Research report

Perception, memory and aesthetics of indeterminate art

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Abstract

Indeterminate art, in which familiar objects are only suggestive, invokes a perceptual conundrum as apparently detailed and vivid images resist identification. We hypothesized that compared with paintings that depict meaningful content, object recognition in indeterminate images would be delayed, and tested whether aesthetic affect depends on meaningful content. Subjects performed object recognition and judgment of aesthetic affect tasks. Response latencies were significantly longer for indeterminate images and subjects perceived recognizable objects in 24% of these paintings. Although the aesthetic affect rating of all paintings was similar, judgement latencies for the indeterminate paintings were significantly longer. A surprise memory test revealed that more representational than indeterminate paintings were remembered and that affective strength increased the probability of subsequent recall. Our results suggest that perception and memory of art depend on semantic aspects, whereas, aesthetic affect depends on formal visual features. The longer latencies associated with indeterminate paintings reflect the underlying cognitive processes that mediate object resolution. Indeterminate art works therefore comprise a rich set of stimuli with which the neural correlates of visual perception can be investigated.
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1. Introduction

Visual indeterminacy occurs when subjects view apparently detailed and vivid images that resist object recognition. Indeterminate art compositions (Fig. 1 and Supplementary figures http://www.robertpepperell.com/Stimuli/Stimuli.html) invoke an unusual state of awareness in which the formal aspects of perception (color, form, motion) become dissociated from the semantic aspects (association, meaning, memory). In contrast with our habitual mode of seeing, in which visual sensation is accompanied by immediate recognition, the indeterminacy effect presents viewers with a perceptual conundrum, namely an apparently meaningful yet persistently meaningless scene, which they struggle to resolve. Robert Pepperell's paintings and drawings are designed to induce a disrupted perceptual condition in which what we see cannot be matched with what we know. Instead of a recognizable depiction, the viewer is presented with a 'potential image' [5], that is, a complex multiplicity of possible images, none of which ever finally resolves. In contrast with traditional abstract compositions, which do not depict natural objects, but rather use purely visual forms of line, color and shape to evoke emotional and aesthetic responses, Pepperell's indeterminate paintings strongly imply natural forms, while at the same time resisting easy or immediate identification. The indeterminacy effect is achieved by suggestively rendering forms, such as bodies, buildings and mountains, from which visual cues that might lead to clearly recognizable entities are omitted [18]. Thus, consistent with Gamboni's definition of indeterminate art, Robert Pepperell's images are neither representational (e.g., a realistic portrait) nor abstract (e.g., a late composition by Mark Rothko). Instead, these images are partially representational, namely they are highly suggestive of forms but not explicitly descriptive of them [5,7].

Object recognition is a highly developed visual skill in primates. Behavioral and electrophysiological studies in humans and monkeys have suggested that object recognition is a rapid process that can be achieved within a few hundred milliseconds [4,26,30]. Moreover, it has been shown that identification of objects within natural scenes is facilitated when the context is meaningful [1,2]. The aim of this study was to investigate the

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Fig. 1. Examples of art paintings used in Experiment 1. (Left) Detail from The Sistine Chapel by Michelangelo. Only one subject rated this painting as very affective. (Right) Succulus by Robert Pepperell. This indeterminate image was rated by 20% of the subjects as containing familiar objects and by 18% of the subjects as a very affective painting.

extent to which viewers perceive recognizable objects in indeterminate art works. We hypothesized that subjects would rapidly recognize familiar objects depicted in representational paintings, but would be slower to detect the presence of recognizable objects in indeterminate paintings. The second aim of the study was to test to what extent judgment of aesthetic affect depends on the recognition of familiar content in paintings. Finally, we tested the extent to which incidental memory of art compositions is influenced by their content or aesthetic affect.

Our results suggest that although the aesthetic impression of all paintings is independent of their content, indeterminate art is perceived and remembered differently than representational paintings.

2. Experimental procedures

2.1. Experiment 1: object recognition and judgment of aesthetic affect

2.1.1. Subjects

Twenty-six right-handed subjects (13 females, mean age 29 years) with normal vision participated in the study. The subjects, students from the Neuroscience Center at the University of Zurich, had no formal art education and reported visiting art museums once a year or less. All subjects signed an informed consent form and received payment for participating in the experiment. After participating in Experiment 1, all subjects filled detailed questionnaires and none of them reported recognizing any of the paintings presented during the experiment.

