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I. Colour in Interdisciplinary Context

Basics of Colour Research

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Abstract

Colour vision is one of the fundamentals of visual perception. Contrary to popular belief, colour is not a property of objects, but rather a construction of our brain. While we have a relatively good understanding of basic processes of colour vision in the early visual pathway, there is still a considerable need for research regarding the involvement of higher brain functions as well as the diverse cultural, social and communicative functions of colours. In relation to colour perception and cultural colour preferences, it is important to study the cortical networks which are involved in memory formation, evaluation and decision-making processes from a psychophysical point of view. The latter are subject to diverse cultural influences, the complexity of which will be outlined at the end of this article using the example of the significance of colours in India and Japan. This is done to illustrate the fact that colour research should include a historico-cultural component, which can be provided by teams of researchers from different disciplines. The goal of the article is to offer the reader a short introduction into the perception of colours and to bridge the gap between the neurobiological perspective and the possible dimensions of an intercultural research approach on the symbolic context and history of colours.

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Colour and perception

Colour is often perceived as an intrinsic property of objects. However, from a physiological point of view, it is understood as a construct of our brain, which represents the spectral properties of reflected light. This process is based on the absorption of light quanta by three classes of specialised photoreceptors, the so-called cones. Each class of cone is sensitive to a different part of the spectrum, i.e. there are short-wavelength (blue) cones, medium-wavelength (green) cones and long-wavelength (red) cones. Colour perception emerges from multiple consecutive processing steps, the first of which take place in the retina of the eye; the processes are completed in several specialised areas of the brain (particularly in the so called human colour centre hV4 and in the subsequent areas of the inferior temporal gyrus)[1]. The result is a robust colour code, which is relatively independent of lighting conditions; the underlying neutral computations are subject of current colour research[2]. Individual colour perception may vary due to the variability of cone sensitivities or due to cognitive factors. Approximately 9 percent of the male population in Europe is affected by colour vision deficiencies, and this can indeed have significant influence on daily life: for example, a reduced ability to discriminate colours like reds, yellows, and greens

[1] See Karl R. Gegenfurtner, 'Cortical Mechanisms of Colour Vision,' *Nature Reviews Neuroscience* 4, 2003, 563–572; Annette Werner, Joel Pokorny, Vivienne Smith, Arne Valberg, Jan Kremers, and Marc Greenlee, 'Psychophysical Correlates of Identified Physiological Processes,' in *The Primate Visual System*: *A Comparative Approach*, ed. Jan Kremer (New York, 2005), 311–349.

[2] Annette Werner, 'Spatial and Temporal Aspects of Chromatic Adaptation and their Functional Significance for Colour Constancy,' *Vision Research* 104, (2014): 80–89; David H. Foster, 'Color Constancy,' *Vision Research* 51, no. 7 (2011): 674–700; Bradley Pearce, Stuart Crichton, Michal Mackiewicz, Graham Finlayson, and Anya Hurlbert, 'Chromatic Illumination Discrimination Ability Reveals that Human Colour Constancy is Optimised for Blue Daylight Illuminations,' *Public Library of Science One* 9, no. 2, (2014): 1–11.

may be decisive in the choice of a profession (e.g. professional drivers, pilots and police officers). Furthermore, inherited or progressive changes in colour sensitivity can be indicative for ophthalmic or neurological diseases.

The biological significance of colour as an additional dimension of visual perception is complex (cf. the distribution of colour vision in the animal kingdom). On the sensory and perceptual level, chromatic contrasts contribute significantly to image analysis[3], identification and evaluation of objects[4] or to quickly recognising of objects and their storage in visual memory[5]. Furthermore, humans and animals use colour as a signal and as an essential means of interspecific and intraspecific communication (e.g. warning colours). As such, colour is an important content of modern media. In human culture, for example in film or fashion, the dimension of colour is extended by the areas of aesthetics and symbolism[6]. The various associations of colour with other sensory modalities such as smell and taste have already been used in 'neuromarketing' for years[7].

In this context, colour preferences – that is colours that are subjectively assessed to be either positive or negative – are of considerable importance since they influence the evaluation of objects and thus also purchasing behaviour. The perception of colour and the resulting evaluation – or prejudice – do not only matter in human purchasing behaviour, but they also play a part in many social contexts. This happens mainly unconsciously and, precisely for this reason, entails consequences. For instance, the purpose of the lighting design in

[3] See Karl Gegenfurtner and Daniel C. Kiper, 'Contrast Detection in Luminance and Chromatic Noise,' *JOSA A* 9, no. 11 (1992): 1880–1888.

