

RAPHAEL ROSENBERG

Bridging Art History, Computer Science and Cognitive Science: A Call for Interdisciplinary Collaboration*

New impulses in our field have often originated in changes in art or new theories from related disciplines – especially the historical and social sciences, literary studies, philosophy and psychology. But they also derive from new technologies such as x-ray and infrared reflectography. Today, the number of technical innovations relevant for art history is greater than ever. They mainly spring from two new and highly dynamic disciplines: computer science and cognitive science. What do these technical innovations have to offer and how should we approach them? I don't expect art history to reinvent itself as a technical discipline, but I do think it's important that we're open to interdisciplinary collaboration. What are the opportunities and conditions for such collaboration? We'll consider one field after the other.

I. Art History and Computer Science

In the previous issue of this journal, Hubertus Kohle provided a trenchant summary of the possibilities held out for art history by advances in digital technology. His eight theses were based on two premises: firstly, that art history has so far failed to connect with the digital humanities; and, secondly, that pictures lend themselves particularly well to computer-aided analysis. Kohle's text is deliberately short. Taking a more nuanced look at his premises will furnish us with a clearer idea of the relationship between art history and computer science.

At first glance Kohle's complaint about the lack of a connection between art history and the development of digital technologies looks completely unfounded: the use of digital resources in our discipline is highly advanced. Much of what Kohle identifies as potential is already everyday reality. He himself was a pioneer and has contributed to advances in this field. The last time I saw analogue slides in a lecture hall was three years ago, at the farewell lecture of a colleague who has since retired. Our generation may have learnt to write without keyboards and smartphones, but we now do digital research on a daily basis. And though we worry about the hegemonic power of data management suppliers, we're happy to use the services of Google & Co. when they provide us with pin-point search results and unexpected finds. Some of us use computers more frequently and more extensively than others, but none of us exclusively for writing.

What's crucial to the positioning of our field in relation to digital technology is not how many PCs we use, but how we use them, be it passively, for research and information gathering, or actively, for the digital processing of data. This is where Kohle's diagnosis is spot on: many art historians are reluctant to actively use electronic data process-

ing. This isn't down to a deficiency in digital literacy so much as a disinterest in quantitative analyses and ultimately springs from our basic conception of science. Quantitative art-historical inquiries were less attractive before the emergence of digital technologies, but they did exist. They serve as a corrective to qualitatively obtained hypotheses and they improve the general validity of qualitative analyses. However, as far as I can see, no quantitative analyses in art history have ever been successful without qualitative analyses. Statistics about works of art are unobtainable in the absence of some form of prior qualitative analysis, without which the works could not be categorised in the first place. Also, statistics themselves need to be interpreted. And much the same goes for the sort of scientific analyses of paintings carried out by the Rembrandt Research Project: meaningful results can only be obtained through the qualitative interpretation of technical data.

In this respect we remain fundamentally distinct from the social sciences, which have been fighting a trench war over qualitative and quantitative methods for more than a hundred years now. The question for art history, then, is not whether research in the age of the digital humanities should be quantitative *instead of* qualitative. What's far more important is whether we're willing to go beyond our customary qualitative analyses to incorporate quantitative approaches *as well*. As long as we confine ourselves to 'reading' pictures, adhering to the radical constructivist supposition according to which there is no truth beyond subjective constructions, quantitative analyses will remain suspicious.¹

Let us turn to Kohle's second premise. I think it's wrong to say that pictures lend themselves particularly well to computer-aided analysis. Optical character recognition and full-text searches work well and have done for a while. Machine translations are improving all the time, especially under the auspices of the developing Semantic Web. By contrast, the automated comprehension of pictures by machines is more labour intensive and less dependable. Computers can quickly and reliably pixelate an image, recording its brightness and colour in code, but recognising forms and objects remains an enormous challenge, to say nothing of the digital analysis of composition, style or iconography. Computer systems are capable of storing vast collections of images, but they have a hard time organising them into art-historically relevant categories. When we search databases for digital images we usually rely on manually supplied textual metadata, not digital analyses of the pictures themselves. And even if the future brings increased processing power and improved algorithms, the automated description of pictures will always lag behind the written word when it comes to clarity and depth of scrutiny or breadth of material. This is because language and writing are far more conventionalised, which allows for greater intelligibility at the semantic and syntactical levels. It is also why semiotic analyses

have remained controversial in art history and have never really caught on as they did in linguistics. So the fact that art history has developed fewer digital research methods than text-based subjects is linked to the nature of their respective media. This is also why the majority of art history projects in the digital humanities are based on the digital processing of textual data, which may or may not be reunited with associated images after it has been analysed.