2.1.2. Stimuli

Sixty representational paintings by various artists (VA) and 60 indeterminate paintings by Robert Pepperell (RP) were used. The VA paintings were selected based on their similarity in compositional structure, tonal range, and color palette to the RP paintings, albeit with recognizable objects (Fig. 1). Additional examples are posted on: http://www.robertpepperell.com/Stimuli/Stimuli.html. Each set included 30 color and 30 monochrome paintings, which subtended visual angles of 9° horizontally and 9° vertically. The paintings were displayed on a black background using Presentation (www.neurobs.com, version 9.13).

2.1.3. Tasks

Subjects performed an object recognition task followed by a judgment of aesthetic affect task. Each painting was presented for 4 s and subjects were

instructed to quickly respond, while the painting was still on the screen, indicating whether the image contained any familiar objects by pressing one of two buttons (1 = yes; 2 = no). The painting then disappeared and subjects had to answer the question "how strongly did this painting affect you?" by pressing one of four buttons (1 = not at all; 2 = a little; 3 = a fair amount; 4 = very). We chose this scale because art appreciation is not necessarily associated with beauty and can also have a negative affect [23]. Color and gray paintings from both sets (VA and RP) were presented in random order.

2.2. Experiment 2: recognition memory

Fourteen subjects (7 females) returned 8 days after participating in Experiment 1 for a surprise memory test. The original 120 paintings from Experiment 1 were randomly mixed with 120 new paintings (60 VA and 60 RP). Each painting was presented for 3 s and subjects pressed one of two buttons to answer the question "have you seen this painting before?" (1 = yes; 2 = no).

2.2.1. Data analysis

The effect of artist (VA versus RP), image type (color versus gray) and memory performance (hits, correct rejections, misses and false alarms) were analyzed using repeated measures ANOVAs. Where appropriate, Greenhouse–Geisser corrections were used and the adjusted degree of freedom reported.

3. Results

3.1. Experiment 1: object recognition and aesthetic judgment

To test the extent to which recognizable objects are perceived in indeterminate paintings, subjects performed an object recognition task (Fig. 2). As expected, subjects recognized familiar objects in virtually all-representational paintings by various artists (VA). Surprisingly, they also reported seeing familiar objects in 24% of the indeterminate paintings (RP). Subjects were more likely to recognize objects in VA paintings than in RP paintings ($F_{(1,25)} = 340$, $p < 0.001$), a highly significant difference that reflects the selection of the paintings used in this experiment. Interestingly, subjects were more likely to recognize objects in color indeterminate paintings (26%) than in gray indeterminate images (21%, $F_{(1,25)} = 14.2$, $p < 0.001$). This
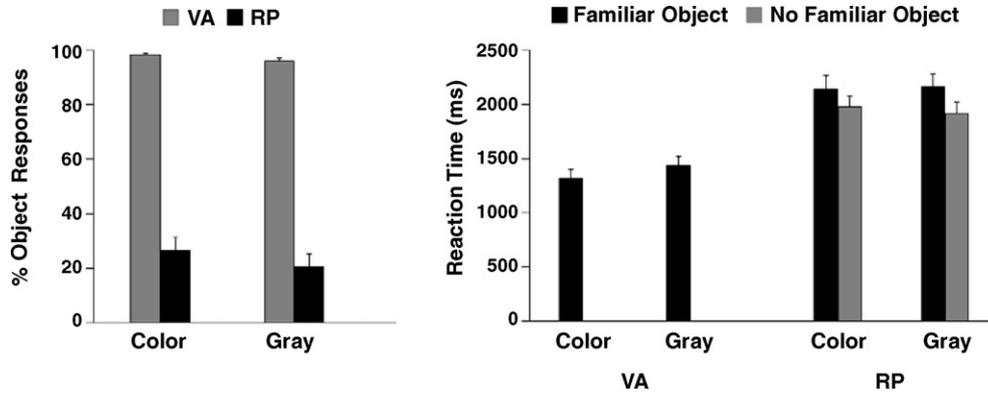
Fig. 2. Object recognition task. Mean percent of paintings with recognized objects (left) and response latencies (right) as a function of artist (VA vs. RP) and color. In this and subsequent graphs, error bars indicate standard errors of the mean.
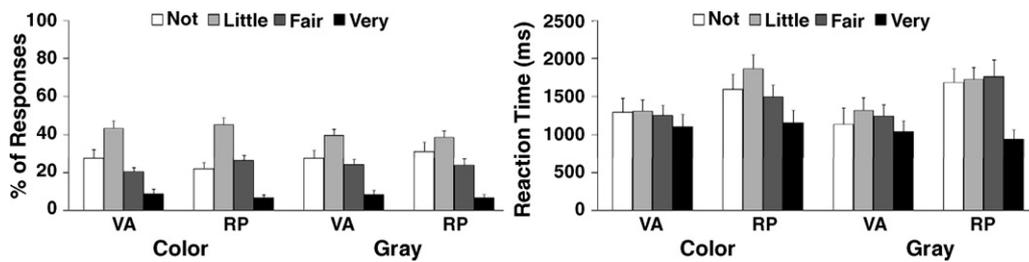