[4] E.g. the degree of ripeness of fruit: See Daniel Osorio and Misha Vorobyev, 'Colour Vision as an Adaptation to Frugivory in Primates,' *Proceedings of the Royal Society London B* 263, no. 1370 (1996): 593–599; Petroc Sumner, John D. Molon, 'Catarrhine Photopigments are Optimized for Detecting Targets Against a Foliage Background,' *Journal of Experimental Biology* 203, no. 13 (2000): 1963–1986.

[5] See Karl R. Gegenfurtner and Jochem Rieger, 'Sensory and Cognitive Contributions of Color to the Recognition of Natural Scenes,' *Current Biology* 10, no. 13 (2000): 805–808.

[6] See Susanne Marschall, *Farbe im Kino*, 2nd revised edn., (Marburg: 2009).

[7] See Gerhard Raab, Oliver Gernsheimer, and Maik Schindler, *Neuromarketing: Grundlagen – Erkenntnisse – Anwendungen* (Wiesbaden: 2009); Hans-Georg Häusel ed., *Neuromarketing: Erkenntnisse der Hirnforschung für Markenforschung, Werbung und Verkauf*, (Munich: 2007).

the fruit and vegetable sections in supermarkets is to influence the customers' product choices directly. So, because of this and for many other reasons, colours play a significant role in industrial contexts. They are a fundamental element of the world in which we live, and they characterise living areas, cities and landscapes, fashion and art. In general, it can be observed that colour – although it can be found everywhere – is only superficially contemplated in social discourse, although it proves to be highly influential when it is regarded more closely. For example, it could be shown in placebo studies that the colour of drugs influences their effect significantly[8]. In the context of colour memory, a wide range of associations and interactions with other sensory modalities take place; the neuroscientific foundations of these processes remain largely unexplored[9].

The synaesthesia is an unusual form of this: the stimulation of a sensory modality (e.g. seeing letters, listening to sounds/music or the smell of scents) triggers the perception of an additional, unstimulated modality, which often, but not exclusively, is a colour[10]. In the case of colour synaesthesia it has been shown that the colour–selective cortical region hV4 is activated, although the specific function of this activation remains unclear[11]. In addition to genetic factors, learning processes may also play a part in this[12]. The phenomenon of synaesthesia is also of importance for the understanding of normal perception processes, where, albeit to a small degree, multi-sensory interactions are acquired as well. Once children have learned that red-

[8] See Arif Khan, Eswara P. Bomminayuni, Amritha Bhat, James Faucett, and Walter A. Brown, 'Are the Colors and Shapes of Current Psychotropics Designed to Maximize the Placebo Response?' *Psychopharmacology* 211, no. 113 (2010): 113–122.

[9] See Raab, *Neuromarketing, Grundlagen*; Häusel, *Neuromarketing: Erkenntnisse*.

[10] See Jamie Ward and Jason B. Mattingley, 'Synaesthesia: An Overview of Contemporary Findings and Controversies,' *Cortex* 42, no. 2 (2006): 129–136; Hinderk M. Emrich, Udo Schneider, and Markus Zedler, *Welche Farbe hat der Montag?: Synästhesie: Das Leben mit verknüpften Sinnen*, 2nd edn., (Stuttgart, 2004); Richard E. Cytowic, *Synesthesia: A Union of the Senses*, 2nd edn., (Cambridge and London: MIT Press 2002).

[11] See Romke Rouw, Steven H. Scholte, and Olympia Colizoli, 'Brain Areas Involved in Synaesthesia: A Review,' *Journal of Neuropsychology* 5, no. 2 (2011): 214–242.

[12] See Edward M. Hubbard, V.S. Ramachandran 'Neurocognitive Mechanisms of Synaesthesia,' *Neuron* 48, no. 3 (2005): 509–520.

hot objects are hot, this knowledge is stored and partly transferred on other red items. Then, acquired as well as associative links between a colour and a temperature sensation may arise. Memory colours, their formation and their influence on visual perception as well as multi-sensory interactions and the phenomenon of the synesthetic sensations, also influence the reception of art, especially of cinematic productions which stand out because of their subtle composition of image and sound[13].