The digital analysis of images, then, is a difficult challenge, but it is also a particularly current one. Computer vision and robotic or so-called machine vision now constitute a large international, and interdisciplinary research area. The results of this research are crucial to the success of driverless cars, for instance. This research area covers the automatic recognition of objects, but it also deals with our fundamental understanding of the mechanisms upon which human perception and perception-based judgements are based. What does this mean for art history? Many information scientists who work on visual issues are keen to cooperate with art historians.² Why are so few of us taking them up on this? One reason is that computer vision is not yet as advanced as computational linguistics. It has very few ready solutions that can be directly applied to the investigation of art-historical questions. Unlike Hubertus Kohle (his fourth thesis), I'm not convinced that such research will be able to discover the historicity of the work of art in its pixels. And I don't believe it will ever be possible to objectively identify an artist's hand with algorithms, though this idea is currently being pursued on numerous fronts in the field of computer science. But when such questions *are* being looked into by information scientists, it would be expedient if art historians were involved. And even if we aren't directly involved in such research, we should at least engage with it critically.

II. Art History and Cognitive Science

Art history and psychology became established academic disciplines at German universities at around the same time: the second half of the nineteenth century. The psychology of art was an important intersection from the very beginning. Over the years this field enjoyed periods of favour in both subjects. Each of them frequently drew on the findings of the other, though actual collaborations were rare.³ For a while, psychology's behavioural orientation alienated it from art and art history. But the cognitive turn in psychology and, even more so, the dynamic refinements in psychophysiological methods over recent years promise new potential for contact and cooperation between the two disciplines.

The Holbein exhibition of 1871 in Dresden was a milestone both for art history and for empirical aesthetics. Theodor Fechner, one of the

founders of experimental psychology, left questionnaires out, asking visitors to compare the two Madonnas.⁴ Such surveys have been refined a great deal since then. They remain a fundamental technique of empirical aesthetics, allowing researchers to quantify their respondents' conscious judgements, or those they become aware of when answering the questions. Subsequent experimental psychology has developed methods for measuring physiological changes. They provide an insight into emotional and mental processes, even when these occur on the subconscious level. In recent years digital technologies have paved the way for a whirlwind revolution in psychophysiological methods. Old techniques are substantially improved, new methods are being invented all the time. The technical apparatus is becoming more powerful, cost-effective and user-friendly, and there's been a concomitant rise in the number of disciplines that use it – even in the humanities. Techniques that look especially attractive to the discipline of art history at the moment include eye tracking, which records the behaviour of the eye; facial electromyography (fEMG) and electrodermal activity (EDA), which make it possible to gauge emotional reactions; then electroencephalography (EEG), functional magnetic resonance imaging (fMRI) and perhaps magnetoencephalography (MEG), which tell us about brain activity.⁵ One obvious application is to analyse the reactions of people viewing art. In principle it is also possible to study artists in the act of creation, though this involves more complex experiments. Using those devices produces large amounts of data that have to be analysed with specific software. The collection of psychophysiological measurements (by art historians) might therefore be considered as part of digital art history. I prefer to call it 'cognitive research in art history' (or in German: *empirische Bildwissenschaft*), to underline the psychophysiological, experimental element that precedes digital processing.⁶

Why should we use psychophysiological methods in art history? What can we achieve by doing so? How will our discipline be affected by such an expansion of methodologies? The field is still young and experiences are limited, so it would be rash to propose any comprehensive answer at this stage. I shall do no more than outline my personal experiences by way of example. In 2006, after a period of preliminary work at the University of Freiburg (Breisgau), I set up the Laboratory for Cognitive Research in Art History (CReA) at the Department for Art History in Heidelberg with a focus on eye tracking. In 2009 I relocated this laboratory to the University of Vienna. My starting point was the history of viewing art. I was struck by the fact that eye movements have been an important topic in art writing for centuries. Indeed, we still describe works in terms of assumed eye movements: 'Looking at this painting, the eye moves from ... to ...'. When using an eye tracker, though, it immediately becomes clear that the eye in fact behaves com-

