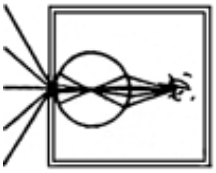

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Vorsprung durch Technik: Multi-Display Learning Spaces and Art-Historical Method

Keywords: art history, image studies, learning space, image display, *ekphrasis*

This paper considers the potential of multi-display learning spaces for presenting visual materials. We suggest that the display ecology can be used to support teaching and learning practices of art history. By display ecology we mean employing 'a variety of tools for collaboration and information sharing […] in which the individual displays influence the roles of others'.[1] Although the use of PowerPoint and similar digital presentation tools has attracted widespread criticism across domains such as business meetings, these tools have supplanted the role of their pre-digital antecedents within art-historical settings with minimal critical comment. This is disappointing, in particular because art history as a discipline and the heuristic processes of discovery of knowledge within it, have always been linked to the mechanisms for visualising a corpus of core materials. We argue that the typical use of PowerPoint-like tools (slideware) invites inappropriate forms of argumentation by presenters and constrains questioning and other forms of interaction by members of audiences.

Our discussion is structured as follows. First, we briefly summarise the use of double-slide projection in the late nineteenth and early twentieth centuries. We refer in particular to Heinrich Wölfflin and his use of projected slides to support art-historical rhetoric in the formalist tradition. We examine how this technology was used to construct methodology and influence discussion. Second, we acknowledge the shift away from the formalist tradition within art history. We discuss how arguments are scaffolded around pictures in the visual culture studies and postmodern iconology traditions. Third, we assess general criticisms of slideware from the vantage point of art history and suggest that the rhetoric that is fostered stunts different forms of engagement. Finally, we consider our experiences of using technology-rich multi-display learning spaces (MD-LS) within postgraduate education in the area of ancient art history and classical archaeology. We describe the emerging methodology. We conclude by suggesting that such settings, if thoughtfully planned, enable presenters and audiences to explore visual evidence together rather than individually and in a predetermined path.

Historical context

The analysis of pictures and other visual evidence forms the core of both research and teaching activities in art-historical disciplines. Such analysis assumes a verbal form which poses problems since what is being studied is material whose essence relies on a visual modality. This challenge of *ekphrasis*, the translation of a visual

experience into a linguistic modality, has been acknowledged since the beginning of modern art-historical inquiry in the eighteenth century.[2] A successive range of tools have been adopted that support art historians to address this challenge, including sets of originals, casts and photographs, lantern slide projectors (used either singly or side-by-side to support double-slide projection), and contemporary digital presentation technologies. Each tool provides a range of possibilities to mediate the activities of art-historical inquiry.[3] First, by altering the structure of the process of viewing and affecting how verbal exposition is synchronised with visual evidence, for example in the course of a lecture. Second, through enabling developments in the rules of activity within the community, such as how argument is structured by presenters and how disagreements between participants are allowed to be resolved in lectures.

Art-historical method works to structure the process of viewing at both material and intellectual levels. Well into the twentieth century, art history was dominated by formalist methods which focused on the style and composition immanent in individual works of art. Priority was given to questions of connoisseurship and the attribution of art works to individual artists. From the early twentieth century onwards this tradition of inquiry utilised the structuring process of comparative viewing.[4] Works of art were described and analysed in relation to other artefacts.

Technology was intertwined in both the development and implementation of the comparative viewing process. Innovations generally have both structural and historical character: they occur by taking advantage of possibilities for change within a system, and by re-moulding available resources. In this sense, the preceding step of introducing lantern slide projectors laid some necessary groundwork for what was to come. Herman Grimm spearheaded this introduction, suggesting that lantern slide projectors could be the 'microscope' of art history and so allow findings to be constructed on top of quantifiable data.[5] Illustrated lectures based around lantern slide projection became internationally popular and came to represent the discipline itself.[6] So the technology and the repertoire of actions around it became accepted practice within the art history community.

