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Golden perception: Simulating perceptual habits of the past

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Abstract. Medieval times were neither dark nor grey; natural light illuminated colourful scenes depicted in paintings through coloured windows and via artificial beeswax candlelight. When we enter, for example, a church to inspect its historic treasures ranging from mosaics to depictions of saints, we do this under quite unfavourable conditions; particularly as we mainly depend on artificial halogen, LED or fluorescent light for illuminating the desired object. As these light spectrums are different from the natural light conditions under which the old masterpieces were previously developed and perceived, the perceptual effects may dramatically differ, leading to significantly altered affective and cognitive processing. Different qualities of processing might particularly be triggered when perceiving artworks which deal with specific material prone to strong interaction with idiosyncratic light conditions, for instance gold-leafed surfaces that literally start to glow when lit by candles. We tested the perceptual experiences of a figurative piece of art which we created in 3 (foreground) by 3 (background) versions, illuminated under three different light conditions (daylight, coloured light and beeswax candlelight). Results demonstrated very different perceptual experiences with stunning effects for the interaction of the specific painting depicted on a gold-leafed background lit by candlelight.

Keywords: empirical aesthetics, art appreciation, gold, light, medieval times, ecological valid testing, preference, understanding, visual effect, Aesthetic Aha.

1 Introduction

There are medieval paintings, arisen in the 10th and 11th centuries, which show no cast shadows and no chiaroscuro modelling (Figure 1a). Around the year 1300, the painters again started to use chiaroscuro, a technique allowing shadows to be cast gradually, which had already been known by antique painters (Sedlmayr, 1959). The chiaroscuro creates an impressive spatial effect by illustrating the light, which illuminates the scene of a painting (Livingstone, 2002). Objects or persons have darker and brighter areas depending on the angle of incident light, and they cast shadows. The light source (a) can be shown within the painting; for example a candle (Figure 1b), torch or even the sun or the moon or (b) can also be located outside of the painting rendering it unnecessary to paint the direct light source itself but rather the effects of the emitted light.

The thought that medieval painters simply did not know how to paint in chiaroscuro technique would be wrong as chiaroscuro was not unknown during the Middle ages. Instead, we have to ask: Why had they decided to use another technique? The art historian Wolfgang Schöne (see Schöne, 1954) not only observed—as other art historians had already done—that in some periods of medieval times, particularly in Ottonian book illustrations (10th and 11th centuries; cf. Figure 1a), there are no cast shadows and no chiaroscuro but the paintings are "light themselves"; they glow from within their depths. He also observed that the figures inside the paintings seem to step out of them in direction of the observer, especially if the painting has a golden background. Golden backgrounds are used only in illuminations, mosaics or paintings on table, in frescos other colours for instance lapis lazuli blue had been applied. One remarkable example is the fresco cycle of the St. Francis legend in the church St. Francesco in Assisi, painted around the year 1300 and thus somewhat later than the Ottonian era (Schöne, 1954). Fortunately, this church is still equipped with the original coloured glass windows, and so we are faced with an original perception condition. Schöne even proposed that it should be mandatory for medieval paintings, frescos or book illustrations to be observed under

Figure 1. (a) Example for an Ottonian book illustration, 10th century; (b) example for chiaroscuro, 17th century. Sources: (a) Bayerische Staatsbibliothek München, Clm 4452 f. 8v, (b) "Christ before the High Priest" by Gerrit von Honthorst (depiction is public domain; original is located at the National Gallery London).

medieval light conditions in order to fully understand the artworks. Importantly, due to the glass used and the positioning of light sources, the illumination of closed rooms in medieval times was either from artificial light emerging from candles or dimmed light filtered by the coloured glass windows through which daylight was entering. In few cases, for instance scriptoriums, also open fireplaces, torches or oil lamps illuminated the beholder's place. These light conditions, and thus, the corresponding wavelengths, typically encountered in these times when perceiving the artworks/books/etc. were also the light conditions the painters typically encountered during their production process. The colourless glass, plus the type of artificial light which we can see in most churches and museums today, dramatically changes the viewing conditions as already noted by a deep analysis of the eyetracking pattern of Duccio's "The Annunciation" (Leonards et al., 2007). For our present paper, the most obvious point is that modern light in particular does not let such paintings "glow"; instead, the depicted scenes appear flat and devoid of any spatial effect.

