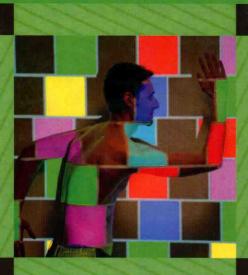
WOODHEAD PUBLISHING SERIES IN TEXTILES



# Colour design Theories and applications

**Edited by Janet Best** 





## Colour design Theories and applications

Edited by Janet Best





Oxford Cambridge

Philadelphia

New Delhi

Published by Woodhead Publishing Limited in association with the Textile Institute Woodhead Publishing Limited, 80 High Street, Sawston, Cambridge CB22 3HJ, UK www.woodheadpublishing.com www.woodheadpublishingonline.com

Woodhead Publishing, 1518 Walnut Street, Suite 1100, Philadelphia, PA 19102-3406, USA

Woodhead Publishing India Private Limited, G-2, Vardaan House, 7/28 Ansari Road, Daryaganj, New Delhi – 110002, India www.woodheadpublishingindia.com

First published 2012, Woodhead Publishing Limited © Woodhead Publishing Limited, 2012; except Chapter 2 © John Barbur and Marisa Rodriguez-Carmona, 2012 and Chapter 7 © Crown copyright, 2012 The authors have asserted their moral rights.

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. Reasonable efforts have been made to publish reliable data and information, but the authors and the publisher cannot assume responsibility for the validity of all materials. Neither the authors nor the publisher, nor anyone else associated with this publication, shall be liable for any loss, damage or liability directly or indirectly caused or alleged to be caused by this book.

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming and recording, or by any information storage or retrieval system, without permission in writing from Woodhead Publishing Limited.

The consent of Woodhead Publishing Limited does not extend to copying for general distribution, for promotion, for creating new works, or for resale. Specific permission must be obtained in writing from Woodhead Publishing Limited for such copying.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation, without intent to infringe.

British Library Cataloguing in Publication Data A catalogue record for this book is available from the British Library.

Library of Congress Control Number: 2011945406

ISBN 978-1-84569-972-7 (print) ISBN 978-0-85709-553-4 (online) ISSN 2042-0803 Woodbead Publishing Se

ISSN 2042-0803 Woodhead Publishing Series in Textiles (print)

ISSN 2042-0811 Woodhead Publishing Series in Textiles (online)

The publisher's policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp which is processed using acid-free and elemental chlorine-free practices. Furthermore, the publisher ensures that the text paper and cover board used have met acceptable environmental accreditation standards.

Typeset by Toppan Best-set Premedia Limited, Hong Kong Printed and bound in the UK by the MPG Books Group

## Colour design

#### The Textile Institute and Woodhead Publishing

The Textile Institute is a unique organisation in textiles, clothing and footwear. Incorporated in England by a Royal Charter granted in 1925, the Institute has individual and corporate members in over 90 countries. The aim of the Institute is to facilitate learning, recognise achievement, reward excellence and disseminate information within the global textiles, clothing and footwear industries.

Historically, The Textile Institute has published books of interest to its members and the textile industry. To maintain this policy, the Institute has entered into partnership with Woodhead Publishing Limited to ensure that Institute members and the textile industry continue to have access to high calibre titles on textile science and technology.

Most Woodhead titles on textiles are now published in collaboration with The Textile Institute. Through this arrangement, the Institute provides an Editorial Board which advises Woodhead on appropriate titles for future publication and suggests possible editors and authors for these books. Each book published under this arrangement carries the Institute's logo.

Woodhead books published in collaboration with The Textile Institute are offered to Textile Institute members at a substantial discount. These books, together with those published by The Textile Institute that are still in print, are offered on the Woodhead website at: www.woodheadpublishing.com. Textile Institute books still in print are also available directly from the Institute's website at: www. textileinstitutebooks.com.

A list of Woodhead books on textiles science and technology, most of which have been published in collaboration with the Textile Institute, can be found towards the end of the contents pages.

