

Discrimination Testing in Sensory Evaluation

Editors

Lauren Rogers, Joanne Hort,
Sarah E. Kemp, Tracey Hollowood

WILEY

Discrimination Testing in Sensory Evaluation

A series of books on selected topics in the field of Sensory Evaluation

The first book in the Sensory Evaluation series is *Sensory Evaluation: A Practical Handbook*, published in May 2009. It focuses on the practical aspects of sensory testing, presented in a simple, 'how to' style for use by industry and academia as a step-by-step guide to carrying out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. Subsequent books in the series cover selected topics in sensory evaluation. They are intended to give theoretical background, more complex techniques and in-depth discussion on application of sensory evaluation that were not covered in the *Practical Handbook*. However, they will seek to maintain the practical approach of the handbook and chapters will include a clear case study with sufficient detail to enable practitioners to carry out the techniques presented.

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Edited by

Lauren Rogers

Joanne Hort

Sarah E. Kemp

Tracey Hollowood

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This edition first published 2024

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John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

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Library of Congress Cataloging-in-Publication Data applied for:

Hardback: 9780470671405

ePDF: 9781118635452

epub: 9781118635445

oBook: 9781118635353

Cover Design: Wiley

Cover Image: © Getty Images/iStockphoto

Set in 9.5/12.5pt STIXTwoText by Straive, Pondicherry, India

Dedications

This book is dedicated to:

Lawrence, Alexandra and James

George, Elizabeth, George and William

Campbell, Emma and Lara

Mike

Contents

List of Contributors xv

Preface to the Series xvii

Preface xxi

Editor Biographies xxiii

Section 1 Introduction 1

1 Introduction 3

Sarah E. Kemp, Tracey Hollowood, Joanne Hort and Lauren Rogers

1.1 Introduction 3

1.1.1 Discrimination Testing as a Tool 3

1.2 Developments of Discrimination Testing 4

1.3 Discrimination as a Technique in Sensory Science 11

1.3.1 Factors Influencing Sensory Discrimination 11

1.3.2 Action Standards and Sensory Discrimination Testing 12

1.3.3 Advantages and Disadvantages 14

1.4 Applications 15

1.4.1 Product Design and Development 15

1.4.2 Quality Assurance/Quality Control 15

1.4.3 Consumer Research 16

1.4.4 Panel Selection and Training 16

1.4.5 Research 16

1.5 Overview of Book 16

References 19

2 General Considerations in Discrimination Testing 25

Harry T. Lawless

2.1 Introduction: Goals of Discrimination Tests 25

2.2 Types of Tests 27

2.2.1 Classification by Task 27

2.2.2 Examples of Tests, Common and Uncommon 28

2.3	General Test Considerations	32
2.4	Basic Statistical Analysis	35
2.4.1	Null and Alternative Hypotheses	35
2.4.2	Exact Binomial, z-Score Approximation, and Chi-Square	36
2.4.3	McNemar and Stuart Maxwell Tests	37
2.5	Test Power and Sample Size; Equivalence and Similarity	38
2.5.1	A Quick Look at Sample Size and Test Power	38
2.5.2	Equivalence and Similarity	40
2.6	Psychological Factors	42
2.7	Summary and Conclusions	43
	References	44
3	An Overview of Sensory Discrimination Tests	49
	<i>Stella Lignou and Victoria Norton</i>	
	References	65
4	Determining Individual Variation in Ability to Discriminate: Factors Affecting Responsiveness and Performance	67
	<i>Sara Spinelli, Caterina Dinnella and Erminio Monteleone</i>	
4.1	Introduction	67
4.2	Overview of the Factors Affecting Individual Differences in Oral and Olfactory Responsiveness	67
4.2.1	Age and Gender	67
4.2.2	Fungiform Papillae	68
4.2.3	Responsiveness to PROP	70
4.2.4	Thermal Taster Status	71
4.2.5	Oral Tactile Acuity	72
4.2.6	Psychological Traits	72
4.2.7	Individual Differences in Odor Sensitivity	73
4.3	Factors Affecting Consumer and Trained Panelists Ability to Discriminate	74
4.3.1	Training and Familiarity	74
4.3.2	Affective Priming	75
4.3.3	Panel Composition	75
4.3.4	Environmental Conditions	76
4.4	Future Developments	76
4.5	Summary	77
	Acknowledgments	77
	References	77
5	Similarity or Equivalence Testing	85
	<i>Linda Lopez</i>	
5.1	Introduction	85
5.2	Practical and Common-sense Approach for Similarity Testing	87
5.2.1	Protocol Consistency	88
5.2.1.1	Specific Quality Control Protocol Consideration	88
5.2.1.2	Test Method Choice and Detailed Operating Instructions	89