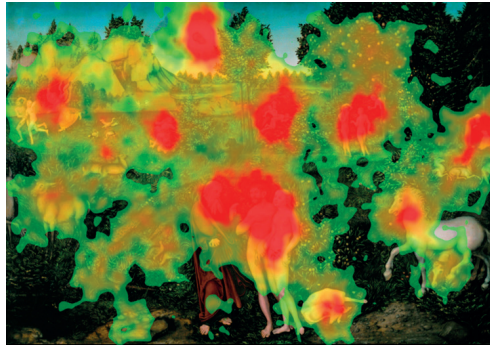
pletely differently to what is supposed in the art literature: the gaze of a subject beholding a painting is not steady, but jerky, constantly switching between fixations (approx. 300 ms) and jumps or 'saccades' (approx. 50 ms). Furthermore, the course of these saccades (the scanpath) never consistently follows that of the compositional lines in the sequence postulated by art historians. Previous studies have been confined to two-dimensional images, but in future eye tracking will also be applied to the viewing of sculpture and architecture.⁷ Analyses of fixations and frequently repeated saccades have shown that the path of the gaze depends on three things: the picture, the person and the viewing conditions. A number of studies currently being conducted at my laboratory are focusing on just these three factors:

1. Areas of the picture empirically shown to be those that the viewer looks at most often are usually the same as those that are emphasised in art-historical analyses. There is also a high correlation between the compositional analyses of art historians and the most frequently repeated saccades. From this we can conclude that the viewer's eyes track the structure of the work of art physiologically, though not as closely as subjective perception would suggest, nor so closely as art-historical texts suppose. Eye tracking, then, is a tool that can verify or falsify art-historical analyses.⁸

2. A comparison of the eye movements of art experts and lay people shows that experts will comprehend the structure of a picture more quickly than lay people. The magnitude of this discrepancy is likely to increase with the complexity of the work. In order to determine whether and how the behaviour of the eye is influenced by cultural background, Hanna Brinkmann has conducted a study of fifty Japanese people (in Tokyo) and fifty Austrians (in Vienna).⁹ All test subjects were university students without any specialist knowledge of art. Both groups viewed the same ten pictures (European and Japanese) on a high-resolution screen for two minutes each with the eye tracker running. They then answered a set of questions about each of the pictures. In her dissertation Brinkmann was able to demonstrate highly significant differences between the two groups on various levels. In the case of Cranach's *Paradise*, for example, the culturally contingent familiarity/unfamiliarity with Christian iconography is evident from the questionnaires. The eye tracking data for the whole viewing period shows that Japanese subjects spend less time looking at the figures and more time looking at the spaces between them, that is, at the background (figs. 1 and 2). Also, there are clear differences in what we might call viewing strategies. In the first moments of viewing each picture, Austrian subjects sought to obtain an overall impression; their fixations were short, the saccades long. After a few seconds they switched to closer inspection of the details; fixations lasted longer, saccades became shorter.



1 Heatmap of the fixations of fifty Austrian subjects viewing Cranach's *Paradise* for two minutes each



2 Heatmap of the fixations of fifty Japanese subjects viewing Cranach's *Paradise* for two minutes each

These chronological phases, which have often been described in the psychological literature, could not be detected in the Japanese subjects; variation in the average duration of their fixations was minimal. One hypothesis to explain this evidence is that the Japanese are also more interested in essentials than incidentals, but that they aren't so intent on apprehending them quickly. These differences correspond to the differing cultures of European and Japanese painting: the aesthetic value of the picture plane is an aspect of Japanese art that has fascinated European artists ever since the 1870s (Japonism). Differences in ocular behaviour are deep rooted. It remains to be seen whether these differences only apply to works of art or whether they also pertain in the case of explicitly non-art images and everyday situations. We plan to investigate this in further studies, and in doing so we hope to find clues that might help determine whether these differences were brought about by the artists of earlier epochs or whether art responds to differences that are extrinsic to it.