Schöne explained the fact that there were medieval painters who did not utilise the chiaroscuro technique with the point that the prevailing medieval religious conviction at this time was God's synonymity with light (metaphysics of light), which is based on Neo-Platonism (Schöne, 1954). The painters did not want to show a scene which is illuminated by daylight, or indeed any other light which can be observed on earth. Their intention was to present the idea or the nature of divine light, particularly as the depicted scenes originated from the Holy Bible. That is why Schöne calls the light of medieval paintings not only "self-illuminating light" (Eigenlicht) but even "revelation light" (Offenbarungslicht) (Schöne, 1954, p. 55). Consequently, anything which is light itself cannot cast a shadow or have darker and brighter areas; thus, anybody who entered a church or opened a book in medieval times saw scenes of the Holy Bible filled with light.

To impose the sensation of paintings suffused with light—actually "being light"—medieval artists, instead of painting holy scenes in a naturalistic style, rather used a special *Formensprache* (i.e. design vocabulary or form language, see Carbon, 2010) signifying specific religious aims. This particular style can be found in shape and form aspects as well as colour and light properties. Regarding shape and form, angels were, for instance, depicted with artificially long arms and fingers just to emphasise their gestures. Concerning colour and light properties, the artists had to achieve the perception

of the colour being used more as a free colour and not so much as a surface colour, which would always be associated with a specific object. A free colour, for example, would be the *blue* of the sky; whereas an example of a surface colour is the *red* of a tomato. According to Schöne (1954), a surface colour is always illuminated, whereas a free colour is always self-luminous. The art historian Hans Jantzen explained the difference between both concepts by using the terms "*Eigenwert*" (probably best to be translated as "eigen value" or "own value") and "*Darstellungswert*" ("presentation value") of the colour. He revealed that in Ottonian book illustrations the *Eigenwert* of colour is high, whereas the *Darstellungswert* of colour is low (Jantzen, 1963, p. 104). By the mere inspection of Ottonian book illustrations it is obvious that the artists used low naturalistic colours which have hardly any descriptive function. The medieval painters also refrained from painting any material structure. There is no discernible difference between the wood surface of a painted object or a tissue. The surface of the colours is smoothly worked-out (Sedlmayr, 1959, p. 42). All these techniques together assist in the perception of the colours as free colours and not as surface colours. Most evidently, this can be seen in the backgrounds, where one is able to find large areas of colours, and sometimes only one colour (this is often gold), but no objects at all. Further enhancement of the impression of light is realised through brightening the colours by adding white pigments.

Although Ottonian book illustrations lack any chiaroscuro modelling, alternative modelling can be found in terms of lines in white or other colours. Schöne (1954) calls this modelling "Modellierungs helle" (brightness of modelling) and Sedlmayr (1959) describes it as "modelling without shadows" and "darkness-free modelling." These kinds of typical medieval modelling produce spatiality—without them the figures would seem totally flat, i.e. two-dimensional.

Although Schöne's hypotheses are appealing, logical and consistent, experimental proof of them is still missing. Testing his hypotheses in an experimental way is quite challenging due to some negative contextual factors: (1) It is quite challenging to simulate original medieval light conditions, and (2) the preservation condition of most medieval works is quite poor. Sometimes, we still find remarkably well-preserved Ottonian book illustrations such as the "Bamberger Apokalypse" (Bamberge Apocalypse) or the "Perikopenbuch Heinrich II" (both from approx. 1000 AD), but the books are too precious for use in typical tests—furthermore, it is hard to find adequate control material. Consequently, we produced our own experimentally varied stimuli and showed them under systematically varying light conditions.