5.2.1.3	Panel Size and Type	89
5.2.1.4	Testing Facility	90
5.2.2	Availability of Historical Data	90
5.2.3	Regular Validation Tests	90
5.2.4	Panel Screening and Correlation to Descriptive or Consumer Data	90
5.3	Evolution of Similarity Testing Methodology	92
5.3.1	Test for Significant Similarity	92
5.3.2	The Two One-Sided Test Approach (TOST) and Interval Testing	93
5.3.3	Thurstonian Scaling	93
5.3.3.1	The Theory and Formulae	94
5.3.3.2	Application of Thurstone Theory to Sensory Forced Choice Tests	95
	Application When Samples Do Not Fully Match a Reference	98
5.4	Example of Similarity Test Application in Claim and Recipe Change	98
5.4.1	Parity and Equivalence Claims	98
5.4.2	Recipe Changes	100
5.4.2.1	Consumer Relevant Size of Difference	100
5.4.2.2	Impact of Product Heterogeneity	101
5.5	Conclusion	102
	References	102
6	Thurstonian Modeling and Signal Detection Theory	105
	<i>Michael J. Hautus</i>	105
6.1	Signal Detection Theory and Thurstonian Modeling	105
6.2	SDT and Two Stimulus Alternatives	106
6.3	The A-Not A Task	108
6.3.1	Proportion of Correct Responses	108
6.3.2	Bias as a Removable Problem	109
6.3.3	The Receiver Operating Characteristic Curve	110
6.3.4	Area Measures of Sensitivity	111
6.3.5	Alternative Distribution Assumptions	113
6.3.6	Confidence-Rating Response Procedure	114
6.3.7	Fitting ROC Curves	116
6.3.8	BEVM vs. BM Revisited	116
6.3.9	Data Analysis Considerations	118
6.3.10	The R-Index	119
6.4	The 2AFC (Paired Comparison) Task	120
6.5	Test Sensitivity	124
6.6	Closing Comments	127
	References	127
7	Sureness Judgements and R-Index Calculations and Their Applications	131
	<i>Danielle van Hout and Hye-Seong Lee</i>	
7.1	Quantifications of Sensory Differences	131
7.2	R-Index	132
7.3	Sureness Judgements	133
7.3.1	Response Bias and Criterion Location	133

7.3.2	Number of Sureness Response Categories	133
7.4	Designing an R-Index Study, Using an A-Not A Task	133
7.4.1	Study Purpose	133
7.4.2	Familiarizing Sensory Panelists with the Reference Product	134
7.4.3	Consumer Familiarity with the Reference Product	134
7.4.4	Number of Products in a Test	135
7.5	R-Index Data Analysis	136
7.5.1	R-Index Analysis of A-Not A Data	136
7.5.2	R-Index Analysis of Ranking Data	138
7.5.3	Converting R-Index Into d'	138
7.5.4	Sample Sizes	139
7.5.5	Significance of R-Index Values	139
7.5.6	Significant Differences Between Two R-Index Values Using Confidence Intervals	140
7.6	Applications	140
7.6.1	R-Index for A-Not A Tests, Comparing Multiple Products with a Reference	140
7.6.2	R-Index for Ranking Applied to Consumer Hedonic Measurements	141
7.6.3	R-Index to Measure Consumers' Concepts or Emotions	141
7.6.4	R-Index for Sensitivity Measurements	141
7.7	Future Developments	142
	Appendix	144
	References	148
8	Replicated Discrimination Testing	151
	<i>Michael Meyners and Bernard Thomas Carr</i>	
8.1	Introduction	151
8.2	General Considerations and Study Design	152
8.2.1	Fatigue and Learning Effects	152
8.2.2	Randomization and Presentation Order	153
8.2.3	Replicated Discrimination Tests to Monitor Panelist Performance	153
8.2.4	Benefits from Replications of Preference Tests	153
8.2.5	Required Sample Sizes	153
8.2.6	Replications can Offer Additional Benefits and Insights	154
8.3	Notation	154
8.3.1	Basic Notation: Number of Assessors and Replications	154
8.3.2	Correct and Incorrect Answers and Guessing Probability	154
8.3.3	Success Probability and Probability of True Discrimination	155
8.3.4	Number of Successes	155
8.3.5	Replicated Discrimination Tests as a Hierarchical Model	155
8.3.6	Success Probabilities for Preference Tests	156
8.3.7	Assessor Heterogeneity	156
8.3.8	Further Notation	157
8.4	Statistical Testing to Show Product Differences	157
8.4.1	Foundations and the Need for Proper Randomization	157
8.4.2	The Naïve Binomial Test	158