#### Contributor contact details

(\* = main contact)

#### Editor and Chapter 10

J. Best Colour Diversity 25 Woodmere Eltham London SE9 5NT

Email: bestjanet@btinternet.com

#### Chapter 1

UK

A. R. Hanson
National Physical Laboratory
Hampton Road
Teddington
Middlesex
TW11 0LW
UK

Email: andrew.hanson@npl.co.uk

#### Chapter 2

J. L. Barbur and M. Rodriguez-Carmona Applied Vision Research Centre City University London Northampton Square London EC1V 0HB UK

Email: j.l.barbur@city.ac.uk; Marisa.Rodriguez-Carmona.1@ city.ac.uk

#### Chapter 3

A. Rizzi\* and C. Bonanomi Dipartimento di Informatica e Comunicazione Università degli Studi di Milano Via Comelico 39/41 20135 Milano Italy

Email: alessandro.rizzi@unimi.it; cristian.bonanomi@unimi.it

#### xiv

#### Chapter 4

B. Mikellides
Oxford School of Architecture
Oxford Brookes University
Headington Campus
Gipsy Lane
Oxford
OX3 0BP
UK

Email: bmikellides@brookes.ac.uk

#### Chapter 5

A. Hurlbert\* and Y. Ling
Institute of Neuroscience
Newcastle University
Newcastle upon Tyne
NE2 4HH
UK

Email: Anya. Hurlbert@ncl.ac.uk

#### Chapter 6

A. Wright 908 Keyes House Dolphin Square London SW1V 3NB UK

Email: abw@colour-affects.co.uk

#### Chapter 7

T. M. Goodman
National Physical Laboratory
Hampton Road
Teddington
Middlesex
TW11 0LW

Email: teresa.goodman@npl.co.uk

#### Chapter 8

J. S. Setchell, Jr P.O. Box 238 Pultneyville New York 14538 USA

Email: john.setchell@eznet.net

#### Chapter 9

D. Mylonas
Wellcome Laboratory of
Neurobiology
University College London
Darwin Building
Gower Street
London
WC1E 6BT

Email: dimitris.mylonas@yahoo.

#### Chapter 11

S. Wilkinson 2D Technologist Hallmark Cards (UK) Bingley Road Bradford BD9 6SD UK

Email: spw7r@hotmail.com

#### Chapter 12

R. M. Osborne Micro Academy Studio House 30 Wayside London SW14 7LN

SW14 /LN

UK

Email: art.school@virgin.net

#### Chapter 13

J. Kopacz

Allegro Interior Architecture

76 Canal Street

Boston

Massachusetts 02114

**USA** 

Email: JKopacz@AllegroIA.com

#### Chapter 14

M. Hidefi

Colour and Trends Consultant

284 Colonial Drive

Guelph Ontario

N1L 0G4

Canada

Email: montaha.hidefi@yahoo.com

#### Chapter 15

B. G. Thomas School of Design University of Leeds

Leeds LS2 9JT

UK

Email: b.g.thomas@leeds.ac.uk

#### Chapter 16

A. Abel

DCC (Europe) Ltd

Holt Mill Road

Waterfoot

Rossendale

BB4 7BY

UK

Email: a.abel@geminidispersions.

com

#### Chapter 17

P. R. Richards

Richtex Textile Consultancy

Vaughan House

8 Cinder Lane

Ollerton

Newark

Nottinghamshire

NG22 9AZ

Email: richtex@btinternet.com

#### Chapter 18

C. Parraman

Centre for Fine Print Research

University of the West of England

Bristol

BS3 2JT

UK

Email: carinna.parraman@uwe.

ac.uk

#### Chapter 19

J. A. King

De Montfort University

The Gateway

Leicester

LE1 9BH

UK

Email: jking02@dmu.ac.uk

#### Chapter 20

K. Haller

Karen Haller Interiors Ltd

267 Westbourne Park Road

Notting Hill

London

W11 1EE

UK

Email: karen@karenhaller.co.uk

#### Chapter 21

J. B. Hutchings 6 Queens Road Colmworth Bedford MK44 2LA UK

Email: john.hutchings@physics.org

#### Chapter 22

C. Sik Lányi
Virtual Environment and Imaging
Technologies Laboratory
Department of Electrical
Engineering and Information
Systems
Faculty of Information Technology
University of Pannonia
H-8200 Veszprem
Egyetem Str. 10
Hungary