Part of the practice associated with lantern-slide projectors reduced the load of *ekphrasis* by adopting a deictic model of argumentation, i.e. by suggesting that the lecturer spoke on behalf of the images themselves. Prior methods of illustrating lectures, such as passing round photographs, meant that the visual and the verbal were poorly synchronised. Members of the audience might have already seen the relevant photograph and half-forgotten it, or else it had not yet reached them. This necessitated hard narrative labour. Narrators needed to describe and argue simultaneously to capture the contextual meaning of their points. With the lantern-slide projector, the visual evidence required in-the-moment was available as a common resource, and orators' new ways of expressing their analysis were able to assume this presence and to concentrate their efforts more selectively. Grimm was keen to highlight the structural objectivity and interpersonal authority which were the perceived result.[7]

The innovation of placing two lantern-slide projectors side by side was in some sense merely a progression, with hindsight predictable. Properties of images can be captured verbally in a straightforward way by progression or comparison and the use of lantern-slide projectors was being commonly advocated. Yet this vantage point misses the qualitative nature of the change which was about to occur — changing how visualisation, on the one hand, and analysis and knowledge production, on the other, mutually supported each other.

Heinrich Wölfflin was specifically interested in comparison, thus opening up an exploratory field for discourse between two items on offer. Wölfflin's technical innovation was indeed double-projection, simultaneously displaying two slides using two lantern projectors which were operated independently of each other.[8] This formed the material basis for Wölfflin's analytical innovation, allowing comparative viewing to operate as a structured comparison of artworks based around five 'binary concepts'. The internal dynamics of this technical and analytical system meant that, over time, new actions were introduced to the repertoire of presenters, building further on the conventions associated with the use of two projectors. An example is the use of 'anchor slides', in which one image is used to provide long-term contextualisation to a sequence of other images presented on the opposite slide-projector.

Wölfflin documented the effects on his own repertoire of rhetorical techniques:

> Not only can more examples be shown, but variants and exceptions can be brought forward without danger of distracting the hearer, since the keynote may be immediately struck anew. Finally, the lecturer has in greater measure the freedom to make the use of exaggerations for purposes of clarification (and entertainment), inasmuch as it is in his power to retract them at any moment.[9]

In turn, the technical repertoire and analytical methodology resulted in particular forms of knowledge production with wider significance, since comparative viewing played a crucial role in the formalist analysis which at the time dominated art history as an academic discipline. Presenters now proceeded according to a specific analytical structure, invoking a yet greater sense of argumentational objectivity and reinforcing the authority of the speaker as an 'ideal beholder' working on behalf of members of the audience.[10] The darkness of the room and the brightness of the images created what has been characterised as an 'epiphanic' experience.[11]

This historical excursus demonstrates that the technical means of visual presentation can form part of a mutually supporting system which also encompasses analytical method and knowledge production, in turn providing new possibilities for the discourse of art history. Or, put differently, analysis within an art-historical tradition can shape the method of presentation and the supporting technological tools; in the process, art-historical analysis is itself re-shaped. To adopt methods of presentation from outside the discipline uncritically means missing out on the rich potential of this interaction.

This argument is not coupled specifically to the formalist tradition. Some of the specifics of practice we describe will be problematic to many art historians viewing

our account from a contemporary perspective. Structurally, the tight clustering of visual objects and the linear drive of the exposition curtailed the construction of alternative dianoetic perspectives based on the visual evidence. Interpersonally, discussion was discouraged by the accreted rules of the lecturing activity, whether explicitly acknowledged or not, and by the darkness of the physical setting.

Contemporary knowledge production

In recent decades, art history has shifted away from the formalist tradition and increasingly values forms of knowledge which are holistic, multi-voiced, more widely contextual, and culturally aware. If we are to suggest that new techniques for visual presentation offer similar forms of systemic interaction as that we have discussed for dual-slide projection and comparative viewing, then we need some understanding of contemporary approaches to analytical method and knowledge production. To proceed only from the assumptions of formalism at this juncture would be a gross error. We therefore provide a brief overview of the interrelated traditions of visual culture studies and postmodern iconology (or image studies), both of which enjoy considerable popularity in contemporary practice.