8.4.3	Potential Power Loss in the Binomial Test and Limitations for Equivalence Problems	159
8.4.4	Reduction of Sample Size in the Analysis to Account for Heterogeneity	159
8.4.5	A Confidence Interval-Based Approach	160
8.4.6	The Beta-Binomial Model	160
8.4.7	The Chance-Corrected Beta-Binomial Model	161
8.4.8	Heterogeneity Implies Product Differences	162
8.4.9	Generalized Linear Mixed Models	163
8.4.10	The Common Limit Model	163
8.4.11	The χ^2 Test	164
8.4.12	Further Methods and Recommendations	164
8.5	Descriptive Analysis and Parameter Estimation	165
8.5.1	Descriptive Analyses Enhance Insights	165
8.5.2	Tabulation of Observed and Expected Success Rates and χ^2 Test	165
8.5.3	Mean Discrimination Rate with Confidence Interval	166
8.5.4	Lower Bound for the Proportion of True Discriminations	166
8.5.5	Model Fitting: Beta-Binomial, Generalized Linear Mixed Models, and Related Approaches	167
8.5.6	Bayesian Methods	167
8.5.7	Thurstonian Approaches	169
8.5.8	Conclusions for Descriptive Analyses	169
8.6	Tests for Equivalence/Similarity	170
8.7	Replicated Preference Tests	171
8.7.1	Success Rates and Test Problems	171
8.7.2	When Preference Tests Must Not Be Replicated	172
8.7.3	Statistical Tests and Models	172
8.7.4	Segmentation in Consumer Preferences	173
8.7.5	Equivalence Tests	173
8.7.6	The No Preference Option	173
8.8	Examples	174
8.9	Conclusions	185
8.10	Recommendations	186
8.11	Glossary and Notation	188
	Acknowledgements	191
	References	191

Section 2 Applications 197

9	Sensory Quality Measurement Based on SDT Discrimination	199
	<i>Hye-Seong Lee, Min-A Kim and Danielle van Hout</i>	
9.1	Introduction	199
9.2	A New Classification of Sensory Discrimination Tests and Their Relative Performance	200
9.2.1	A New Way of Classification of Sensory Discrimination Tests	200

9.2.2	Conducting the Discrimination Tests and Collecting the Data	203
9.2.3	Performance Differences Between the Various Designs of Discrimination Tests	205
9.3	Reference-based Discrimination Test Methodology: SDT Sensory Quality Measurements	209
9.3.1	Introduction	209
9.3.2	Test Design	210
9.3.3	Familiarization Procedure	211
9.3.3.1	Repeated Reference Tastings	211
9.3.3.2	Specified Categorization Task	211
9.3.3.3	2-AFC with Reminder	212
9.3.4	Utilizing Signal Detection Theory Indices: Data Processing Approach and Applications	212
9.3.4.1	Discrimination d' : A Measure of the Size of Product Difference	213
9.3.4.2	Criterion Location, c : A Measure of the Subject Judgments	216
9.3.4.3	Recognition $d'(d'_{Rec})$: A Measure to Check the Panel Performance	217
9.3.5	A Strategy for Defining and Maintaining Action Standards	220
9.3.6	Case Study: Driving Consumer Relevance in Sensory Quality Control Through Action Standard Optimization: Bridging the Gap Between Sensory Panel and Consumer Sensitivity	221
9.3.6.1	Introduction	221
9.3.6.2	Establishing the Current Sensory Panel-based AS	221
9.3.6.3	Methods and Materials	222
9.3.6.4	Data Analysis	222
9.3.6.5	Results	223
9.3.6.6	Optimizing the Sensory Panel-based AS to Become More Consumer-Relevant	226
9.4	Further Development	226
9.4.1	Further Development of the Sensory Panel as a Predictive Tool for Consumer Perception	226
9.4.2	Further Development of the Reference-Based Methodology for Consumer Research for Affective Tests	227
	References	228
10	Discrimination Testing in Flavors and Fragrances: A Practical View	233
	<i>Karine Miot, Carlos Gómez-Corona and Isabelle Cayeux</i>	
10.1	Introduction to Discrimination Testing for Flavors and Fragrances	233
10.1.1	General Considerations	233
10.1.2	Methodology	236
10.1.2.1	Panelists	236
10.1.2.2	Test Location	237
10.2	Discrimination Testing for Flavors	238
10.2.1	Product – Stimuli – Flavor	238
10.2.2	Applications	240