Email: lanyi@almos.uni-pannon.hu

#### Chapter 23

J. H. Townsend
Tate Conservation Department
Tate Britain
Millbank
London
SW1P 4RG
UK

Email: joyce.townsend@tate.org.uk

#### Woodhead Publishing Series in Textiles

1	Watson's textile design and colour Seventh edition
	Edited by Z. Grosicki

2 Watson's advanced textile design Edited by Z. Grosicki

3 Weaving Second edition

P. R. Lord and M. H. Mohamed

4 Handbook of textile fibres Vol 1: Natural fibres

J. Gordon Cook

5 Handbook of textile fibres Vol 2: Man-made fibres
J. Gordon Cook

6 Recycling textile and plastic waste

Edited by A. R. Horrocks

7 New fibers Second edition T. Hongu and G. O. Phillips

8 Atlas of fibre fracture and damage to textiles Second edition J. W. S. Hearle, B. Lomas and W. D. Cooke

9 **Ecotextile '98**Edited by A. R. Horrocks

10 Physical testing of textiles

B. P. Saville

11 Geometric symmetry in patterns and tilings C. E. Horne

12 Handbook of technical textiles

Edited by A. R. Horrocks and S. C. Anand

13 Textiles in automotive engineering

W. Fung and J. M. HardcastleHandbook of textile design

14 Handbook of textile design J. Wilson

15 **High-performance fibres** *Edited by J. W. S. Hearle* 

16 Knitting technology Third edition D. J. Spencer

#### xviii Woodhead Publishing Series in Textiles

- 17 **Medical textiles** *Edited by S. C. Anand*
- Regenerated cellulose fibres

  Edited by C. Woodings
- 19 Silk, mohair, cashmere and other luxury fibres Edited by R. R. Franck
- 20 Smart fibres, fabrics and clothing Edited by X. M. Tao
- 21 **Yarn texturing technology**J. W. S. Hearle, L. Hollick and D. K. Wilson
- 22 Encyclopedia of textile finishing H-K. Rouette
- 23 Coated and laminated textiles W. Fung
- 24 Fancy yarns
  R. H. Gong and R. M. Wright
- 25 Wool: Science and technology
  Edited by W. S. Simpson and G. Crawshaw
- 26 **Dictionary of textile finishing** *H-K. Rouette*
- 27 Environmental impact of textiles K. Slater
- 28 Handbook of yarn production P. R. Lord
- 29 **Textile processing with enzymes** *Edited by A. Cavaco-Paulo and G. Gübitz*
- 30 The China and Hong Kong denim industry Y. Li, L. Yao and K. W. Yeung
- 31 The World Trade Organization and international denim trading Y. Li, Y. Shen, L. Yao and E. Newton
- 32 Chemical finishing of textiles W. D. Schindler and P. J. Hauser
- 33 Clothing appearance and fit J. Fan, W. Yu and L. Hunter
- 34 **Handbook of fibre rope technology** H. A. McKenna, J. W. S. Hearle and N. O'Hear
- 35 Structure and mechanics of woven fabrics *J. Hu*
- 36 Synthetic fibres: nylon, polyester, acrylic, polyolefin Edited by J. E. McIntyre
- Woollen and worsted woven fabric design E. G. Gilligan
- 38 Analytical electrochemistry in textiles P. Westbroek, G. Priniotakis and P. Kiekens