Visual culture studies

Contemporary visual culture studies is an attempt to address the challenges posed by the new forms of transmission of mass media information that have emerged since the 1960s.[12] The discipline examines the relationships between the content of a visual representation and the medium used to deliver it, focussing on the social significance of these relationships and so drawing attention to issues of audience. The methodology of visual culture studies is based on the fundamental assumptions of semiotics, i.e. the production and circulation of signs, and its post-structuralist revision, the multi-stability of signs and their involvement in processes of recirculation. In short, this is a framework of visual transmission and audience perception.

The visual culture studies approach has been widely used to analyse mass media and popular culture. A socio-political mission is conspicuous: the ideologies of viewing are dissected, the mechanisms of existing power in both image production and consumption are highlighted, forms of visual representation are targeted as propagandistic, and the ideological implications of media in terms of class, gender, and culture are foregrounded. This wide scope means that elements of formalism, feminism, gender studies, narratology, psychoanalysis, the gaze, post-colonial anthropology, and so on, are borrowed as deemed appropriate. Many of these theories and methods are themselves rooted in semiotics.

Visual culture studies operates at a trans-disciplinary, even supra-disciplinary level.[13] The aim is to provide a (post-)structural frame for the study of culture as it is visually manifested. Applied to the study of, for example, ancient art history, visual culture studies draws attention to social and religious rituals and political practice, viewing and the relationship between text and images, and reception and emulation of Greek art in Roman culture.

Postmodern iconology

Postmodern iconology, or image studies, aims to pursue the types of epistemic meaning elicited by an image in terms of aesthetics and philosophy. Discussed most prominently by W.J.T. Mitchell[14], postmodern iconology is a hermeneutical method whose process of inquiry starts from the image itself. So postmodern iconology stands in contrast to visual culture studies' conceptualisation of images in terms of audience and transmission.

Critical iconology aims to achieve a trans-disciplinary methodological reach, and borrows questioning strategies from antecedents which vary considerably in their age and vantage point. The very name signifies the influence of Erwin Panofsky's methodological approach to iconology which, although pre-semiotic, did influence the development of semiotics.[15] Borrowing from Panofsky's model involves assessing the visual elements within an image – figures and objects – in terms of their position within the history of styles and iconographical types. So postmodern iconology attains a more historical perspective than semiotics-based forms of inquiry. But the emphasis of the method has shifted away from Panofsky's focus on symbolic meaning towards issues of production and perception. Instead of constructing a hegemonic system, postmodern iconology borrows from formalism, traditional iconography, and elements of intermedial and reception-focussed study.

Criticisms of PowerPoint

The famous detractor of PowerPoint, Edward Tufte, argues:

> PowerPoint's convenience for some presenters is costly to the content and the audience. These costs arise from the cognitive style characteristic of the standard default PP presentation: foreshortening of evidence and thought, low spatial resolution, an intensely hierarchical single-path structure as the model for organizing every type of content, breaking up narratives and data into slides and minimal fragments, rapid temporal sequencing of thin information rather than focused spatial analysis, conspicuous chartjunk and PP Phluff, branding of slides with logotypes, a preoccupation with format not content, incompetent designs for data graphics and tables, and a smirky commercialism that turns information into a sales pitch and presenters into marketeers. This cognitive style harms the quality of thought for the producers and the consumers of presentations.[16]

Tufte, who is an information visualisation expert, proffers myriad substantive complaints based mainly on content analysis of corporate presentations and PowerPoint manuals. He labels an example of corporate slideware guidelines 'a witless PP pitch on how to make a witless PP pitch'.[17] We propose to briefly attempt the task of analysing the relevance of Tufte's criticisms to art-historical presentations. We distinguish between these latter and the presentations Tufte studied in terms of, first, the differences in typical content and structure of materials and, second, how the slideware is used in-the-moment to support analysis and knowledge production.