10.2.3	Case Studies	241
10.2.3.1	Integration of Two Flavors: Evaluation in Tasting Solution	241
10.2.3.2	Sugar Reduction in Beverages in Laboratory Samples	242
10.2.3.3	Salt Reduction in Sausages in Pilot Plant/Plant Samples	246
10.3	Discrimination Testing for Fragrances	248
10.3.1	Product – Stimuli – Fragrance	248
10.3.2	Applications	249
10.3.3	Case Studies	252
10.3.3.1	Lilial Removal in Shampooing Products	252
10.3.3.2	Validation of New Capsules in a Fabric Softener	254
10.4	Bringing Social Responsibility into Discrimination Testing for Flavors and Fragrances	256
10.4.1	Blind and Visually Impaired Panelists	256
10.4.2	Panelists in Vulnerable Social Conditions	257
10.5	What the Future Might Be in the Flavor and Fragrance Industries	259
10.5.1	Adapting to New Social and Environmental Challenges in the Industry	259
10.5.2	What Will Be the Place of Machine Learning and Artificial Intelligence in Discrimination Testing? What Might a Future Panelist Look Like?	260
10.5.3	The Future Panelist Will Be “Connected”	261
10.6	Conclusions and Final Considerations	261
	References	262
11	Kids as Sensory Detectives: Application of Discrimination Testing with Children to Identify If Differences Exist Between Two or More Products	265
	<i>Cindy Beeren</i>	
11.1	Introduction: Sensory Testing by Kids	265
11.2	Kids’ vs. Adults’ Sensitivities	266
11.2.1	Smell	266
11.2.2	Taste	266
11.2.3	Vision	267
11.2.4	Touch	267
11.2.5	Hearing	268
11.2.6	Sensory Fusion	268
11.3	Kids vs. Adults’ Preferences	268
11.4	Food Neophobia	269
11.5	So Why Use Kids?	270
11.5.1	Appropriate Sensitivity	271
11.5.2	Understanding the Sensory Perceptions as Perceived by Kids	271
11.5.3	Appearance	272
11.6	Ethical Considerations	272
11.7	Environment for Testing with Kids	274
11.8	Sensory Screening	276
11.8.1	Why Screen Kids for Testing?	276
11.8.2	Basic Taste Screening	277
11.8.3	Odor Descriptive Screening	277

- 11.8.4 Visual Screening 277
- 11.8.5 Texture Descriptive Screening 277
- 11.9 Training Session 279
- 11.9.1 Training in Different Methods 279
- 11.10 Test Methods 281
- 11.10.1 Language 284
- 11.10.2 Scales 284
- 11.11 Final Thoughts 285
- 11.11.1 Motivation and Incentives 285
- 11.11.2 Health and Sensory Test 286
- 11.11.3 Future Kids Sensory Detectives 286
- References 287

12 Expanding Attribute-Specific Difference Tests with Multisample Paired Comparison Paradigms 291

Curtis R. Lockett

- 12.1 Introduction 291
- 12.1.1 Simple Examples 294
- 12.1.2 Going Beyond a Pair of Products 298
- 12.2 Practical Considerations 299
- 12.3 Mosteller's Extension of Thurstone 300
- 12.4 Bradley-Terry Models 301
- 12.5 Elo and mElo 302
- 12.6 Friedman-Style Rank Analysis 302
- 12.7 Considerations on Choosing an Appropriate Method 303
- 12.8 Future Developments 313
- References 314

13 Summary 317

Sarah E. Kemp, Tracey Hollowood, Joanne Hort and Lauren Rogers

- 13.1 Introduction 317
- 13.2 Overall Comparison of Methods 317
- 13.3 Current/Recent Developments 320
- 13.3.1 Which Test? 320
- 13.3.2 Analysis of Discrimination Tests 320
- 13.3.3 Difference or Similarity Testing 321
- 13.3.4 Which Assessor? 323
- 13.4 Future 324
- 13.4.1 Ethical Considerations in Sensory Discrimination Testing 324
- 13.4.2 Experimental Design of Discrimination Tests 325
- 13.4.3 Replicated Discrimination Testing 325
- 13.4.4 New Discrimination Tests 325
- 13.4.5 Participants in Discrimination Tests 326
- 13.5 Conclusions 327
- References 327

List of Contributors

Cindy Beeren

EdiBee
Altea
Spain

Whyteleaf Community Hub
Whyteleaf
UK

Isabelle Cayeux

Perception & Cognitive Neurosciences
Department, Science & Research,
dsm-firmenich
Geneva, Switzerland

Caterina Dinnella

Department of Agriculture, Food,
Environment and Forestry (DAGRI)
University of Florence
Florence
Italy

Carlos Gómez-Corona

Human Insights Department, Taste
Texture, and Health BU dsm-firmenich
Neuilly-sur-Seine
France

Michael J. Hautus

School of Psychology, Faculty of Science
The University of Auckland
Auckland
New Zealand

Tracey Hollowood

Formerly Managing Director of
Sensory Dimensions Ltd
UK

Joanne Hort

Food Experience and Sensory Testing
Laboratory (Feast)
Massey University
Palmerston North
New Zealand