#### 39 Bast and other plant fibres

R. R. Franck

#### 40 Chemical testing of textiles

Edited by Q. Fan

#### 41 Design and manufacture of textile composites

Edited by A. C. Long

#### 42 Effect of mechanical and physical properties on fabric hand

Edited by Hassan M. Behery

#### 43 New millennium fibers

T. Hongu, M. Takigami and G. O. Phillips

#### 44 Textiles for protection

Edited by R. A. Scott

#### 45 Textiles in sport

Edited by R. Shishoo

#### 46 Wearable electronics and photonics

Edited by X. M. Tao

#### 47 Biodegradable and sustainable fibres

Edited by R. S. Blackburn

#### 48 Medical textiles and biomaterials for healthcare

Edited by S. C. Anand, M. Miraftab, S. Rajendran and J. F. Kennedy

#### 49 Total colour management in textiles

Edited by J. Xin

#### 50 Recycling in textiles

Edited by Y. Wang

#### 51 Clothing biosensory engineering

Y. Li and A. S. W. Wong

#### 52 Biomechanical engineering of textiles and clothing

Edited by Y. Li and D. X-Q. Dai

#### 53 Digital printing of textiles

Edited by H. Ujiie

#### 54 Intelligent textiles and clothing

Edited by H. R. Mattila

#### 55 Innovation and technology of women's intimate apparel

W. Yu, J. Fan, S. C. Harlock and S. P. Ng

#### 56 Thermal and moisture transport in fibrous materials

Edited by N. Pan and P. Gibson

#### 57 Geosynthetics in civil engineering

Edited by R. W. Sarsby

#### 58 Handbook of nonwovens

Edited by S. Russell

#### 59 Cotton: Science and technology

Edited by S. Gordon and Y-L. Hsieh

#### 60 Ecotextiles

Edited by M. Miraftab and A. R. Horrocks

61 Composite forming technologies

Edited by A. C. Long

62 Plasma technology for textiles Edited by R. Shishoo

63 Smart textiles for medicine and healthcare

Edited by L. Van Langenhove

64 Sizing in clothing

Edited by S. Ashdown

65 Shape memory polymers and textiles *J. Hu* 

66 Environmental aspects of textile dyeing Edited by R. Christie

67 Nanofibers and nanotechnology in textiles Edited by P. Brown and K. Stevens

68 Physical properties of textile fibres Fourth edition W. E. Morton and J. W. S. Hearle

69 Advances in apparel production Edited by C. Fairhurst

70 Advances in fire retardant materials Edited by A. R. Horrocks and D. Price

71 Polyesters and polyamides

72 Advances in wool technology
Edited by N. A. G. Johnson and I. Russell

Edited by N. A. G. Johnson a

Military textiles

Edited by E. Wilusz

74 3D fibrous assemblies: Properties, applications and modelling of threedimensional textile structures
J. Hu

Edited by B. L. Deopura, R. Alagirusamy, M. Joshi and B. S. Gupta

75 **Medical and healthcare textiles**Edited by S. C. Anand, J. F. Kennedy, M. Miraftab and S. Rajendran

76 Fabric testing
Edited by J. Hu

77 **Biologically inspired textiles** *Edited by A. Abbott and M. Ellison* 

78 Friction in textile materials Edited by B. S. Gupta

79 **Textile advances in the automotive industry** *Edited by R. Shishoo* 

80 Structure and mechanics of textile fibre assemblies Edited by P. Schwartz

81 Engineering textiles: Integrating the design and manufacture of textile products

Edited by Y. E. El-Mogahzy

82	Polyolefin	fibres:	Industrial	and	medical	applications
	Edited by	S. C. C	. Ugbolue			

#### 83 Smart clothes and wearable technology Edited by J. McCann and D. Bryson

## 84 **Identification of textile fibres** *Edited by M. Houck*

85 Advanced textiles for wound care Edited by S. Rajendran

## 86 Fatigue failure of textile fibres Edited by M. Miraftab

87 Advances in carpet technology Edited by K. Goswami

## 88 Handbook of textile fibre structure Volume 1 and Volume 2 Edited by S. J. Eichhorn, J. W. S. Hearle, M. Jaffe and T. Kikutani

89 Advances in knitting technology Edited by K-F. Au

## 90 Smart textile coatings and laminates Edited by W. C. Smith

91 Handbook of tensile properties of textile and technical fibres Edited by A. R. Bunsell

## 92 **Interior textiles: Design and developments** *Edited by T. Rowe*

## 93 **Textiles for cold weather apparel** *Edited by J. T. Williams*

94 Modelling and predicting textile behaviour Edited by X. Chen

#### 95 Textiles, polymers and composites for buildings Edited by G. Pohl

96 Engineering apparel fabrics and garments
J. Fan and L. Hunter

## 97 **Surface modification of textiles** *Edited by O. Wei*

98 **Sustainable textiles** *Edited by R. S. Blackburn* 

## 99 Advances in yarn spinning technology Edited by C. A. Lawrence

#### 100 Handbook of medical textiles Edited by V. T. Bartels

101 **Technical textile yarns** *Edited by R. Alagirusamy and A. Das* 

## 102 **Applications of nonwovens in technical textiles** *Edited by R. A. Chapman*

103 Colour measurement: Principles, advances and industrial applications Edited by M. L. Gulrajani

xxii	Woodhead	Publishing	Series	in	Textiles
, ,, ,,,	***********	1 Gonorining	001100		Ortelloc