Fig. 3. Judgment of aesthetic affect task. Percentage of affective ratings (left) and response latencies (right) as a function of artist and color.

effect was significant for both representational (mean difference = 2.4%; $T_{(25)} = 2.42$, $p < 0.023$) and indeterminate (mean difference = 5.6%; $T_{(25)} = 2.788$, $p < 0.010$) paintings. In terms of response latencies, there was no apparent effect of color or an interaction between artist and color. Nevertheless, the time taken to detect objects in RP paintings (2140 ms) was significantly longer than the time taken to detect objects in VA paintings (1400 ms; $F_{(1,21)} = 108$, $p < 0.001$). Finally, there was no significant effect of response type ("Yes, I recognize familiar objects" versus "No, I don't recognize any familiar objects") on reaction times for the RP paintings.

To compare the aesthetic affect judgment of determinate and indeterminate paintings, subjects were asked to rate how strongly each painting affected them (Fig. 3). Interestingly, regardless of the artist (VA versus RP) or image type (color versus gray), all subjects similarly rated the affect of all paintings and the differences between artists, color or their interaction were not statistically significant. Despite this similarity in affect ratings, we found differential response latencies: it took subjects longer to judge the aesthetic affect of RP (1526 ms) than VA (1233 ms; $F_{(1,17)} = 11.9$, $p < 0.003$) paintings.

To characterize the relationship between recognition and aesthetic judgment, we tested whether reaction time during the object recognition task could predict the subsequent aesthetic rating of a painting. As shown in Fig. 4, the response latencies for RP paintings varied with their affective strength, such that longer reaction times in the object recognition task were later associated with stronger affect ratings ($F_{(3,21)} = 9.6$, $p < 0.001$). Interestingly, this effect was true for all RP paintings, both those that were perceived as containing recognizable objects ("Yes"

responses) and the true indeterminate ones ("No" responses). However, longer reaction times during the object recognition task did not predict stronger affect ratings for the VA paintings.

3.2. Experiment 2: recognition memory

In Experiment 1, subjects performed a dual task, namely object recognition followed by judgment of aesthetic affect, however, they were not instructed to explicitly memorize the paintings. To test whether memory recall of paintings depends on meaningful content and aesthetic judgment, 14 of the 26 subjects returned for a surprise memory test 8 days after participating in Experiment 1. Subjects were presented with equal numbers of old and new VA and RP paintings and were asked to indicate whether they had seen each painting before (Fig. 5). Subjects correctly remembered more VA paintings (hits = 59%,
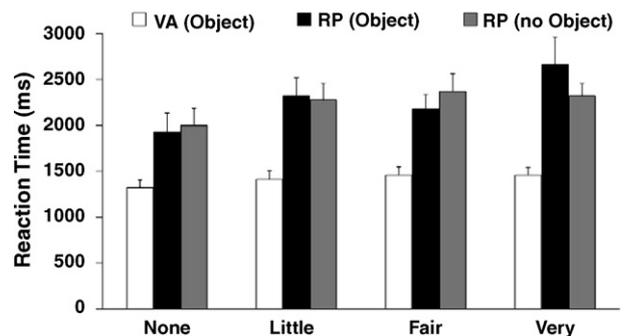