2 Experiment

In the following, we simulated three painting techniques differing in the amount of modelling used—(a) medieval modelling, (b) naturalistic modelling and (c) without any modelling—and combined them with three specific light conditions—(a) typical candlelight when objects were illuminated by artificial light in medieval times, (b) typical coloured light when objects were lit by natural light through coloured windows, e.g. in cathedrals, and (c) light simulated by modern technology as daylight. The main aim of the experiment was to assess the perceptual impact induced by inspecting the specific combinations of our experimental factors of painting techniques and lighting conditions.

2.1 Method

2.1.1 Participants

Ten participants (five female and five male; mean age: 25.9 years, range: 22–30 years) from the University of Bamberg volunteered in the study. They were naïve to the purpose of the experiment and had normal or corrected-to-normal vision as assessed by the Snellen eye-chart test. All participants had normal colour vision as demonstrated by a short version of the Ishihara colour test. None of the participants had any special training in history subjects in general or art history in particular.

2.1.2 Stimuli and apparatus

The stimuli consisted of nine figurative paintings, painted by an artist (P.D., the second author) specifically for the sake of the experiment; always based on the same scene depicting a seagull on a mono-coloured background. The pictures (size: W × H = 14.8 × 16.8 cm) were presented in a black passé-partout, size: 34.7 × 37.0 cm standing on a bookrest on a table with a height of 72.0 cm. We followed a 3 [*background*] by 3 [*modelling*] experimental design yielding nine paintings (see stimulus-based variables in Table 1). The used colours have been made by the artist from mineral and organic pigments and the binder from Gummi Arabicum (also known as Gum Arabic). Manufactur-

Table 1. Description of stimulus-based variables *background* and *modelling*.

Background	Gold	Brown	Yellow
	Leaf gold (23 carat)	Dark red brown Moroccan ochre	Wild saffron
Modelling	Medieval	Naturalistic	Without
General description	A gull not illuminated by a light source, with modelling consisting of lines	A gull which is illuminated by a light source (located outside of the painting) and therefore has brighter and darker areas and casts a shadow	A gull which is not illuminated by a light source, painted without any modelling or contour
Wings	Titan white, red Moroccan ochre, lapis lazuli	Titan white, red Moroccan ochre, lapis lazuli, black lamp pigment	Titan white, red Moroccan ochre, lapis lazuli
Body	Burnt umber, yellow Moroccan ochre, titan white	Black lamp pigment, burnt umber, yellow Moroccan ochre, titan white	Burnt umber, yellow Moroccan ochre, titan white
Contour	Black lamp pigment	None	None
Cast shadow	None	Black lamp pigment	None

ers of the pigments were Kremer Pigmente GmbH & Co.KG (D-88317 Aichstetten, Germany) and J. J. Gerstendörfer GmbH & Co.KG (D-91104 Schwabach, Germany). Further details can be retrieved from the second author.

In order to avoid any religious associations we have chosen a gull instead of an angel, for instance, as motif. Regarding the background colours, we decided to use a yellow background because it is a shining colour, the colour which is most similar to gold (e.g., in the heraldic tradition gold is often substituted by yellow). The dark brown colour was used in order to investigate the effect of a dark colour in opposite to the shining backgrounds yellow and gold. So we could test whether the effect, if it could be seen by the participants, depends on the golden background or whether it could also be observed on a colour background which is very shiny and on colour background which is the opposite, namely dark.

Figure 2 gives an example of three of the nine paintings of a gull with different types of modelling and different background colours.

All combinations of the stimulus-based variables were further crossed with the variable *light* subsuming the levels *candlelight, coloured light,* and *daylight* (Table 2). For an illustration of the latter two light sources, see Figure 3.

2.1.3 Procedure

The whole experiment consisted of two phases lasting approx. 2 up to 3.5 hrs in total, depending on the participant's pace. At no point was there any time pressure on the participants, who inspected one picture after another.