Danielle van Hout

Aigora
Richmond, VA
USA

Sarah E. Kemp

Consultant and formerly Head of Global
Sensory and Consumer Guidance
Cadbury Schweppes
UK

Min-A Kim

Division of Food and Nutrition
Chonnam National University
Gwangju
South Korea

Harry T. Lawless

Cornell University
Ithaca, NY
USA

Hye-Seong Lee

Department of Food Science and
Biotechnology, College of Engineering
Ewha Womans University
Seoul
South Korea

Stella Lignou

University of Reading
Reading
UK

Linda Lopez

S&T, Givaudan International
Kemptthal
Switzerland

Curtis R. Luckett

University of Tennessee
Knoxville, TN
USA

SCiFi Foods
San Leandro, CA
USA

Michael Meyners

Discovery & Innovation Platforms,
Procter & Gamble Service GmbH
Schwalbach am Taunus
Germany

Karine Miot

Sensory Department, Perfumery & Beauty
BU dsm-firmenich
London
United Kingdom

Erminio Monteleone

Department of Agriculture, Food,
Environment and Forestry (DAGRI)
University of Florence
Florence
Italy

Victoria Norton

University of Reading
Reading
UK

Lauren Rogers

Freelance Sensory Scientist
UK

Sara Spinelli

Department of Agriculture, Food,
Environment and Forestry (DAGRI)
University of Florence
Florence
Italy

Bernard Thomas Carr

Carr Consulting
Evanston, IL
USA

National Wine and Grape Industry Centre
Charles Sturt University
Wagga Wagga, New South Wales
Australia

Preface to the Series

Sensory evaluation is a scientific discipline used to evoke, measure, analyze and interpret responses to products perceived through the senses of sight, smell, touch, taste and hearing (Anonymous 1975). It is used to reveal insights into the way in which sensory properties drive consumer acceptance and behavior and to design products that best deliver what consumers want. It is also used at a more fundamental level to provide a wider understanding of the mechanisms involved in sensory perception and consumer behavior.

Sensory evaluation emerged as a field in the 1940s. It began as simple “taste testing” typically used in the food industry for judging the quality of products such as tea, cheese, beer, and so on. From the 1950s to the 1970s, it evolved into a series of techniques to objectively and reliably measure sensory properties of products and was typically used to service quality assurance and product development. Through the 1980s and 1990s, the use of computers for data collection and statistical analysis increased the speed and sophistication of the field, so that sensory, consumer, and physicochemical data could be combined to design products that delivered to consumer needs.

Today, sensory evaluation is a sophisticated, decision-making tool that is used in partnership with marketing, research and development, and quality assessment and control throughout the product lifecycle to enable consumer-led product design and decision-making. Its application has spread from the food industry to many others, such as personal care, household care, cosmetics, flavors, fragrances, and the automotive industry. Although it is already widely used by major companies in the developed market, its use continues to grow in emerging markets, smaller companies, and new product categories, as sensory evaluation is increasingly recognized as a necessary tool for competitive advantage.

The field of sensory evaluation will continue to evolve and it is expected that faster, more flexible, and more sophisticated techniques will be developed. Social networking tools are transforming the way research is undertaken, enabling direct and real-time engagement with consumers. The use of sensory evaluation by marketing departments will continue to grow, particularly in leveraging the link between product sensory properties and emotional benefits for use in branding and advertising. Advances in other fields, such as genomics, brain imaging, and instrumental analysis, will be coupled with sensory evaluation to provide a greater understanding of perception.

Owing to the rapid growth and sophistication of the field of sensory evaluation in recent years, it is no longer possible to give anything but a brief overview of individual topics in a single general sensory science textbook. The trend is toward more specialized sensory

books that focus on one specific topic, and to date, these have been produced in an ad hoc fashion by different authors/editors. Many areas remain uncovered.

We, the editors, wanted to share our passion for sensory evaluation by producing a comprehensive series of detailed books on individual topics in sensory evaluation. We are enthusiastic devotees of sensory evaluation, who are excited to act as editors to promote sensory science. Between us, we have over 120 years of industrial and academic experience in sensory science, covering food, household, and personal care products in manufacturing; food service; consultancy; and provision of sensory analysis services at local, regional, and global levels. We have published and presented widely in the field; taught workshops, short courses, and lecture series; and acted as reviewers, research supervisors, thesis advisors, project managers and examiners. We have been active in many sensory-related professional bodies, including the Institute of Food Science and Technology Sensory Science Group, of which many of us are past Chairs, the European Sensory Science Society, of which one of us is a past Chair, the Institute of Food Technologists, the British Standards Institute, and ASTM International, to name but a few. As such, we are well placed to have a broad perspective of sensory evaluation and pleased to be able to call on our network of sensory evaluation colleagues to collaborate with us.

