backbone of HCI .....	26
1.9 Other readings .....	28
1.10 Resources .....	28
Student exercises .....	29
<b>CHAPTER 2 The human factor .....</b>	<b>31</b>
2.1 Time scale of human action .....	32
2.2 Human factors .....	33
2.3 Sensors .....	34
2.3.1 Visual (seeing) .....	34
2.3.2 Auditory (hearing) .....	37
2.3.3 Tactile (touch) .....	41
2.3.4 Olfactory (smell) and gustatory (taste) .....	42
2.3.5 Other senses .....	43
2.4 The brain .....	43
2.4.1 Perception .....	43
2.4.2 Cognition .....	46
2.4.3 Memory .....	48
2.5 Responders .....	50
2.5.1 Limbs .....	50
2.5.2 Voice .....	55
2.5.3 The eye as a responder .....	56
2.5.4 The brain as a responder .....	59
2.6 Language .....	59

2.6.1	Redundancy in language .....	61
2.6.2	Entropy in language .....	63
2.6.3	Language modelling for text creation .....	64
<b>2.7</b>	<b>Human performance .....</b>	<b>65</b>
2.7.1	Reaction time .....	66
2.7.2	Visual search .....	70
2.7.3	Skilled behaviour .....	72
2.7.4	Attention .....	75
2.7.5	Human error .....	76
2.7.6	Outliers .....	83
2.7.7	Accidents .....	85
	Student exercises .....	85
<b>CHAPTER 3</b>	<b>Interaction elements .....</b>	<b>93</b>
<b>3.1</b>	<b>Techniques .....</b>	<b>94</b>
3.1.1	Pointing .....	95
3.1.2	Selecting .....	96
3.1.3	Point-select improvements .....	96
3.1.4	Alternate inputs .....	99
3.1.5	Single-switch scanning .....	103
3.1.6	Gesture input .....	108
<b>3.2</b>	<b>Hard controls and soft controls .....</b>	<b>110</b>
<b>3.3</b>	<b>Control-display relationships .....</b>	<b>112</b>
3.3.1	Spatial relationships .....	113
3.3.2	CD gain and transfer function .....	118
3.3.3	Latency .....	120
3.3.4	Property sensed and order of control .....	122
<b>3.4</b>	<b>Mental models and metaphor .....</b>	<b>125</b>
<b>3.5</b>	<b>Modes .....</b>	<b>130</b>
3.5.1	Mode switching .....	132
3.5.2	Feedback and mode errors .....	133
3.5.3	Graphics and 3D .....	135
<b>3.6</b>	<b>More about degrees of freedom .....</b>	<b>140</b>
<b>3.7</b>	<b>Mobile context .....</b>	<b>144</b>
<b>3.8</b>	<b>Interaction errors .....</b>	<b>147</b>
3.8.1	Lost information .....	148
3.8.2	Caps_Lock error .....	149
3.8.3	Hyper-scrolling .....	149
3.8.4	Focus uncertainty .....	151
3.8.5	Little errors linger .....	152
	Student exercises .....	155
<b>CHAPTER 4</b>	<b>Scientific foundations .....</b>	<b>161</b>
<b>4.1</b>	<b>What is research? .....</b>	<b>161</b>
4.1.1	Research must be published .....	163

4.1.2	Citations, references, impact . . . . .	164
4.1.3	Research must be replicable . . . . .	166
4.1.4	Research vs. engineering vs. design . . . . .	167
4.1.5	The nature of research . . . . .	169
<b>4.2</b>	What is empirical research? . . . . .	171
<b>4.3</b>	Research methods . . . . .	172
4.3.1	Observational method . . . . .	172
4.3.2	Experimental method . . . . .	173
4.3.3	Correlational method . . . . .	174
4.3.4	Precision and relevance in experimental methodology . . . . .	175
4.3.5	User study vs. usability evaluation . . . . .	176
<b>4.4</b>	Observe and measure . . . . .	177
4.4.1	Observation . . . . .	177
4.4.2	Measurement scales . . . . .	178
<b>4.5</b>	Research questions . . . . .	183
<b>4.6</b>	Internal validity and external validity . . . . .	185
<b>4.7</b>	Comparative evaluations . . . . .	188
<b>4.8</b>	Relationships: causal and circumstantial . . . . .	190
<b>4.9</b>	Research topics . . . . .	192
4.9.1	Ideas . . . . .	193
4.9.2	Finding a topic . . . . .	195
	Student exercises . . . . .	199
<b>CHAPTER 5</b>	<b>Designing HCI experiments</b> . . . . .	<b>203</b>
<b>5.1</b>	What methodology? . . . . .	204
<b>5.2</b>	Ethics approval . . . . .	205
<b>5.3</b>	Experiment design . . . . .	206
<b>5.4</b>	Independent variables . . . . .	207
<b>5.5</b>	Dependent variables . . . . .	210
<b>5.6</b>	Other variables . . . . .	213
5.6.1	Control variables . . . . .	213
5.6.2	Random variables . . . . .	214
5.6.3	Confounding variables . . . . .	214
<b>5.7</b>	Task and procedure . . . . .	217
<b>5.8</b>	Participants . . . . .	219
<b>5.9</b>	Questionnaire design . . . . .	221
5.9.1	Demographics and experience . . . . .	221
5.9.2	Participant opinions . . . . .	223
<b>5.10</b>	Within-subjects, between-subjects . . . . .	226
<b>5.11</b>	Order effects, counterbalancing, and Latin squares . . . . .	228
<b>5.12</b>	Group effects and asymmetric skill transfer . . . . .	233
<b>5.13</b>	Longitudinal studies . . . . .	237
<b>5.14</b>	Running the experiment . . . . .	240
	Student exercises . . . . .	241