Fig. 4. Recognition and affect. Reaction time during the object recognition task as a function of the subsequent aesthetic affect rating.
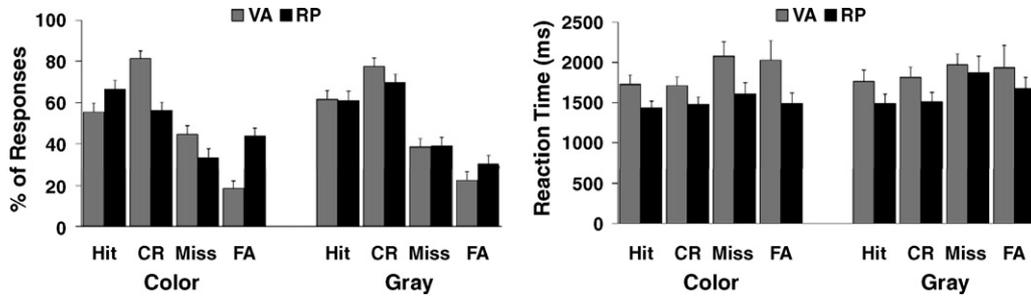
Fig. 5. Recognition memory task. Percent of responses (left) and reaction times (right) as a function of artist and color. Hits = correctly recognized old paintings; correct rejections (CR) = correctly recognized new paintings; misses = incorrectly recognized old paintings; false alarms (FA) = incorrectly recognized new paintings.

correct rejections = 79%) than RP paintings (hits = 65%, Correct Rejections = 62%) and the difference was statistically significant ($F_{(1,13)} = 12.4$, $p < 0.005$). A significant interaction between response type and artist was observed ($F_{(1,13)} = 21.3$, $p < 0.001$). Although there was no difference in the percentage of misses between representational and indeterminate paintings, we found an increase of 17% in the number of falsely recognized new RP paintings as compared with VA paintings ($p < 0.001$). Analysis of d' has also shown a main effect of artist ($F_{(1,13)} = 14.1$, $p < 0.002$): $d' \pm$ S.E. for color and gray VA paintings were 1.17 ± 0.08 and 1.15 ± 0.09, respectively, and 0.63 ± 0.09 and 0.89 ± 0.13, for color and gray RP paintings, respectively.

Overall, reaction times to RP paintings (1568 ms) were faster than reaction times to the VA paintings (1877 ms; $F_{(1,13)} = 16.8$, $p < 0.001$). We found a significant interaction between artist and color ($F_{(1,13)} = 6.5$, $p < 0.024$), with shorter response latencies for color than gray RP paintings ($p < 0.012$). Moreover, hits and correct rejections were faster than misses ($F_{(2,25)} = 4.87$, $p < 0.017$).

We then tested whether paintings that were rated as very affective in Experiment 1 were also more likely to be correctly remembered in Experiment 2. As shown in Fig. 6, the aesthetic rating of a painting indeed influenced its subsequent recall. For both VA and RP paintings, the stronger the affect rating of an image was, the more likely this painting was to be remembered.
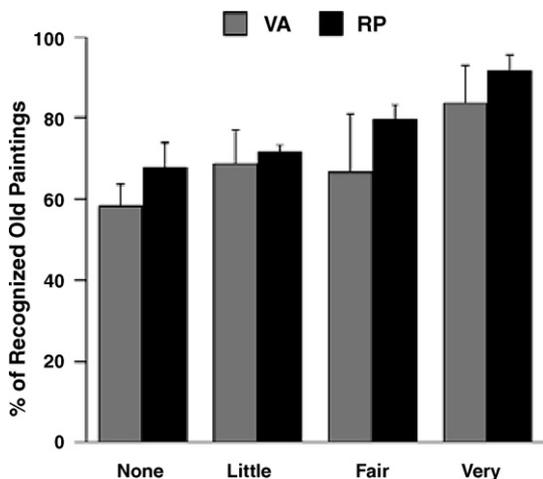

Fig. 6. Memory and affect. Influence of aesthetic affect rating during Experiment 1 on subsequent memory recall in Experiment 2.

This effect of strong aesthetic impression as a memory predictor was highly significant ($F_{(3,12)} = 9.1$, $p < 0.002$).