As we have already discussed, art historians have been engaged in practice with slide projection technologies for well over a century and these tools have interacted with and partially shaped analysis and discourse within the discipline over the course

of that time. This historical component guides presenting activity in the discipline. It may also explain why some of the worst excesses of slideware use are routinely avoided. Art historical practitioners perceive their own discipline as one where presenters speak well in front of slides.[18] Art historians frequently structure a heavily verbal narration around slides containing only pictures and mainly avoid Tufte's hierarchical bullet lists and 'chartjunk' such as clipart. Where digital slideware is perceived as an advance over lantern slides, it is due to its ability to present multiple pictures on one slide and to merge text and pictures (and even video and music). Image captions providing citation details are added easily and are common. Annotations drawing attention to elements within image objects are useful in complementing more traditional forms of highlighting, such as hand gestures or the use of a laser pointer.

Where the overt hierarchy of structure is avoided, the single-path nature of presentation is fully present. The low resolution of the computer projectors used with slideware, in comparison to lantern slide projectors, means that slides that juxtapose multiple images may render those objects insufficiently legible. The result is that many presenters favour only a single image on each slide, in effect returning to the situation before dual-slide projection was introduced in the early twentieth century. To be precise, Tufte is complaining about low resolution in terms of *information*, while we are using the word to mean the number of pixels that are displayed. But the effect here is the same: sequentiality, i.e. many slides are required, separated by time rather than space. A heavy descriptive load is placed once more on exposition, the verbal mode, which must describe the works not currently present, as well as argue (structurally) and persuade (interpersonally). This fragments art-historical narrative.

If we want to point towards a better system of tool, analysis and knowledge production for art history, then we need to first establish what kind of presentation the discipline wants. Our summary of post-formalist traditions emphasised the explicit ways in which meaning is to be elicited from context. For visual culture studies, this meaning is socio-political, semiotic and centred around issues of audience. Postmodern iconology's attention is on production with a heavy focus on historical trajectory. Rather than seeing meaning as immanent in the images, and thus potentially authoritative, this kind of contextualised knowledge production is participatory and allows for multiple interpretations. There is a desire to be persuasive, but also a desire for engaged audiences to disagree and resist, while remaining constrained within boundaries of relevance set by presenters. The situation is analogous to that of visual argumentation within film: 'we are neither compelled to share the point of view of the filmmaker, nor entirely free to supply pragmatic inferences or critical assessments of our own'.[19]

So our situation is both similar to and different from that considered by Tufte. The engineering and business presentations he tackles need to discuss issues which are causal, multivariate, comparative, evidence-based and resolution-intense.[20] The art history presentations we want share many of these properties. But Tufte's reasons for fomenting such discussions are to give the presenter nowhere to hide: to open the authority of the presenter to scrutiny by disallowing baseless assertions; to avoid

the sloppy presentation of analysis which — in the most extreme cases in engineering — can lead to fatal accidents. So Tufte seeks to ascertain the *facts*, and derive authority by enforcing *rigour*. Our reasons for wanting discussion activity to be mediated differently by tools is to support better *conversations*, opening up the space for response in order to better engage audiences with our *ideas*. This is not a question of assessing reliability, but of supporting multiple, valid, vantage points. In this context, those presenters whose ideas are challenged and re-interpreted by members of the audience have achieved a measure of success, rather than having been undermined.

This is our point of departure from Tufte. We share his distaste for PowerPoint slideware, but Tufte's vision of abandoning this slideware entirely in favour of written reports, to be read in communal silence at the start of a meeting, does not move us towards achieving our aims of better shared experiences of *ekphrasis*. We want the audience to engage with our narrative in-the-moment. So, while our art-historical presentations may be causal, multivariate, comparative, evidence-based and resolution-intense, they will also be deictic, performative, subtly orchestrated and both cognitively and interpersonally interactive.

Multi-display learning spaces in action

To illustrate some of our points, we provide an overview of a technology-rich learning space in a university and describe how this has been used to teach ancient art history to students of classics. A detailed empirical report is offered elsewhere.[21] We limit ourselves here to a focus on technology and our experiences of using it.