Colour and cognition

Colours are an essential phenomenon of visual experience, and they influence a broad spectrum of areas of human life, including the selection of the colour of cars, clothing, housing facilities or web design. Basic research in psychophysics has shown that there are gender differences in colour preferences among Europeans. There is an overall preference for blue, which is overlaid by a distinct preference for red by women, and, on the other side, for blue/green by men[14]. These significant differences seem to also be modulated by cultural context, as Chinese experimental subjects gave more weight to red. This tendency was almost equal for women and men (in China, the colour red is associated with luck, among other things). Gender differences also matter concerning the linguistic development of colour discrimination. Girls develop a nuanced colour vision earlier than boys, and they can conceive colours linguistically at an earlier age[15].

The significance of colour in human society has recently been highlighted by the tremendous echo of the 'dress-illusion'[16] in social media: one and

[13] See Marschall, *Farbe im Kino*; Marschall, 'Fließende Farben – tanzendes Licht: Empfindungsräume im Film,' in *Synäthesie-Effekte: Zur Intermodalität der ästhetischen Wahrnehmung*, eds. C. Robin, G. Marc, and K. Gertrud (Munich: Wilhelm Fink Verlag, 2010), 207–223; Marschall, 'Die Symphonie der Empfindungen: Synästhesie als Filmerfahrung,' in *Was ist Farbe?: Beleuchtungen eines alltäglichen Phänomens*, ed. G. Arnold (Berlin: Weidler Buchverlag, 2011), 85–110.

[14] See Yazhu Ling and Anya C. Hurlbert, 'Role of Color Memory in Successive Color Constancy,' *JOSA A* 25, no. 6, (2008): 1215–1226.

[15] See Marc H. Bornstein, 'On the Development of Color Naming in Young Children: Data and Theory,' *Brain and Language* 26, (1985): 72–93.

[16] See for example David Brainard and Anya Hurlbert, 'Colour Vision: Understanding #theDress,' *Current Biology* 25, (2015): R549–R568; Annette Werner and Alisa

the same photo of a two-coloured dress caused two utterly different colour perceptions in the individual viewers (blue/black or white/gold). This impressively showed that colour – although it is perceived as an intrinsic property of objects – is indeed a construct of our brain when considered from a neurophysiological point of view. As such, it is subject to significant individual variability. The strikingly ambivalent effect of the dress illusion also demonstrates that the influence of cognitive factors on colour perception had long been underestimated.

For example, cognitive factors play a role in the interpretation of the lighting conditions; this is essential for the colour constancy, which means that the perception of colour does not change, even if the lighting conditions are modified[17]. The effect of colour memory is another example of cognitive influences. The colour memory ensures that the colour values of scenes or objects are significantly more saturated in our memory (lower percentage of white), as they are with regard to their colourimetric values. Besides, the perception of an object's colour is affected by the memory of it, the memory colour[18]. A banana, for instance, is perceived to be more yellow than it actually is in correspondence to its spectral reflectance[19], and a polar bear is perceived to be whiter than a comparable object even under modified lighting if the latter lacks a 'diagnostic' colour[20].

There is a complex interaction between the current perception of colours and the memory of coloured objects. The psycho-physically

Schmidt, 'The #Dress Phenomenon an Empirical Investigation into the Role of the Background,' Vision Science Society Annual Meeting, *Journal of Vision* 16, no. 12 (2016): 742–742. doi: 10.1167/16.12.742.

[17] See Hannah E. Smithson, 'Sensory, Computational and Cognitive Components of Human Colour Constancy,' *Philosophical Transactions B* 360, no. 1458 (2005): 1329–1346; Werner, 'Spatial and Temporal Aspects'.

[18] See Maria Olkkonen, Thorsten Hansen, and Karl Gegenfurtner, 'Color Appearance of Familiar Objects: Effects of Object Shape, Texture, and Illumination Changes,' *Journal of Vision* 8, no. 13 (2008): 116; Maria Olkkonen and Sarah R. Allred, 'Short-Term Memory Affects Color Perception in Context,' *PloS one* 9, no. 1 (2014): 1–11.

[19] See Thorsten Hansen, Maria Olkkonen, Sebastian Walter, and Karl Gegenfurtner, 'Memory Modulates Color Appearance,' *Nature Neuroscience* 9, (2006): 1367.

[20] See Annette Werner, Lara Zebrowski, and Ismael Kelly-Perez, 'The Colour of Real Objects: Influence of Surface Material, 3D Shape and Memory,' in *12th Conference of the International Colour Association*, (Newcastle: 2013).

measurable effects of colour memory, as well as the cognitive influences on the perception of colour, are also of importance for the reception of art: The intensification effect in our memory is considered in the design of photo films where colour values are increased when the film is developed. In a study, these influences of colour memory could be made visible as activation in the primary visual cortex[21]. This kind of colour effect seems to occur primarily with objects of characteristic (diagnostic) colours, but this is not the case for objects that exist in different colours[22].