3. Eye tracking can now be done with no physical contact between device and subject, with high-resolution screens and, in some cases, with high-grade, framed facsimiles. Nevertheless, there still is a clear distinction to genuine works of art in a museum. In order to account environmental influences we conducted several experiments comparing the laboratory and the museum. In collaboration with the Fraunhofer Institute for Digital Media Technology in Ilmenau we developed a hidden eye tracker that covertly recorded the eye movements of visitors to Vienna's Kunsthistorisches Museum. Permission to use the collected data was only obtained from the viewers after the fact. Further studies are looking at how the viewing of art is influenced by contextual factors such as museum education programmes (audio guides).¹⁰

Psychological theories have been influencing the basic assumptions of art history for a long time, from empathy theory and gestalt psychology to Gombrich's interpretation of ecological psychology. Theoretical developments in psychology and neuroscience remain relevant to

us today. But in addition we now have sophisticated and non-invasive means of investigating the emotional and cognitive processes involved in the reception and even production of art. The new experimental approach allows us to verify basic assumptions and to elaborate new theories on the basis of empirical evidence. Our eye-tracking studies are one example of the new type of cooperation between art history and psychology. The relevance of these experiments can be demonstrated with reference to the idea of a history of seeing. The notion of historical variations in perception was and still is a basic assumption for many art historians – from Moritz von Thausing's inaugural lecture in Vienna (1873), through Alois Riegl and Heinrich Wölfflin to Michael Baxandall and Jonathan Crary. Assumptions such as this tend to steer historical analyses, though the analyses themselves are often used to confirm the very assumptions they make. Experimental studies break this vicious circle. Eye-tracking experiments with living human subjects have shown how a person's culture and expertise affect the behaviour of the eye. And though the subjects of these experiments are not historical subjects, distinctions identified in the present provide a sound basis for better understanding differences of the past.

This (new) form of collaboration with psychologists will entail some major readjustments, both substantial and organisational, in the research habits of art historians. Valid empirical results can only be obtained on the basis of clear hypotheses by experimentally testing variable factors. This is diametrically opposed to the sort of descriptive-inductive scholarship customary in art history. Empirical studies are very time consuming. They need to be planned and prepared in minute detail. Conducting them with a statistically significant number of subjects can take several months, to say nothing of analysing the actual data. Even ignoring the need for interdisciplinary input and technical expertise, it would still be impossible for one person to carry out such studies alone. Teamwork becomes the norm, and publications have to mirror that. The most obvious is to publish each study as a paper with several authors – those who participated in the study. Indeed, where student dissertations have an experimental orientation, the Faculty of Historical and Cultural Studies at the University of Vienna is already following the model of the empirical sciences in accepting cumulative collections of multiauthored papers.

III. Conclusion: Do We Need a Systematic Art History?

Unlike scholars from neighbouring disciplines, art historians tend to regard the investigation of systematic questions as a relatively insignificant institutional issue. But the distinction between literary criticism

and linguistics goes back as far as classical antiquity. Linguistics has meanwhile produced the independent sub-disciplines of computational linguistics and psycholinguistics. The late nineteenth century saw musicology split into historical, systematic and (later) ethnographic sub-disciplines, each with its own professorships and learned societies.¹¹ Music informatics and music psychology sometimes occur as sub-disciplines in their own right. Unlike philology and musicology, art history has never taken institutional ownership of systematic research. Systematic questions are discussed in relation to historical examples by researchers with established historical knowledge. This unity has its advantages, and it is important that we retain it, but it would be tragic if that meant entirely relinquishing responsibility for the systematic research of visual art.

Art history no longer has a monopoly on the analysis of art. Information scientists working on computer vision are developing algorithms for the analysis of pictures; psychologists are conducting a number of studies on the viewing of art, sometimes in interdisciplinary networks within 'empirical aesthetics'; some neuroscientists are relating artistic regularities to the anatomy and function of the brain and trying to establish neuroaesthetics as an independent discipline.¹² As art historians, how do we position ourselves within this expanding research landscape? If we arrogantly choose to ignore it, we'll soon lose command of our field. Art history, as an auxiliary historical science, will then be left with nothing but archival research. It might be possible to engage with these fields passively in the short term, but in the long term there's no other option than to become actively involved with them, and for two reasons. Firstly, it's difficult to understand the results and limitations of digital analyses and, even more so, cognitive studies without previous experience in those areas. Secondly, these fields will only be able to achieve satisfactory results with the help of our knowledge: our cooperation is necessary for the elaboration of questions and criteria, for the selection of 'stimuli' (the works to be used as examples in empirical studies) and to verify the validity of the experimental conditions.