Presenting art-historical argument to students involves drawing on the same repertoire of actions used to communicate with academic peers. Partly this is an inevitable consequence of the fact that presenters have styles. But the commonality also serves a purpose: to introduce students to the art-historical discipline as a community of practice.[22] We want students to become art historians, and we do this by fostering engagement with authentic disciplinary discourse, in this case arguing about evidence from a vantage point influenced by methodological assumptions. A key difference exists, however, with regard to our desire for engaged, critical discourse about pictures. Students may be reticent, shy, and hesitant in their attempts to intervene or lack willingness to even try. So our challenge is rendered more difficult.

The work we describe here took place in England as part of the Visual Learning Lab project.[23] The aim was to investigate the use of presentation technologies across a range of projects. We had already been involved in investigating use of PolyVision Thunder[24], and other novel presentation technologies, within an open access university library setting. For this work, we wanted to strip away the distractions of unusual teaching environments and radically idiosyncratic technology to focus on the use of PowerPoint across multiple screens within a small seminar room.

Multi-Slides[25] is a plug-in for Microsoft PowerPoint which allows the presentation slides to be cascaded simultaneously across multiple screens, as shown in Fig. 1. The information resolution of the presentation, i.e., the amount of information that can be seen at the same time, is therefore increased. Sets of slides juxtaposed together in space form a display ecology of shared information, rather than only being encountered one at a time. Somewhat ironically, given our prior discussion of its limitations, a perceived advantage of Multi-Slides was that users could call upon their existing skills when authoring presentation materials by using PowerPoint itself. Later, at the presentation venue, the cascade of presentation materials is easy to set up by using a dialog box where the order in which material is displayed across the various screens is defined. In the seminar room used for this work, six large screens were available across two walls of the room. The slide cascade was set to move across the screens in order from left to right.[26]

Fig. 1. A multi-display learning space at the University of Nottingham.
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The topic of the presentations was *Ancient Art and Its Interpreters*, being the title of a seminar-based Master of Arts module in which students are encouraged to think critically about ways of interpreting Greek and Roman art and archaeology. A number of sites, statues, vases, paintings, sarcophagi, and other artefacts are introduced alongside various analytical methodologies. Students are expected to have some prior knowledge in the seminars and to this end are set a series of recommended readings. To support discussion within the seminars, different recommended reading is suggested for students, or groups of students, within the cohort.

The effect of the presentation tool on the structuring of visual materials was felt before the seminars, at the authoring stage. Motivated by a desire to enable

comparisons across the spatially juxtaposed slides, the tutor started to construct her materials in 'chunks'[27] of six, matching the number of screens across which these slides would be displayed and anticipating their simultaneous display. The number of slides actually authored approached double that for equivalent sessions presented more conventionally. Yet the composition of the slides was overwhelmingly simple: nearly always just a single image, perhaps with a caption underneath. Given the abundance of slides, there was little temptation to fit multiple items on a single slide since this was not necessary to enable comparison. Over time, these sets of slides were so precisely authored to be shown together that they became thought of as a single entity, a 'slide-chunk'. The standard Microsoft PowerPoint authoring environment is ill-suited to authoring slides in this way. The slides cannot be seen together and so their juxtapositions are not easily checked, forcing the author to think about this task abstractly.

When enacting the presentation, the tool supported what we termed a 'loosened' episodic structure, varying from the standard single-path, with the presentation progressing in a linear manner overall, but operating in discursive episodes at the granularity of 'slide-chunks' rather than individual slides. An episode began by introducing six slides. A verbal argument was enacted by the presenter, and then time was provided for critical response. In general, enough visual material was available in spatially parallel form to support plausible art-historical discussion. The structure of the series of episodes, which would make up the seminar, was designed in advance to be cumulative. It aimed at building a lengthy participative discussion out of the framework formed by the individual episodes. Occasionally, the presenter briefly returned to the previous episode, necessitating a cumbersome backward-stepping through six slides. In other cases, progression between episodes was visually supported by displaying the first three slides of the current episode with the last three slides of the previous one. These 'mezzanine' episodes were less effective since the visual juxtaposition often appeared haphazard.