Against this background, the aesthetic history of the cinema proves to be very revealing since films as fictional and documentary art forms have 'filed' and aesthetically elevated appearances of colours in reality. In the first decades of the twentieth century, the products of the original black-and-white light art were painted by hand or were dipped in dye baths to colour them (monochrome); based on technological innovations in the 1930s they developed into an art of moving colour compositions[23]. The gestalt psychologist David Katz assumed that coloured films could train our colour vision and sharpen our perception of 'the appearance of the colours'[24] in reality. From an aesthetical point of view, the film can be located on the threshold between painting, i.e. the still picture composition, and the moving image, which integrates all the other arts. At the same time, the film can produce distinct connections with reality due to its disposition as a photographic art form. Therefore, film and photography are key media for the history of colours in everyday culture, clothing, furniture and car design. At the same time, these two media play a decisive role in the development of imaginary experiences of colour, which is a highly elusive and emotionally compelling part of our visual culture.

In addition, colour memory plays an integral part in the formation of colour preferences. Colour preferences can be both context-free

[21] See Michael M. Bannert and Andreas Bartels, 'Decoding the Yellow of a Gray Banana,' *Current biology* 23, no. 22 (2013): 2268–2272.

[22] See Karen B. Schloss, Eli D. Strauss, and Stephen E. Palmer, 'Object Color Preferences,' *Color Research & Application* 38, no. 6 (2013): 393–411.

[23] See Marschall, *Farbe im Kino*.

[24] See David Katz, *Der Aufbau der Farbenwelt*, 2nd revised edn., (Leipzig: Barth, 1930).

and related to objects or scenes, and they follow universally valid laws, but they also vary on an individual level. Furthermore, it has been shown that colour preferences are not fixed, but may change during individual development[25] or because of experiences[26]. There is a universal tendency to favour shades of blue[27], but there are also gender-specific differences[28]. Context and age, as well as semantic and cultural influences also affect colour preferences[29].

Two leading causes are discussed as underlying neural mechanisms of colour preferences: (a) a physiologically-fixed weighting of sensory processes in colour processing[30] and (b) the weighting of colour sensations by cognitive processes, where colours are evaluated in a positive or negative way in association with objects or scenes[31]. According to the ecological valance theory[32], colour preferences are

[25] See Lászlo Beke, Gábor Kutas, Youngshin Kwak, Gee Young Sung, Du-Sik Park, and Peter Bodrogi, 'Color Preference of Aged Observers Compared to Young Observers,' *Color Research & Application* 33, no. 5, (2008): 381–394; Chloe Taylor, Alexandra Clifford, and Anna Franklin, 'Color Preferences are not Universal,' *Journal of Experimental Psychology: General* 142, no. 4 (2013): 1015–1027.

[26] See Eli D. Strauss, Karen B. Schloss, and Stephen E. Palmer, 'Color Preferences Change after Experience with Liked/Disliked Coloured Objects,' *Psychonomic Bulletin & Review* 20, no. 5 (2013) 935–943.

[27] See I.C. McManus, Amanda L. Jones, and Jill Cottrell, 'The Aesthetics of Color,' *Perception* 10, no. 6 (1982): 651–666; G. W. Granger, 'Objectivity of Colour Preferences,' *Nature* 170, no. 4322 (1952): 778–780; Li-Chen Ou, Ronnier M. Luo, Andrée Woodcock, and Angela Wright, Angela 'A Study of Colour Emotions and Colour Preferences. Part I: Colour Emotions for Single Colours,' *Color Research & Application* 29, no. 3 (2004): 232-240; S.E. Katz and F.S. Breed, 'The Color Preferences of Children,' *Journal of Applied Psychology* 6, no. 3 (1922): 255–266.

[28] See Anya C. Hurlbert and Yazhu Ling, 'Biological Components of Sex Differences in Color Preference,' *Current Biology* 17, no. 16 (2007): R623–R635.

[29] See Stephen E. Palmer, Karen B. Schloss, and William S. Griscom, 'Individual Differences in Perceptual Preference,' *Society for Imaging Science and Technology*, no. 16 (2016), 1–6.

[30] See Hurlbert, and Ling, 'Biological Components of Sex'.