This brings us back to the broader debate about digital art history. Clearly, our discipline is no longer conceivable without digitisation. But it's also clear that very few institutions have realised or acted upon the significance of this technology. How should art history respond to the challenges and opportunities of digital technology? Should we establish specialist professorships or centres for digital art history and/or cognitive art history – alongside those for the art history of the middle ages, the modern era, modernity and/or the art history of specific regions and genres (architecture, new media etc.)? Should we make computer science and/or cognitive science mandatory parts of the art history curriculum? I would argue strongly against this. Not so much

because of the obvious danger of reallocating capacities and the concomitant orphaning of historical and regional specialities (though it's not inconceivable that some capacities would be freed up in the process of condensing numerous smaller departments into a few larger ones); there are practical and content-related grounds for my objection. I don't believe digital and cognitive art history can be done by single individuals. They require interdisciplinary cooperation in order to function successfully, cooperation between, on the one hand, art historians who develop questions relating to works they have been exhaustively studying and, on the other, information or cognitive scientists with a thorough command of the rapidly developing methods of their disciplines. A basic knowledge of the other subjects is extremely helpful here, so it would be good if art history programmes could offer and encourage outside courses in computer science, psychology or cognitive science (which would hardly be detrimental to general employability). And if new professorships are to be established in these areas, I would strongly advise against narrow definitions such as 'digital art history.' As a more general denomination I think 'systematic art history' would have better prospects. One important purpose of such new professorships would be to construct interdisciplinary bridges in the form of collaborations between groups of researchers.

* My thanks to Gerd Blum, Johannes Grave, Heidrun Rosenberg, Klaus Speidel and Michael Zimmermann for their comments on previous drafts of this text, and to Jonathan Blower for the translation.

1 For an in-depth discussion of critical realism versus radical constructivism in art history see Branko Mitrović, [Rev.] Ian Verstegen, *A Realist Theory of Art History* (Ontological Explorations), London/New York 2013, in: *Journal of Art Historiography* 14, 14 June 2013, URL: <https://arthistoriography.files.wordpress.com/2016/05/mitrovic-review.pdf> (date of last access 18 August 2016) and Ian Verstegen, *A Realist Theory of Art History*, London/New York 2013.

2 One example is the workshop *VISART: Where Computer Vision Meets Art*, which is being organised for the third time in October 2016 as part of the major European Conference on Computer Vision.

3 This exchange has been the subject of intense historiographical investigation in recent years. See Mark Jarzombek, *De-Scribing the Language of Looking: Wölfflin and the History of Aesthetic Experientialism*, in: *Assemblage* 23, 1994, 29–69; Frank Büttner, *Das Paradigma 'Einfühlung' bei Robert Vischer, Heinrich Wölfflin und Wilhelm Worringer*, in: Christian Drude and Hubertus Kohle (eds.), *200 Jahre Kunstgeschichte in München*, München/Berlin 2003, 82–93; Magdalena Bushart, *'Form' und 'Gestalt.' Zur Psychologisierung der Kunstgeschichte um 1900*, in: Otto G. Oexle (ed.), *Krise des Historismus – Krise der Wirklichkeit*, Göttingen 2007, 147–179; Georg Vasold, *Ernst Brücke und die Anfänge der Wiener Schule der Kunstgeschichte*, in: *Austriace* 72, 2011, 101–116; Karl Clausberg, *Aktualgenese & barocke Bewegtheit. Vor-Gestalten der Neuro-Ästhetik*, in: *Kunstgeschichte. Open Peer Reviewed Journal*, 9 May 2011, URL: <http://www.kunstgeschichte-ejournal.net/132/2/Clausberg.pdf> (date of last access 16 August 2016); Ákos Moravánszky, *The Optical Construction of Urban Space: Hermann Maertens, Camillo Sitte and the Theories*