A significant factor supporting the mode of analysis and knowledge production was that of physical space, or more broadly materiality. The students had a clear field of view across all the screens and could scrutinise what they liked within them by slightly turning their heads. In fact, students were also able to consult their own private papers (handwritten notes, paper copies of their set reading, etc.). The display ecology was therefore complex. Yet, during exposition, the presenter was able to suggest how to navigate through this information in various ways. First, the verbal narrative made clear reference to the images on display, inviting immediate scrutiny. Second, a laser pointer was used to highlight image elements using circling and underlining motions. Third, the presenter used bodily movement, physically walking around the room to stand next to an appropriately chosen screen. This latter mechanism served to support a multi-voiced deicticism, imperfectly realised. The presenter could speak on behalf of the artworks depicted in the images and quickly appear to change role (or shift persona) by moving in space to stand next to a different image.

The spatial configuration associated with the display ecology supported a change in

how the presenter *performed* analysis and knowledge production. This, in turn, provided a mechanism for the constrained freedom of interpretation which we described previously as being analogous to film. The techniques combined with other situational factors, such as the prior knowledge of the audience, the cumulative structure of the topics being discussed, and the constant (and therefore predictable) visually partitioned structure of the room to reduce inappropriate forms of cognitive load.[28] We wanted the experience of students to be intellectually participatory (germane cognitive load) yet as free as possible of confusing or overwhelming visual stimuli (extraneous cognitive load). We contend that the mechanisms of orchestration allowed us to achieve this. The less frequent episodic transitions, produced by having double the amount of slides but only transitioning approximately one-sixth the number of times due to the size of 'slide-chunks', seemed to enable a relaxed, contemplative atmosphere.

As well as cognitive interaction we also wanted to encourage more visible, interpersonal responses. Yet student reticence had not disappeared overnight. Students needed encouragement to speak and — more broadly — to develop their voice within the discipline. Partly, the rhetorical method used to provide this encouragement involved asking questions which students were empowered to answer using the visual materials being displayed. This is a form of visually-stimulated *prolepsis* — i.e. students were supported in anticipating and responding to the points of the presenters. This method went some way to address the imbalance in authority. Once a student had started to speak, the pedagogical task of encouraging them to flesh out their contributions more fully was rendered easier because the evidence underpinning their analysis remained available.

Students responded in a variety of ways supported by the presentation tool. Students themselves used laser pointers to support shared looking around the room in order to provide an evidential basis for their arguments. They referred to the screen 'over there'. On the other hand, we deliberately marked screens with numbers, but were not successful in encouraging presenters to cite these numbers in their verbal exposition. On some rare occasions, students stood up and walked to the screens, emulating the performance of the speaker. Taking inspiration from the Design, Functions, Tasks (DeFT)[29] framework for learning with multiple representations, students were encouraged to think in terms of contextualisation, complementarity and competition. For example: an anchor slide depicting an aerial photograph of the Sperlonga grotto was used to contextualise catalogue images of artefacts originally discovered there; different views of a wine vessel were provided to allow students to provide an argument which linked together the unfolding narrative across the vessel's surfaces; and, to encourage thinking about competing evidence, images providing divergent interpretations of a myth were used to allow students to contradict the presenter's interpretation.

The timescale of our intervention did not allow for these actions to develop to become ordinary practice within the community. We argue that these early signs are suggestive of a potential for new interaction between visualisation tools, modes of analysis and knowledge production that are appropriate within the contemporary

context of art history.