4. Discussion

The aim of this study was to compare visual perception and memory of determinate, representational paintings with perception and memory of indeterminate art compositions. Although the indeterminate paintings are only suggestive of familiar content, subjects perceived recognizable objects in 24% of these images. This result is perhaps not surprising, as the visual system imposes top-down interpretations on ambiguous bottom-up retinal input. In primates, the process of parsing the world into meaningful objects is mediated by activation in the ventral occipitotemporal cortex, the so called "what" pathway, which is dedicated for object recognition [9,32]. Recent functional brain imaging studies in humans have shown that object and face perception elicit activation in a distributed cortical network that encompasses a wide expanse of the visual ventral stream [10–12,20]. Our finding that viewers perceive recognizable objects in indeterminate paintings, in which such objects are only suggestive, is consistent with reports about the perception of ambiguous figures [16,19], illusory contours [17,28], binocular rivalry [31], and visual mental imagery [13], which showed activation in object-responsive regions in extrastriate cortex.

Subjects were significantly faster to perceive recognizable objects in representational paintings than in indeterminate paintings. Previous studies have shown that object recognition is a rapid process. For example, it takes humans and monkeys a few hundred milliseconds to detect an animal in a natural scene [4,26,30]. In our current study, the representational paintings were cluttered scenes that included landscapes, still life, and religious images. As subjects were not instructed to detect a specific target and were not cued as to the location of the target, the general instruction ("do you recognize any familiar objects") resulted in longer reaction times. It is of great interest that subjects were significantly slower to decide whether they saw any familiar objects in the indeterminate paintings, and that there was no difference between the "Yes" and "No" responses. This increase in response latencies suggests that subjects tried to resolve the indeterminacy, or likely performed a visual search by trying to match the ambiguous visual input with representations of familiar objects stored in memory. A recent

electrophysiological study has shown an increase in neuronal activity in V4 when monkeys learned to identify degraded visual images, suggesting that resolving indeterminate pictures is mediated by an increased amount of information communicated by neurons in this region [22]. It has been suggested that figure-ground segmentation of visual scenes depends on perceptual grouping of image elements that belong to the same object [24]. Our findings indicate that this seemingly effortless process occurs not only with familiar objects, but also with indeterminate stimuli that do not contain "real" objects. It therefore seems that the primate brain is a compulsory object viewer, namely automatically segments indeterminate visual input into coherent images.

After making the object recognition decision, subjects had a couple of seconds to view each painting before rating its aesthetic affect. As some art works can be strongly, yet negatively affective, we did not ask the subjects to report whether the affect was positive or negative, but to rate its strength. Their responses revealed a universal judgment of aesthetic affect. Regardless of the nature of the paintings or their color, all subjects similarly rated all paintings. A recent study in which subjects rated the beauty of portraits, landscapes and abstract paintings has shown similar findings, namely virtually identical proportions of paintings that were perceived as beautiful, neutral or ugly, regardless of their type [15]. Consistent with previous findings [27], our findings further suggest that aesthetic affect of paintings is not only independent of semantic meaning, but also independent of the presence or absence of any meaningful content. Nevertheless, we found longer response latencies during the rating of the indeterminate paintings, suggesting that aesthetic judgment is facilitated when the content of an image is comprehensible. We also found an interaction between the response latency during the object recognition task and the later aesthetic rating. Thus, the longer it took to decide whether an indeterminate painting contained familiar objects, the more likely this painting was to be subsequently rated as very affective.

The surprise memory test revealed that although subjects were not explicitly instructed to memorize the paintings while performing the object recognition and aesthetic rating tasks, and despite the long time interval (8 days) between encoding and retrieval, they were able to correctly recall a reasonable number of the previously seen paintings. We found that subjects better remembered the representational paintings, as reflected by their mean correct responses to old and new VA images. The lower memory recall for the indeterminate paintings could be due to their lack of meaningful content. An alternative, but not exclusive explanation is that it was difficult to remember the RP paintings because they had no prior associations to representations stored in memory. Consistently, we have recently shown that in a recognition memory task of art paintings that included portraits, landscapes and abstract compositions, subjects correctly remembered 89% of the old portraits but only 59% of the old abstract paintings [35].