The book series *Sensory Evaluation* covers the field of sensory evaluation at an advanced level and aims to:

- be a comprehensive, in-depth series on sensory evaluation
- cover traditional and cutting-edge techniques and applications in sensory evaluation using the world's foremost experts
- reach a broad audience of sensory scientists; practitioners; and students by balancing theory, methodology, and practical application
- reach industry practitioners by illustrating how sensory can be applied throughout the product life cycle, including development, manufacture, supply chain, and marketing
- cover a broad range of product applications, including food, beverages, personal care, and household products.

Our philosophy is to include cutting-edge theory and methodology, as well as illustrating the practical application of sensory evaluation. As sensory practitioners, we are always interested in how methods are actually carried out in the laboratory. Often, key details of the practicalities are omitted in journal papers and other scientific texts. We have encouraged authors to include such details in the hope that readers will be able to replicate methods themselves. The focus of sensory texts often tends to be food and beverage products assessed using olfaction and taste. We have asked authors to take a broad perspective to include non-food products and all the senses.

The book series is aimed at sensory professionals working in academia and industry, including sensory scientists, practitioners, trainers, and students; and industry-based professionals in marketing, research and development, and quality assurance/control, who need to understand sensory evaluation and how it can benefit them. The series is suitable as:

- reference texts for sensory scientists, from industry to academia
- teaching aids for senior staff with responsibility for training in an academic or industrial setting

- course books, some of which to be personally owned by students undertaking academic study or industrial training
- reference texts suitable across a broad range of industries; for example, food, beverages, personal care products, household products, flavors, fragrances.

The first book in the series, *Sensory Evaluation: A Practical Handbook*, was published in May 2009 (Kemp et al. 2009). This book focuses on the practical aspects of sensory testing, presented in a simple, “how to” style for use by industry and academia as a step-by-step guide to carry out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. Further books in the series cover the basic methodologies used in the field of sensory evaluation: discrimination testing, descriptive analysis (Kemp et al. 2018), time-dependent measures of perception (Hort et al. 2017), and consumer research. They give theoretical background, more complex techniques, and in-depth discussion on application of sensory evaluation, while seeking to maintain the practical approach of the handbook. Chapters include clear case studies with sufficient detail to enable practitioners to carry out the techniques presented. Later books will cover a broad range of sensory topics, including applications and emerging trends.

The contributors we have selected are world-renowned scientists and leading experts in their field. Where possible, we have used originators of techniques. We have learned a lot from them as we have worked with them to shape each book. We wish to thank them for accepting our invitation to write chapters and for the time and effort they have put in to making their chapters useful and enjoyable for readers.

We would also like to thank our publisher, Wiley Blackwell, and the team for seeing the potential in this series and helping us bring it to fruition. We would also like to thank the anonymous reviewers of the series for their constructive comments.

We hope you will find the Sensory Evaluation book series both interesting and beneficial, and enjoy reading it as much as we have producing it.

Sarah E. Kemp
Joanne Hort
Tracey Hollowood
Lauren Rogers

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Preface

Discrimination tests are one of the key sets of methods in a sensory scientist's toolbox. The aim of this book is to provide a comprehensive and up-to-date overview of the area, the tests, and their applications.

Discrimination tests are covered in classic general sensory science texts, including Meilgaard et al. (2016), Lawless and Heymann (2010), and Stone et al. (2020). These have limited space to give to the topic, which makes it difficult to strike a balance between theory and practical application. To the editors' knowledge, there are two previous publications devoted to discrimination tests. Bi (2015, updated from the first edition in 2008) produced a very detailed book that thoroughly covers the statistical aspects of discrimination testing, as well as information about consumer emotions, time intensity, and shelf-life. Rogers (2017) edited a practical handbook for sensory scientists with chapters and case studies dedicated to the most popular sensory discrimination tests.

The editors saw a need for a book devoted to discrimination testing that would provide in-depth theoretical and practical coverage of traditional and recently developed approaches, as well as cover several of the many applications of sensory science such as food, home and personal care, and ingredient testing. In addition, the book also considers discrimination testing with different subjects and those with differing discrimination abilities, as well as replicated discrimination tests and the use of discrimination tests in determining sensory quality. The scope of this book includes history, theory, techniques and applications of discrimination tests. The book also includes case studies to bring the applications to life, making it an essential reference for sensory scientists.

The book is structured in two sections. Section 1 is an introduction covering general topics in discrimination testing, including history, general considerations, determining discrimination abilities, similarity, and approaches to replicated tests. This section also delves into Thurstonian modeling and the use of sureness judgments to quantify the size of the sensory differences. Section 2 covers some applications of discrimination testing such as the use of children to conduct the tests, the use of attribute-specific tests with many samples, and conducting discrimination tests in the flavors and fragrances industries.