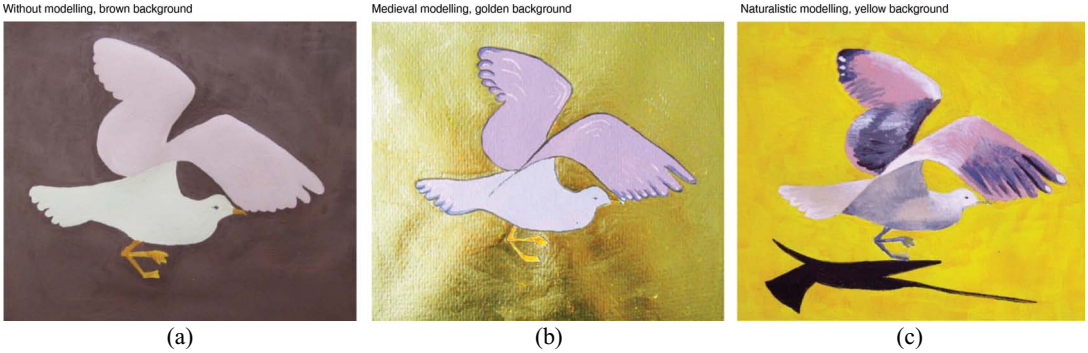


Figure 2. Illustration of three out of 3 [background] × 3 [modelling] = 9 versions: (a) without modelling and brown background, (b) medieval modelling and golden background, (c) naturalistic modelling and yellow background.

Table 2. Light sources used (variable *light*).

Light source	Description of setting
Candlelight	Two beeswax candles, diameter 6 cm (manufacturer: Company Diller), which were placed on the left and right side of the picture, to simulate the primary artificial light source of the medieval era (see Figure 3b)
Coloured light	Translucent paper of the colours green, yellow, red and blue in front of two bins with a neon lamp inside, to simulate the incidence of light from medieval windows of churches or scriptoria. The bins were standing on the left and right side of the table, on which the participants were seated, and in front of them were the presented pictures (see Figure 3a)
Daylight	Simulated with daylight lamps on the ceiling

Phase 1: "Free inspection". Participants freely inspected an initial painting (*background*: gold; *modelling*: medieval) under all three light conditions in the following order: firstly daylight, then coloured light and lastly candlelight. The participants were allowed to move and pick up the painting. They were asked to verbalise their impressions and changes of impressions from one light condition to another.

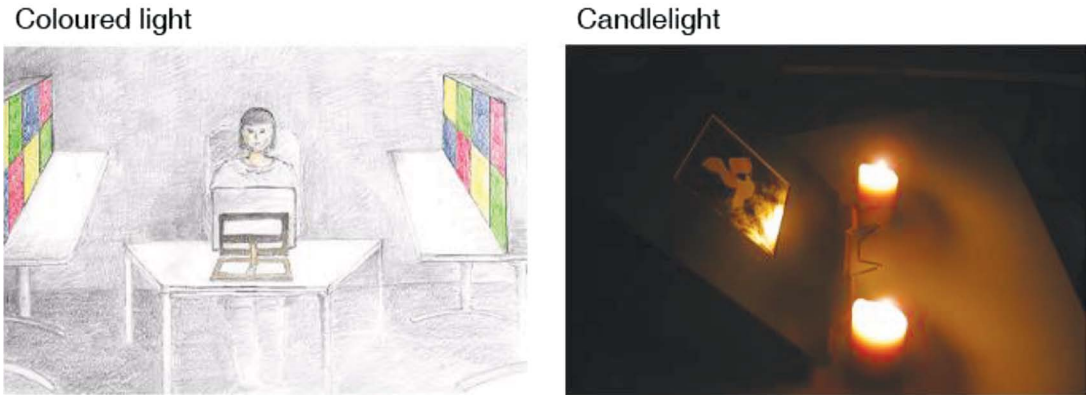
Phase 2: "Guided inspection". Participants inspected all materials under all light conditions in a random order; the light conditions changed every three trials, with repetition of the order of light conditions after $3 \times 3 = 9$ stimuli; the order of light conditions was randomised across participants. The participants were asked to answer a 50-item questionnaire for each picture, addressing questions on the impression of the foreground object (the gull), on the relationship between the foreground and the background, the clearness of the depicted object and finally on the holistic impression of the painting as such. This was done with seven-point rating scales (1 = not at all, 7 = very strong or 1 = very poor, 7 = very good, dependent on the type of question). The questionnaire addressed key variables regarding the testing of the impression triggered by the specific combination of colour and material conditions explained above. The variables referred to four categories in which we were mainly interested; i.e. *Object* ($N = 16$; e.g., "To what extent does the gull glow against myself"), *Multilayer* ($N = 17$; e.g., "How much is the gull located on a different layer than the background?"), *Clearness* ($N = 3$; e.g., "How clear can the gull be seen?"), and *Overall* ($N = 14$; e.g., "How mystical is the general impression of the painting?"). Note that these categories were pre-experimentally defined and were not further validated as latent factors or the like.