104	Fibrous and composite materials for civil engineering applications
	Edited by R. Fangueiro
105	New product development in textiles: Innovation and production
	Edited by L. Horne
106	Improving comfort in clothing

106 Improving comfort in clothing Edited by G. Song

107 **Advances in textile biotechnology** *Edited by V. A. Nierstrasz and A. Cavaco-Paulo* 

108 **Textiles for hygiene and infection control** *Edited by B. McCarthy* 

109 **Nanofunctional textiles** *Edited by Y. Li* 

110 **Joining textiles: Principles and applications** *Edited by I. Jones and G. Stylios* 

111 **Soft computing in textile engineering** *Edited by A. Majumdar* 

112 **Textile design** *Edited by A. Briggs-Goode and K. Townsend* 

113 **Biotextiles as medical implants** *Edited by M. King and B. Gupta* 

114 **Textile thermal bioengineering** *Edited by Y. Li* 

115 Woven textile structure
B. K. Behera and P. K. Hari

116 Handbook of textile and industrial dyeing. Volume 1: Principles, processes and types of dyes

Edited by M. Clark

117 Handbook of textile and industrial dyeing. Volume 2: Applications of dyes Edited by M. Clark

118 Handbook of natural fibres. Volume 1: Types, properties and factors affecting breeding and cultivation

Edited by R. Kozlowski

119 **Handbook of natural fibres. Volume 2: Processing and applications** *Edited by R. Kozlowski* 

120 Functional textiles for improved performance, protection and health Edited by N. Pan and G. Sun

121 Computer technology for textiles and apparel Edited by Jinlian Hu

122 Advances in military textiles and personal equipment Edited by E. Sparks

123 Specialist yarn and fabric structures Edited by R. H. Gong

124 **Handbook of sustainable textile production** *M. I. Tobler-Rohr* 

125	Woven textiles: principles, developments and applications	į
	Edited by K. Gandhi	

- 126 **Textiles and fashion: materials design and technology** *Edited by R. Sinclair*
- 127 **Industrial cutting of textile materials** *I. Vilumsone*
- 128 Colour design: theories and applications Edited by J. Best
- 129 False twist textured yarns C. Atkinson
- 130 Modelling, simulation and control of the dyeing process R. Shamey and X. Zhao
- 131 **Process control in textile manufacturing** *Edited by A. Majumdar, A. Das, R. Alagirusamy and V. K. Kothari*
- 132 Understanding and improving the durability of textiles Edited by P. A. Annis
- 133 Smart textiles for protection
  Edited by R. Chapman
- 134 Functional nanofibres and applications Edited by Q. Wei
- 135 The global textile and clothing industry Edited by R. Shishoo
- 136 **Simulation in textile technology: theory and applications** *Edited by D. Veit*

#### Contents

	Contributor contact details Woodhead Publishing Series in Textiles	xiii xvii
Part I	Colour and colour perception	1
1	What is colour? A. R. Hanson, National Physical Laboratory, UK	3
1.1 1.2 1.3 1.4 1.5	Introduction Visible light Organising colours Conclusions References	3 5 7 20 23
2	Variability in normal and defective colour vision: consequences for occupational environments J. L. Barbur and M. Rodriguez-Carmona, City University London, UK	24
2.1	Introduction	24
2.2	Vision information channels	25
2.3 2.4	The concept of the luminous efficiency function Photoreceptor contrasts and the CIE $(x,y)$ chromaticity chart	27 31
2.5	Individual differences in colour vision	33
2.6	Methods of assessing colour vision loss	40
2.7	Anomaloscope variability in the parameters of the	70
2.7	yellow match	46
2.8	Colour assessment and diagnostics (CAD) test	49
2.9	Colour in occupational environments	62
2.10	Colour in healthcare	70
2.11	Conclusions	76
2.12	Sources of further information and advice	77
2.13	Acknowledgements	77
2.14	References	77