Each chapter includes theory, psychological aspects, methodology, statistical analysis, applications, practical considerations, case studies and examples, future developments, and a reference list. The aim is to give a balance between theory and practice, with enough theory for readers to fully understand the background and underlying mechanisms of the

technique, and in many instances enough detail to enable the reader to carry out the methodology.

We thank all authors for giving their time and effort to their chapter despite their busy schedules, and for their patience with the process.

We hope you find this book as interesting and beneficial to read as we did to produce.

Lauren Rogers
Tracey Hollowood
Joanne Hort
Sarah E. Kemp

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Editor Biographies

Tracey Hollowood BSc (Hons), PhD, is the former director of Sensory and Consumer Research for Sensory Dimensions Ltd, she has over 25 years of academic and industrial experience and has been published extensively. She established the UK's first postgraduate certificate in Sensory Science and managed Nottingham University's Sensory Science Centre. She was a previous chair of the Institute of Food Science and Technology (IFST) Midland Branch and the Sensory Science Group (SSG).

Joanne Hort, BEd (Hons), PhD, CSci, FIFST, MNZIFST, RSensSci, is the Fonterra-Riddet Chair of Consumer and Sensory Science at Massey University in New Zealand (NZ) following on from her various academic roles, latterly SABMiller Chair of Sensory Science at the University of Nottingham. Initially, Professor Hort studied food technology and began her career in teaching. However, she returned to university to receive her doctorate concerning the modelling of the sensory attributes of cheese from analytical and instrumental measures in 1998 and then took up a post as lecturer at Sheffield Hallam University. She was appointed as a lecturer in Sensory Science at the University of Nottingham in 2002. There she established the University of Nottingham Sensory Science Centre, obtaining her Chair in 2013. Her multidisciplinary approach combining analytical, brain imaging and sensory techniques provided rich insight into multisensory interactions, individual variation, temporal changes in flavor perception and the emotional response to sensory properties. In 2017, she took the position of inaugural Fonterra Riddet Chair in Consumer and Sensory Science at Massey University where she has established the Food Experience and Sensory Testing (Feast) lab, complete with digital immersive space for research on emotional response in ecologically valid environments. She has over 120 publications and sits on the editorial board for Food Quality and Preference. She is a fellow of the Institute of Food Science and Technology (IFST), member of the NZIFST and NZ Royal Society. She is vice president of the Pangborn Sensory Science Trust, a founder member and past chair of the European Sensory Science Society, and a founder member and past chair of the UK IFST Sensory Science Group.

Sarah E. Kemp, BSc (Hons), PhD, CSci, FIFST, RSensSci, is a chartered sensory and consumer science professional with more than 35 years of experience in academia and industry. Dr Kemp gained a BSc in Food Technology in 1986 and a PhD in Taste Chemistry in 1989 from the Food Science and Technology Department at the University of Reading, UK. In

1990, she did a postdoctoral research fellowship in sensory science at the Monell Chemical Senses Center in Philadelphia, USA. Dr Kemp has held many positions in industry, including manager of Sensory Psychology (US) and director of European Consumer and Marketing Research (France) in the Fragrance Division at Givaudan; product area leader and sensory science leader in Foods Consumer Science at Unilever Research, Colworth, UK; head of Global Sensory and Consumer Guidance at Cadbury Schweppes, UK; and director of Sensory and Consumer Services at Reading Scientific Services Limited, UK. Dr Kemp has also set up and run her own consultancy service and catering company. She has written numerous scientific articles in the field of sensory evaluation, has provided sensory training courses, including lecturing on the European Masters Course in Food Science, and has worked on bodies developing standards in sensory evaluation, including ASTM and the British Standards Institution, where she is chair of Committee AW/012 Sensory Analysis. She is a fellow of the Institute of Food Science and Technology and a founder member, past chair, and examiner for the IFST's Sensory Science Group, as well as being a member of other professional sensory societies and a past Governor of East Kent College, UK.

Lauren Rogers is a freelance sensory scientist living in the beautiful Staffordshire Peak District. Lauren fell in love with sensory science in the early 1990s when she worked for Dalgety Plc, a food ingredients company. Later, she worked for GlaxoSmithKline, mainly on beverages such as Ribena and Horlicks. Lauren became a freelancer in 2009 and, as well as working for several different clients on many different product types and many different qualitative and quantitative methods, Lauren lectures on sensory science at the University of Nottingham and Le Cordon Bleu. Lauren is particularly interested in the sensory, consumer, and emotional attributes of brands; sensory shelf-life; panel performance; and sensory claim substantiation. She has experience in many food products including ingredients, snack products, drinks, and pet-food. She also has worked on many home and personal care products such as shampoos, conditioners, toothpastes, and creams. Lauren is a fellow of the Institute of Food Science and Technology (IFST) and an active member of the IFST's Sensory Science Group, maintaining their sensory science qualifications. She is also a member of the Market Research Society, the Sensometrics Society, the Society of Sensory Professionals and the ASTM E-18 (Sensory) Committee. Lauren is a member of the British Standards Society working on various international sensory science standards. Lauren has previously published two books, *Sensory Panel Management* and *Discrimination Testing in Sensory Science*.