[31] See Nicholas Humphrey, 'The Colour Currency of Nature,' T. in *Colour for Architecture*, eds. Porter and B. Mikellides, (London, 1976) 95–98; Ou, 'A Study of Colour Emotions'; Schloss, 'Color Preferences'.

[32] See Stephen E. Palmer and Karen B. Schloss, 'An Ecological Valence Theory of Human Color Preference,' *Proceedings of the National Academy of Sciences of the United States of America* 107, no. 19 (2010): 8872–8882.

based on a perceived 'value' of the colours concerning expected benefits. Different factors such as culture, social context, and object category determine which benefits are expected from different colours. This is a highly adaptive process, which explains the individual variability of colour preferences that can be observed. The question of the neuronal basis of colour preferences is closely linked with the more extensive subject area of aesthetics. The integration of sensory, cognitive and affective organisational processes are the underlying basics of visual preferences and the perception of aesthetics in general. Many cortical and subcortical structures are involved in these processes[33]. These structures process and connect multimodal sensory information with memories and with negative or positive evaluations from centres in the brain which belong to the reward system and the formation of emotions[34].

Language is an essential medium for the perception of colour. In the 1960s, the linguists Berlin and Kay did research on 'Basic Color Terms'; in doing so, they have made a fundamental contribution to prototype semantics[35]. The Sapir-Whorf-hypothesis[36] was developed in American linguistics; it implies that linguistic systems do not just reproduce human perception and thinking, but rather form these processes. Experiences emerge in and through the language that is available in the respective cultural collective. It becomes clear that all languages include 'Basic Color Terms' and, at the same time, a variety of culture-specific alternatives of colour names. Valid principles of colour can be differentiated from subjective, individual and culture-specific versions on a psychophysical level, which contributes to the complexity of the

[33] See reviews by Steven Brown, Xiaoquing Gao, Loren Tisdelle, Simon B. Eickhoff, and Mario Liotti, 'Naturalizing Aesthetics: Brain Areas for Aesthetic Appraisal across Sensory Modalities,' *Neurolmage* 58, no. 1 (2011) 250–258; Camilo J. Cela-Conde, Luigi Agnati, Joseph P. Huston, Francisco Mora, and Marcos Nadal, 'The Neural Foundations of Aesthetic Appreciation,' *Progress in Neurobiology* 94, no. 1 (2011): 39–48.

[34] See Brian Knutson, Scott Rick, Elliott G. Wimmer, Drazen Prelec, and George Loewenstein, 'Neural Predictors of Purchases,' *Neuron* 53, no. 1 (2007): 147–156.

[35] See Brent Berlin and Paul Kay, *Basic Color Terms: Their University and Evolution*, (Berkeley and Los Angeles: University of California Press, 1969).

[36] See Benjamin Lee Whorf, *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf*, (London, 2015).

linguistic material. The discriminability of colours and colour areas, for instance, is significantly affected by language, as was shown in a comparison of Europeans (with a linguistic distinction between blue and green) with the people of the Berinmo from New Guinea (with a uniform colour name for both colour areas)[37]. When regarded from a historical perspective, linguistic factors also influence the development of visual culture, which, on the other side, is determined by images, rituals, patterns, substances, clothing, materials as well as light and geological conditions.

Colour and culture

The importance of colour in India and Japan may serve as an example that illustrates the potential complexity of such relations. Every traveller who has been to Asia has experienced the intensity of the colour environments in the various Asian cultures. India's excessive variegation, for example, has already become an advertising cliché of the tourism industry. The colourfulness of this culturally and socially extremely heterogeneous subcontinent can equally be understood in a proverbial or literal way. The ubiquitous, complex language of colour is hard to decipher for the uninitiated since it is based on millennia-old traditions and religious rituals. In India, colour is used as a distinct language system, and nobody doubts its relevance. Colour not only shapes poetry, painting and sculptural art; due to its importance in society, it also defines today's ritual practice, the differentiated clothing practice and, last but not least, the Indian cinema culture. Colour signals serve as a medium of social and political identity; thereby they create distance between social groups and sometimes complicate the communication within a post-colonial culture, which is still defined by the caste system. It can be observed that the symbolic order of colours has partly stayed the same over the centuries, whereas other parts have changed continuously in relation to social and cultural conditions. Especially in times of historical changes, colour played a prominent part in Indian society. The kings of premodern times, for example, referred to their power as *citra,* which means excellence.