Vorsprung durch Technik[30]

Multi-display learning spaces, built around technological tools, can facilitate forms of complex argumentation well suited to current analytical methods such as visual culture studies and postmodern iconology. The audience can be invited to participate and to construct a shared analytical experience based on valuing and nurturing multiple perspectives. In contrast to Grimm's microscope analogy, multi-display learning spaces are perhaps closer to the spirit of Aby Warburg's *Mnemosyne* picture boards of the 1920s.[31] Warburg grouped visual evidence according to themes and used relationality as an analytical principle to drill towards what he termed the 'psycho-history' of images. The *Mnemosyne* and multi-display learning spaces share an apparently banal but fundamental concept with visual culture studies and postmodern iconology: that the knowledge to be derived from images studied within relational frameworks is more meaningful than the sum of what could be extrapolated from each image individually. If the relation between tool, analysis and knowledge production can be successfully developed to encapsulate such a fundamental and inescapable tenet, in the process it may offer art-historical methodology an alternative to its reliance on single-path verbal and textual analyses. Rather than being regarded as threatening to bring forth its obsolescence — as suggested by the title *Technology and the Death of Art History* of this conference — technology will have then made yet another core contribution to the discipline.

CHArt editorial note

This paper has been reviewed by Pauline de Souza in March 2011 and Ashley Harper in October 2011, and was subsequently revised by the Authors. CHArt wishes to thank both reviewers for their insightful comments.

Notes

All URLs valid at the time of writing.

1 See Huang, E.M., Mynatt, E.D. & Trimble, J. P. (2006) 'Displays in the Wild: Understanding the Dynamics and Evolution of a Display Ecology', *Lecture Notes in Computer Science*, 3968, pp. 321–336. The quoted text is from p. 321. Huang *et al.* describe how multiple displays support workplace collaboration between Mars Exploration Rover mission staff at the NASA Jet Propulsion Labs. One difference between this work and our own should be highlighted immediately. Huang et al. describe how different displays serve to *form* an ecology despite the individual displays not having been *designed* as a unified system. Our own work examines the use of an ecology of displays that are underpinned by a single technical system. Of course, other sources of information (such as personal devices) could also form part of such an ecology in principle, though we do not analyse the use of personal display technologies in this paper.

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6 Dilly, H. (1995), 'Die Bildwerfer: 121 Jahre kunstwissenschaftliche Dia-Projektion'. *Zwischen Markt und Museum. Rundbrief Fotografie*, Sonderheft 2, Göppingen: Museum Association of Baden-Württemberg, pp. 39–44; Nelson (2000), p.415.

7 Grimm, H. (1981) 'Die Umgestaltung der Universitätsvorlesungen über neuere Kunstgeschichte durch die Anwendung des Skioptikons (1892)', *Theorie der Fotografie I. 1839–1912*, Kemp, W. (ed.), Munich: Schirmer-Mosel.

8 Bligh, B., Lorenz, K. (2010) 'The rhetoric of Multi-Display Learning Spaces: exploratory experiences in visual art disciplines', *Seminar.net: International Journal of Media, Technology and Lifelong Learning*, 6:1. pp. 7–27. See particularly pp. 16–17 for an account of Wölfflin.

9 Fawcett, T. (1983) 'Visual facts and the Nineteenth-century art lecture', *Art History*, 6, pp. 442–460.

10 On the ideal beholder, see: Landsberger, F. (1924) *Heinrich Wölfflin*, Berlin: Elena Gottschalk, pp. 93–94.

11 On the epiphanic experience, see: Dilly, H. (1995), 'Die Bildwerfer: 121 Jahre kunstwissenschaftliche Dia-Projektion'. *Zwischen Markt und Museum. Rundbrief Fotografie*, Sonderheft 2, Göppingen: Museum Association of Baden-Württemberg, p. 42.

12 On visual culture studies, see: Bryson, N., Holly, M.A. and Moxey, K. (eds) (1994), *Visual Culture. Images and interpretations*, Middletown: Wesleyan University Press; Mirzoeff, N. (1999), *An Introduction to Visual Culture*, London: Routledge; Elkins, J. (2003), *Visual Studies: A sceptical introduction*, London: Routledge; Dikovitskaya, M. (2005), *Visual Culture: The study of the visual after the cultural turn*, Cambridge, MA: MIT Press. For a critical assessment, see Mitchell, W.J.T. (2002), 'Showing Seeing: A critique of visual culture', *Journal of Visual Culture* 1, pp. 165–181; Schulz, M. (2005), *Ordnungen der Bilder. Eine Einführung in die Bildwissenschaft*, Munich: Wilhelm Fink Verlag, pp. 86–124.