Section 1

Introduction

1

Introduction

Sarah E. Kemp¹, Tracey Hollowood², Joanne Hort³ and Lauren Rogers⁴

¹ Consultant and formerly Head of Global Sensory and Consumer Guidance, Cadbury Schweppes, UK

² Formerly Managing Director of Sensory Dimensions Ltd, UK

³ Food Experience and Sensory Testing Laboratory (Feast), Massey University, Palmerston North, New Zealand

⁴ Freelance Sensory Scientist, UK

1.1 Introduction

Sensory discrimination tests are methodologies used in fields such as foods and beverages, home and personal care, cosmetics, and consumer goods to assess whether two samples are perceptibly different. The two samples being tested generally come from two production batches. These different batches might use, for example, different ingredients, different manufacturing processes, or different packaging. Discrimination tests are also used to evaluate and quantify individuals' abilities to perceive and differentiate various sensory attributes or a holistic difference between products. Participants are typically presented with pairs of products and are tasked with identifying differences or similarities in sensory characteristics, such as appearance, aroma, taste, flavor or texture. These tests play a crucial role in quality control, product development, and market research, for example, providing valuable insights into consumer preferences and aiding in the improvement of product formulations based on perceived sensory attributes.

1.1.1 Discrimination Testing as a Tool

Imagine that you are the new product development manager for a major snack manufacturer and have been tasked with an innovative global wellness project to further reduce the levels of salt and fat in the company's flagship product. Several designs of experiment studies are currently being discussed by the team and the next step is to discuss the project timings for the assessment of the sensory aspects of the products arising from these experiments. You have a meeting with the sensory manager to discuss the plans and the sensory methods available to help meet the project's action standards. There are several classes of sensory methods available to you, including descriptive, temporal and consumer methods, however, you agree

with the global sensory manager that discrimination tests¹ are the best choice for this stage of the project as the differences between products should be slight: there is no point in conducting a discrimination test on products that are obviously different. The sensory manager has explained that if you need to know *how* products are different, you will need a different method (for example, quantitative descriptive analysis or free choice profiling). The sensory discrimination tests will allow you to determine if consumers will notice the difference between the chemically and physically different products from the experimental design studies and the current gold standard products.

To use a sensory discrimination test, three things are usually required: people to assess the samples, the choice of the test and some samples to assess. Obviously, a sensory scientist is also required to choose and administer the test, as well as to analyze and report the results. The person who takes part in the test is often someone who has been screened for their sensory acuity (ISO 2023) and trained in the test method, although they might also be naïve consumers. By training in the method first, the participant is focused on the items in the test and not the execution of the test itself. This person assesses the items presented to them using the training they received, answering the question posed by the test; for example, selecting the odd sample in a discrimination test known as a triangle test (Sinkinson 2017) or rating the difference between samples on a scale (Whelan 2017). The results from all participants in the test are then analyzed to make a final decision based on the objectives and action standard(s).

There are many different sensory discrimination tests available to the sensory scientist to help meet the types of objectives they might encounter. The choice of test will depend on several factors, with the primary considerations being the type of product being tested and the objectives of the test. There is a tendency for businesses to habitually use one discrimination test for all objectives, but not all objectives are equal: for an interesting discussion about the choice of sensory test related to the objective(s) of the research, see Lawless and Heymann (2010, pp. 8–10).

When the focus of the discrimination test is to answer a product-related question, the intended use of the results and the test's position within the project stages are important factors in the choice of test (Meilgaard et al. 2016).

1.2 Developments of Discrimination Testing

Sensory discrimination testing began early in the 20th century and was originally referred to as difference testing (Meiselman et al. 2022), however, the initial “discrimination tests” were conducted by Weber and Fechner in the early 19th century to examine the relationship between physical stimuli and sensory experience (David 1963). This field of study, now referred to as psychophysics, was characterized by the researchers' belief that sensations could not be measured directly. Consequently, they employed a variety of indirect methods and experiments to gauge perception. Weber's experiments in 1834 explored the

¹ Ideally, sensory discrimination tests should be referred to as sensory discrimination “methods”, however, the word “test” has been used so frequently that it is in common usage, and so the word ‘test’ has been used throughout this chapter.