- of 'Aesthetic Perception,' in: *The Journal of Architecture* 17, 2012, 655 – 666; Bernadette Collenberg-Plotnikov, 'Zoologen und Physiker als die berufensten Forscher in Sachen der Ästhetik'? – Zur Bestimmung der experimentellen Ästhetik in der Allgemeinen Kunstwissenschaft, in: *Zeitschrift für Ästhetik und Allgemeine Kunstwissenschaft* 58, 2013, issue 1, 11 – 34; Branko Mitrović, 'Visuality After Gombrich: the Innocence of the Eye and Modern Research in the Philosophy and Psychology of Perception,' in: *Zeitschrift für Kunstgeschichte* 76, 2013, 71 – 89; Jutta Müller-Tamm, Henning Schmidgen and Tobias Wilke (eds.), *Gefühl und Genauigkeit. Empirische Ästhetik um 1900*, Munich 2014.
- 4 Gustav Theodor Fechner, *Bericht über das auf der Dresdner Holbein-Ausstellung ausgelegte Album*, Leipzig 1872. My thanks to Helmut Leder for the reference to this source, which has received rather less attention than Fechner's *Vorschule der Ästhetik*, Leipzig 1876.
 - 5 For an up-to-date survey of the field, see Joseph P. Huston, Marcos Nadal, Francisco Mara et al. (eds.), *Art, Aesthetics, and the Brain*, Oxford 2015.
 - 6 Closely related terms include 'neuronal art history' and 'neuroarthistory'; see Karl Clausberg, *Neuronale Kunstgeschichte. Selbstdarstellung als Gestaltungsprinzip*, Vienna 1999 and John Onians, *Neuroarthistory from Aristotle and Pliny to Baxandall and Zeki*, London 2007. Neither of these terms were coined primarily in relation to experimental studies.
 - 7 One example, though with data from a single subject: Christoph Wagner, Mapping the Eye. Laocoön and Eye Movement in Art, in: Michael F. Zimmermann (ed.), *Vision in Motion: Streams of Sensation and Configurations of Time*, Zurich/Berlin 2016, 201 – 219.
 - 8 For instance, with the help of an eye-tracking study I was able to refute Kurt Badt's exemplary analysis of Tintoretto's *Last Supper* in S. Giorgio Maggiore: Raphael Rosenberg, 'Blicke messen. Vorschläge für eine empirische Bildwissenschaft,' in: *Jahrbuch der Bayerischen Akademie der Schönen Künste* 27, 2014, 71 – 86.
 - 9 Brinkmann's dissertation was funded by the ÖAW (DOC-team 68), the research in Tokyo was sponsored by the FWF (P 25821). The thesis is to be published (open access) in the coming months.
 - 10 For the comparison of laboratory and exhibition space see David Brieber, Marcos Nadal, Helmut Leder et al., Art in Time and Space: Context Modulates the Relation Between Art Experience and Viewing Time, in: *PLoS ONE* 9, 2014, issue 6, 3 June 2016, URL: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0099019> (date of last access 16 August 2016). For a study conducted using a calibration free eye tracker cf. Mario Thalwitzer, Hanna Brinkmann and Raphael Rosenberg, Using a Concealed, Calibration Free Eye-Tracker for Studying Art Perception in the Museum, in: Ulrich Ansorge, Thomas Ditye, Arnd Florack et al. (eds.), Abstracts of the 18th European Conference on Eye Movements, in: *Journal of Eye Movement Research* 8, 2015, issue 4, 140. Claudia Pitnik is currently conducting a study with audio guides at CReA.
 - 11 The first classic formulation of the distinction between historic and systematic musicology goes back to Guido Adler, Umfang, Methode und Ziel der Musikwissenschaft, in: *Vierteljahrsschrift für Musikwissenschaft* 1, 1885, 5 – 20.
 - 12 See the journals *Psychology of Aesthetics, Creativity, and the Arts* (official journal of the American Psychological Association APA, Division 10) and *Empirical Studies of the Arts* (official journal of the International Association of Empirical Aesthetics).

Photo Credits: 1, 2 © Hanna Brinkmann, CReA, Vienna.