[37] See Jules Davidoff, Ian Davies, and Debi Roberson, 'Colour Categories in a Stone-Age Tribe,' *Nature* 398, no. 6724, (1999): 203-204.

The term *citra* is a Sanskrit term and signifies 'colourful iridescence'. So, power was equated with the visual wealth of a prism. The king was perceived as radiant and golden, just like the sun and the gods. At that time, the kings had to undergo the *abhiseka*-ritual that includes the application of liquid colours. Today the practice of baptising statues of gods with colour is still called *abhiseka*[38]. The ritual offshoot of this colour baptism, which is practised as part of the Holi-festival in spring, is now celebrated all over the world and has been integrated into secular party culture. This can be regarded as an immediate effect of globalisation.

In the world and especially in Asia, the cultural complexity of colour use in the present time is based on various factors such as texts, religious practices, social order, etc. In Japan, the traditional colours have to be traced back to the old Japanese hierarchy of the *Ritsuryô*-system (*kan'i junkai*). It had been established by Shôtoku Taishi (574–622) in the year 603, and it was based on Chinese models. This colour language continues to have an effect up to the present day. In the *Ritsuryô*-system, social rank and hierarchy were indicated by specific colours (*kinjiki*, forbidden colours) that were reserved for the court nobility. The lower classes were only allowed to use 'admissible colours' (*yurushiiro*). Most traditional colour names in Japan trace back to names of plants and animals that represented the respective colours. There is a close connection to traditional dyeing techniques. The colour spectrum could only be expanded in the modern age when synthetic colours became available. During the reign of Shôtoku Taishi, Buddhism, which had come to Japan in the sixth century, was finally established. The Buddhist pantheon in Japan – especially the pantheon of esoteric Buddhism of the ninth century – is characterised by a complex colour symbolism, which also had a significant influence on ritual practice. During this time an amalgamation of local rites (*Shintô*) and Buddhist practices took place, which contributed to the emergence of new structures and practices in folk religion. The colour symbolism of these elements still defines life in Japan today. The Daruma figurine (Bodhidharma is a Buddhist saint in Zen Buddhism

[38] Dr. Elena Mucciarelli, a scholar of Indian studies, has suggested this text passage.

serves as an example for this: With its striking red colour, it is one of the most popular lucky charms in Japan and can be found in many areas of everyday life[39]. The painted eyes of candidates in political elections are considered to be a good subject for popular and distinctive images in the media[40].

When reflecting upon the diverse societal, social and psychological functions of colours – such as their application in colour coding in traffic or science (e.g. in the MRI or other imaging techniques) – it becomes apparent how often we must rely on the coding system of colours in crucial recognitional contexts. Depending on the culture, colours are used differently on a semiotic and symbolic level. This has consequences for both the global economy as well as for internet communication, which expands boundlessly. It becomes clear just how far-reaching the effect of colours is when one considers the changes that have taken place in the work environment induced by digital media. Today, most people – especially in industrialised countries – work with computers and they are confronted with user interfaces, which are supposed to be handled intuitively through the application of coloured icons. A distinct and internationally comprehensible colour coding helps to facilitate orientation, mainly because our perception system is optimised for this form of visual communication. Furthermore, an increasing amount of educational institutions utilise e-learning programs, which must be designed in a way that promotes the users' learning processes.

The background of the global use of colours as well as cultural colour preferences determine the effects of colours in the communication of knowledge. However, the colour preferences of different cultures sometimes also include structures of prejudice, especially in the assessment of skin colour or gender representations. The symbolic connections between gender and colour or age and colour vary in all cultures. The influence of colour on consumer behaviour is subject to ethical issues since most customers are not aware of the unconscious mechanisms of action.

[39] About the colour red, see http://rot-webdoku.de (accessed 27 August 2018).

[40] In collaboration with Prof. Dr. Robert Horres, a scholar of Japanese Studies from the University of Tuebingen, this area of research is being further investigated.

Despite all global research activities, there are still significant gaps in the interdisciplinary and interculturally oriented colour research. One reason for this might be a chromophobic discourse which has been maintained in intellectual circles and which sometimes overlaps with traditional gender discourses. Femininity has always been associated with colour, feeling, imagination and irrationality, while masculinity has always been associated with form, reason, logic and rationality[41]. These arbitrary assignments have given rise to the idea that colour is something marginal, pure décor; this ignores the fact that the relevance of colours for our perception, orientation and ultimately our well-being is evident and has been proven many times.

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[41] See David Batchelor, *Chromophobie: Angst vor der Farbe*, (Vienna, 2002).

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