13 Bal, M. and Bryson, N. (1991), 'Semiotics and art history', *Art Bulletin* 73, p. 175.

14 Most recently: Mitchell, W.J.T. (2006) *What Do Pictures Want? The lifes and loves of images*, Chicago: Chicago University Press, pp. 28–56, esp. pp. 48–56.

15 On Panofsky's iconology, see Panofsky, E. [1939] *Studies in Iconology: Humanistic themes in the art of the Renaissance*, Boston: Westview Press, (1972); Ferretti, S. (1989) *Cassirer, Panofsky and Warburg: Symbol, Art and History*, New Haven: Yale University Press.

16 Tufte, E. (2006) *Beautiful Evidence*, Cheshire, CT: Graphics Press, p.158, emphasis in original.

17 Tufte, E. (2006) *Beautiful Evidence*, Cheshire, CT: Graphics Press, p.177.

18 Nelson (2000), p.420 considers the experience of an art historian watching a presentation by a medical doctor.

19 Alcolea-Banegas, J. (2009) 'Visual arguments in film', *Argumentation*, 23:2, pp. 259–275.

20 Tufte, E. (2006) *Beautiful Evidence*, Cheshire, CT: Graphics Press, pp. 170–171.

21 For a longer discussion on this topic, oriented towards a discussion of learning spaces, see Bligh, B. and Lorenz, K. (2010) 'The rhetoric of Multi-Display Learning Spaces: exploratory experiences in visual art disciplines', *Seminar.net: International Journal of Media, Technology and Lifelong Learning*, 6:1. pp. 7–27. See Bligh, B. & Sharples, M. (2010) 'The affordances of presentations in Multi-Display Learning Spaces for supporting small group discussion', *Lecture Notes in Computer Science*, 6383, pp. 464–469 for a technical overview.

22 Wenger, E. (1998) *Communities of Practice: learning, meaning and identity*. Cambridge: Cambridge University Press.

23 A Centre for Excellence in Teaching and Learning, funded by the Higher Education Funding

Council for England. See http://www.nottingham.ac.uk/visuallearninglab/ for more details.

24 See http://www.youtube.com/watch?v=cn9DasZpdps for a video overview of the PolyVision Thunder presentation tool.

25 See http://www.multi-slides.com/

26 Bligh, B. and Lorenz, K. (2010) 'The rhetoric of Multi-Display Learning Spaces: exploratory experiences in visual art disciplines', *Seminar.net: International Journal of Media, Technology and Lifelong Learning*, 6:1, p. 19.

27 The word chunk is used to mean a *subdivision* of an ongoing stream of information, chosen so as to support convenient recall later. We use the term by loose analogy with the term 'chunking', used in both psychology and computer science. One difference between these uses is that, in human cognition and machine memory management, chunks are usually constructed so as to be convenient relative to *memory* size; in our case, the choice is made because of the convenience of later *display*.

28 For a discussion on the limitations of applying cognitive load theory to classroom instruction and other orchestrated scenarios such as that discussed here, see de Jong, T. (2010) 'Cognitive load theory, educational research, and instructional design: some food for thought', *Instructional Science*, 38, pp.105–134.

29 Ainsworth, S. (2006) 'DeFT: A conceptual framework for considering learning with multiple representations', *Learning and Instruction*, 16, pp. 183–198.

30 *Vorsprung durch Technik* (Ger.), progress through technology, a slogan of German Audi car maker.

31 Warnke, M. And Brink, C. (eds) (2000), *Aby Warburg. Gesammelte Schriften. Studienausgabe: Der Bilderatlas Mnemosyne*, 2:2:1, Berlin: Akademie-Verlag.