Interestingly, we found significant increase in false alarms for indeterminate compared to determinate paintings. These results indicate that subjects mistook significantly more new indeterminate paintings as old ones, presumably due to their high degree of visual similarity, or because they recognized RP's unique style. This interpretation is also supported by the shorter latencies to the indeterminate images. Moreover, our previous study has shown that subjects falsely recognized new paintings as old ones when these new paintings were visually similar to old prototypes the subjects previously memorized [35].

We found that subjects correctly remembered more paintings they had previously rated as very affective. Previous studies have shown that incidental memory performance for arousing pictures was better during both immediate and delayed recall [3]. Moreover, recent fMRI studies have shown that emotional stimuli evoke stronger activation than neutral stimuli in visual and limbic areas [14,33], and that memory for pleasant and aversive stimuli is mediated by enhanced activation in the amygdala [8].

It is of interest that when the color paintings were compared with the monochrome ones, some differences were observed. Subjects recognized familiar objects in more color than gray paintings, suggesting that color provides important surface cues for object identification. Moreover, subjects responded faster to indeterminate color paintings during the memory recall test. These findings are consistent with previous behavioral studies in which object recognition, naming, and memory retrieval were facilitated when color pictures were compared with black and white line drawings or grayscale pictures [6,21,25,34]. Taken together, these observations suggest that high-level vision is influenced not only by shape (form), but also by surface (texture, color) information [29]. Although 10 of the 26 subjects reported in their post-experiment briefing that color paintings were more affective than gray paintings, and only two subjects reported that gray paintings were more affective than color paintings, the mean aesthetic affect ratings of color paintings did not differ from those of monochrome paintings. It therefore seems that the rapid aesthetic impression subjects had to form in the experiment was influenced more by the formal aspects of the paintings.

In sum, our study shows that Robert Pepperell's indeterminate images, in which recognizable objects are only suggested, comprise a special class of art paintings that can be used to further elucidate the neural correlates of visual perception. Although the aesthetic affect of all painting was virtually identical, the indeterminate images were perceived and remembered differently from representational paintings that depict meaningful content. Recognition of familiar objects and subsequent memory of art compositions are affected by their content, whereas, aesthetic judgment of paintings is independent of their meaning and is influenced by their formal visual features.

Acknowledgement

References

[1] M. Bar, Visual objects in context, Nat. Rev. Neurosci. 5 (2004) 617–629.
[2] I. Biederman, Perceiving real-world scenes, Science 177 (1972) 77–80.

[3] M.M. Bradley, M.K. Greenwald, M.C. Petry, P.J. Lang, Remembering pictures: pleasure and arousal in memory, J. Exp. Psychol. Learn. 18 (1992) 379–390.

[4] M. Fabre-Thorpe, G. Richard, S.J. Thorpe, Rapid categorization of natural images by rhesus monkeys, Neuroreport 9 (1998) 303–308.

[5] D. Gamboni, Potential Images: Ambiguity and Indeterminacy in Modern Art, Reaktion Books, London, 2002.

[6] K.R. Gegenfurtner, J. Rieger, Sensory and cognitive contributions of color to the recognition of natural scenes, Curr. Biol. 10 (2000) 805–808.

[7] E. Gombrich, Art & Illusion: A study in the Psychology of Pictorial Representation, Phaidon Press, London, 1960.

[8] S.B. Hamann, T.D. Ely, S.T. Grafton, C.D. Kilts, Amygdala activity related to enhanced memory for pleasant and aversive stimuli, Nat. Neurosci. 2 (1999) 289–293.

[9] J.V. Haxby, B. Horwitz, L.G. Ungerleider, J.M. Maisog, P. Pietrini, C.L. Grady, The functional organization of human extrastriate cortex: a PET-rCBF study of selective attention to faces and locations, J. Neurosci. 14 (1994) 6336–6353.

[10] J.V. Haxby, M.I. Gobbini, M.L. Furey, A. Ishai, J.L. Schouten, P. Pietrini, Distributed and overlapping representations of faces and objects in ventral temporal cortex, Science 293 (2001) 2425–2430.

[11] A. Ishai, L.G. Ungerleider, A. Martin, J.L. Schouten, J.V. Haxby, Distributed representation of objects in the human ventral visual pathway, Proc. Natl. Acad. Sci. U.S.A. 96 (1999) 9379–9384.