2.2 Results and discussion

The obtained data were analysed in a two-stepped fashion starting with the analysis of the quantitative data from the rating scales of Phase 2 via general linear models, and then with the examination of the qualitative data of that phase by content of the participants' verbal descriptions.

2.2.1 Analyses of the quantitative data (rating scales)

To assess the perceptual impact of gold-leafed surfaces in combination with, e.g., typical beeswax candlelight or coloured light, which was typically used in cathedrals to light paintings of Saints, we will focus with regard to quantitative data on the analysis of the following variables which we assigned to



(a) (b)

Figure 3. Illustration of experimental light settings: (a) coloured light and (b) candlelight.

Table 3. Focused rating scales split by the four dimensions (in parentheses you can find the number of associated variables for these dimensions) testing the impression of specific combinations of experimental factors. Parentheses in the variable fields give the direction of the variable towards the appropriate dimension, with "+" indicating a positive and "-" a negative relationship.

Dimension			
Glowing (n = 3)	*Multilayer (n = 3)*	*Visibility (n = 3)*	*Supernatural (n = 1)*
Colour of gull is glowing (+)	Gull lifts from the background (+)	Contrast of gull is high (+)	Overall impression is mystical (+)
Gull shines against me (+)	Unity of gull and background (-)	Gull appears to be clearly an object (+)	n.a.
Gull is full of light (+)	Gull seems to hover above the background (+)	Visibility of the gull is high (+)	n.a.

four main dimensions (Table 3): (1) *Glowing* indicates a specific quality of the object which seems to glow, (2) *Multilayer* indicates more than one pictorial layer of the painting, (3) *Visibility* indicates how well the object can be recognised and (4) *Supernatural* indicates the overall impression of something depicted which could be described as being mystical, supernatural, otherworldly.

For all four dimensions, we conducted separate three-way (multivariate) mixed-design analyses of variance ((M)ANOVAs) with *background* (*gold*, *brown*, *yellow*), *light* (*candlelight*, *coloured*, *daylight*) and *modelling* (*medieval*, *naturalistic*, *without*) as independent variables. Note: Before the variable "Unity of gull and background" (dimension *Multilayer*) was fed into the regarding MANOVA, we reversed its scale direction to make it concordant with the remaining variables (cf. information on the direction of variables in parentheses of Table 3).

As we were mainly interested in the interaction of the different manipulations operationalised by the factors *background, light* and *modelling*, we will refer only to the interactive effects of these factors; results of the significant effects on the basis of the fully saturated models can be retrieved from Table 4.

As can be seen in Table 4, the interaction between *background* and *light* was significant for all four dimensions, whereas *background* × *modelling* failed significance for the dimension *Glowing* and the remaining interactions were only significant for *Visibility.* Figure 4 shows for two exemplary variables how strong the visual effect of the specific assembly of gold-leafed surface and light from beeswax candles truly is: the gull was particularly "full of light" when the candlelight illuminated the bird accomplished in gold-leafed technique, and specifically for this combination we also revealed the optimum of an overall mystical impression of the scene.