<b>CHAPTER 6 Hypothesis testing .....</b>	<b>243</b>
<b>6.1 Utility software: GoStats .....</b>	<b>245</b>
<b>6.2 Analysis of variance .....</b>	<b>245</b>
6.2.1 Why analyse the variance? .....	246
6.2.2 Non-significant ANOVA results .....	251
6.2.3 More than two test conditions .....	253
6.2.4 Post hoc comparisons .....	253
6.2.5 Between-subjects designs .....	255
6.2.6 Two-way analysis of variance .....	257
6.2.7 Doing an ANOVA with GoStats .....	260
6.2.8 Testing for a group effect .....	262
<b>6.3 Chi-square test .....</b>	<b>264</b>
6.3.1 Example 1 .....	264
6.3.2 Chi-square calculations .....	265
6.3.3 Chi-square in GoStats .....	266
6.3.4 Example 2 .....	267
6.3.5 Example 3 .....	268
<b>6.4 Lilliefors test for normality .....</b>	<b>269</b>
6.4.1 Example 1 .....	270
6.4.2 Example 2 .....	271
6.4.3 Example 3 .....	272
<b>6.5 Non-parametric tests for ordinal data .....</b>	<b>274</b>
6.5.1 Mann-Whitney U test .....	275
6.5.2 Wilcoxon Signed-Ranks test .....	276
6.5.3 Kruskal-Wallis test .....	278
6.5.4 Friedman test .....	279
<b>6.6 Discussion .....</b>	<b>281</b>
<b>6.7 Parametric vs. non-parametric tests .....</b>	<b>282</b>
Student exercises .....	285
<b>CHAPTER 7 Modelling interaction .....</b>	<b>293</b>
<b>7.1 Descriptive models .....</b>	<b>293</b>
7.1.1 Delineating a problem space .....	294
7.1.2 Quadrant model of groupware .....	295
7.1.3 Key-action model (KAM) .....	296
7.1.4 Bimanual control model .....	299
7.1.5 Circumplex model of affect .....	303
7.1.6 Three-state model of graphical input .....	305
<b>7.2 Predictive models .....</b>	<b>308</b>
7.2.1 Linear regression model .....	309
7.2.2 Fitts' law .....	312
7.2.3 Choice reaction time .....	319
7.2.4 The keystroke-level model .....	322
7.2.5 Skill acquisition .....	339
7.2.6 More than one predictor .....	343

<b>7.3</b>	A model continuum model .....	347
	Student exercises .....	348
<b>CHAPTER 8</b>	<b>Writing and publishing a research paper .....</b>	<b>361</b>
<b>8.1</b>	Conference papers, journal papers .....	361
<b>8.2</b>	Parts of a research paper .....	362
8.2.1	Title .....	363
8.2.2	Abstract .....	364
8.2.3	Keywords .....	366
8.2.4	Introduction .....	366
8.2.5	Method .....	367
8.2.6	Results and discussion .....	370
8.2.7	Conclusion .....	373
8.2.8	References .....	373
<b>8.3</b>	Preparing the manuscript .....	373
8.3.1	Environment .....	374
8.3.2	Formatting .....	375
8.3.3	Citations and references .....	376
8.3.4	Visual aids .....	379
8.3.5	Writing for clarity .....	382
	Student exercises .....	385
	Bibliography .....	391
	Glossary .....	431
	Index .....	437