[12] A. Ishai, L.G. Ungerleider, A. Martin, J.V. Haxby, The representation of objects in the human occipital and temporal cortex, J. Cogn. Neurosci. 12 (2000) 35–51.

[13] A. Ishai, L.G. Ungerleider, J.V. Haxby, Distributed neural systems for the generation of visual images, Neuron 28 (2000) 979–990.

[14] A. Ishai, L. Pessoa, P.C. Bikle, L.G. Ungerleider, Repetition suppression of faces is modulated by emotion, Proc. Natl. Acad. Sci. U.S.A. 101 (2004) 9827–9832.

[15] H. Kawabata, Z. Zeki, Neural correlates of beauty, J. Neurophysiol. 91 (2004) 1699–1705.

[16] A. Kleinschmidt, C. Buchel, S. Zeki, R.S. Frackowiak, Human brain activity during spontaneously reversing perception of ambiguous figures, Proc. Roy. Soc. B-Biol. Sci. 265 (1998) 2427–2433.

[17] M.M. Murray, M.L. Imber, D.C. Javitt, J.J. Fox, Boundary completion is automatic and dissociable from shape discrimination, J. Neurosci. 26 (2006) 12043–12054.

[18] R. Pepperell, Seeing without objects: visual indeterminacy and art, Leonardo 39 (2006) 394–400.

[19] F. Phillips, C.H. Thompson, M.G. Voshell, Effects of 3-D complexity on the perception of 2-D depictions of objects, Perception 33 (2004) 21–33.

[20] P. Pietrini, M.L. Furey, E. Ricciardi, M.I. Gobbini, W.H. Wu, L. Cohen, M. Guazzelli, J.V. Haxby, Beyond sensory images: object-based representation in the human ventral pathway, Proc. Natl. Acad. Sci. U.S.A. 101 (2004) 5658–5663.

[21] C.J. Price, G.W. Humphreys, The effects of surface detail on object categorization and naming, Q. J. Exp. Psychol. 41 (1989) 797–827.

[22] G. Rainer, H. Lee, N.K. Logothetis, The effect of learning on the function of monkey extrastriate visual cortex, PLoS Biol. 2 (2004) E44.

[23] H. Read, The Meaning of Art, Pelican, London, 1951.

[24] P.R. Roelfsema, Cortical algorithms for perceptual grouping, Ann. Rev. Neurosci. 29 (2006) 203–227.

[25] B. Rossion, G. Pourtois, Revisiting Snodgrass and Vanderwart's object pictorial set: the role of surface detail in basic-level object recognition, Perception 33 (2004) 217–236.

[26] G.A. Rousselet, M. Fabre-Thorpe, S.J. Thorpe, Parallel processing in high-level categorization of natural images, Nat. Neurosci. 5 (2002) 629–630.

[27] P. Russell, Effort after meaning and the hedonic value of paintings, Br. J. Psychol. 94 (2003) 99–110.

[28] D.A. Stanley, N. Rubin, fMRI activation in response to illusory contours and salient regions in the human lateral occipital complex, Neuron 37 (2003) 323–331.

[29] J. Tanaka, D. Weiskopf, P. Williams, The role of color in high-level vision, Trends Cogn. Sci. 5 (2001) 211–215.

[30] S. Thorpe, D. Fize, C. Marlot, Speed of processing in the human visual system, Nature 381 (1996) 520–522.

[31] F. Tong, K. Nakayama, J.T. Vaughan, N. Kanwisher, Binocular rivalry and visual awareness in human extrastriate cortex, Neuron 21 (1998) 753–759.

[32] L.G. Ungerleider, M. Mishkin, Two cortical visual systems, in: D.J. Ingle, M.A. Goodale, R.J.W. Mansfield (Eds.), Analysis of Visual Behavior, MIT Press, Cambridge, MA, 1982.

[33] P. Vuilleumier, J.L. Armony, J. Driver, R.J. Dolan, Effects of attention and emotion on face processing in the human brain: an event-related fMRI study, Neuron 30 (2001) 829–841.

[34] L.H. Wurm, G.E. Legge, L.M. Isenberg, A. Luebker, Color improves object recognition in normal and low vision, J. Exp. Psychol. Human 19 (1993) 899–911.

[35] E. Yago, A. Ishai, Recognition memory is modulated by visual similarity, NeuroImage 31 (2006) 807–817.