Besides effects of *background* and *light*, Figure 5 also documents interactive effects with *modelling*: especially when *gold* was used within *medieval* modelling, participants were able to perceive different layers in the painting, i.e. the gull was perceived as an entity of its own, being independent from the background.

Table 4. Significant effects shown as effect sizes (η_p^2) revealed by the (M)ANOVAs based on rating scaling variables; all empty cells indicate non-significant results.

	Dimension			
Effect	*Glowing*	*Multilayer*	*Visibility*	*Supernatural*
Background	0.504	0.578	0.603	0.787
Light	0.431	0.315		0.371
Modelling			0.377	
Background × light	0.212	0.264	0.316	0.319
Background × modelling		0.207	0.235	0.248
Light × modelling			0.205	
Background × light × modelling			0.154	

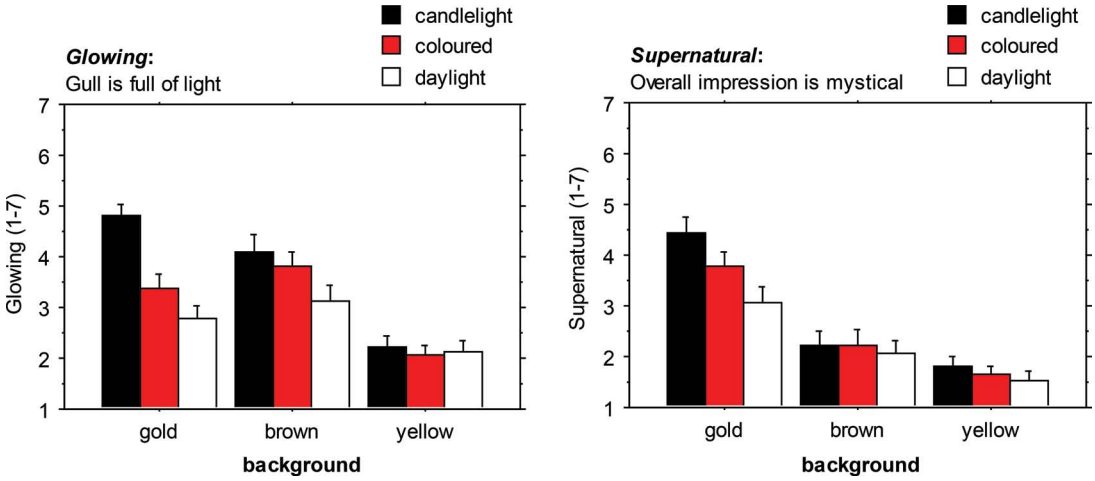


Figure 4. Results illustrating interactions of *background* × *light* for the dimension *Glowing* (left) and *Supernatural* (right). Error bars indicate ±1 standard error of the mean (SEM).

2.2.2 Analyses of the qualitative data (verbal descriptions)

Participants' qualitative reports comprised verbal descriptions in note form. On average, they used 23.4 (SD = 14.5), 25.7 (SD = 11.3) and 28.4 (SD = 11.2) words for describing the light conditions *candlelight, coloured* and *daylight*, respectively. Repeatedly, participants reported "specific strong contrast" for the *candlelight* condition. The *candlelight* condition was further appreciated as having more "harmony" and presenting a clearer view on the composition, while the golden nature was no longer perceived as gold but more or less as a dark substance letting the major scene glow. Meanwhile, the painting inspected under daylight was very often qualified as "unrealistic," "unnatural," "unclear" and "flat." This overall pattern of results is quite compatible with the aforementioned analyses based on rating scales.

3 General discussion

The present paper aimed to analyse typical painting techniques used in medieval times under different light conditions. We contrasted artificial daylight to (a) coloured light typically encountered in cathedrals with original coloured windows and (b) beeswax candlelight. We inspected particularly strong changes in the perception of artworks which were specifically prepared for this study when we used a gold-leafed background. In a phase where participants verbally described their visual experiences as well as in a phase where they responded to rating scales, we observed very different perceptions

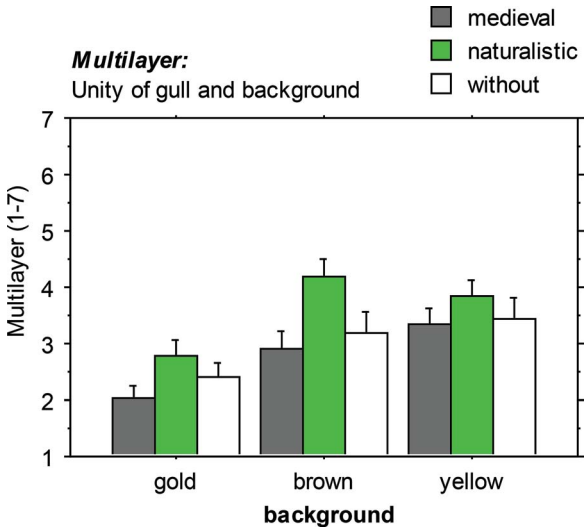


Figure 5. Results illustrating the interaction of *background* × *modelling* for the dimension *Multilayer*. Error bars indicate ±1 standard error of the mean (SEM).

of the same scene when the light quality was changed. In line with earlier research conducted by Leonards et al. (2007), beeswax candlelight was shown to change the perception of artworks. This effect was not only a minor, quantitative one in the sense of merely better contrasts—perceiving little more details or seeing the scene in a slightly different colour spectrum—but as was already assumed by Schöne (1954), the way under which an artwork from medieval times is illuminated changes the whole meaning and understanding of the inspected work. In extreme cases, the artwork will not be properly understood when the light condition differs substantially from the original setting under which it was created—it might also lead to a failure to experience "Aesthetic Aha!" (Muth & Carbon, 2013) followed by insufficient interest in the artwork and its elaboration.

Specifically when parts of artworks are gold leafed, it seems impossible to abstract from unfavourable and artificial light conditions. Nowadays, we can inspect a large number of medieval masterpieces in museum contexts, arranged in unnatural settings and illuminated by specific light conditions which are in accord with preservation issues or simply due to economic considerations. This might turn out fatal when attempting to decipher and understand such artworks. The misleading idea of bright and spotted lights might be that any kind of such hard and bright light will uncover hidden messages and deeper meanings, although in fact the specific faint light of a simple beeswax candle is the real catalyst for revealing such messages. Due to the candle's nature of selectively lightening and dimming a complex pattern of locations, such lighting conditions help us to understand what the medieval masters perceived on their own and what they wanted to express by their delicate works of art.

3.1 Epilogue

Certainly, we cannot simulate the perception of medieval times by use of light and surface conditions alone, but the present experiment demonstrates that we can simulate at least parts of the perceptual conditions which people in those times were faced with. This is one further step towards understanding the visual habits of the past, and thus a key to understanding human cognition (and subsequent action) of earlier times as well as different cultures. Further studies could try to activate specific perceptual schemata by providing participants with more information on the meaning of symbols, painting techniques and the artists' aims or by animating participants to really contemplate on the pieces of arts. Other experimental ideas might deal with the contextual presentation conditions of such artworks: nowadays, many of these precious works are literally displaced in nicely lit vitrines to be found in museums where different pieces are collected and grouped according to categories or taxonomies. This means that the presentation conditions are maximally different from the objects' original embedment centuries ago. If we make joint efforts to bring experts from different research and practice approaches together, inter alia art historians, artists, stonecutters, light engineers, restoration scientists, semioticians, historians and perceptual scientists, we will be able to start a fascinating journey to the "perceptual past."

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