

Design as Externalization: enabling research

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Abstract

The article is concerned with a central contribution of designing to information visualization in the digital humanities. The activity is characterized as one of *externalization*, instantiation in visible or tangible form of ideas that might otherwise be internal to the minds of the designer and other participants. A spectrum of different interpretations of this process in the existing literature is discussed, focusing on early attempts to theorize designing as a means of creating new knowledge, and especially the ways in which that new knowledge contributes to defining or redefining the question or problem to be addressed. The arguments are illustrated with recent practical examples from the authors' own work in designing with a range of cultural organizations, museums and archives. The article concludes with reflections on how projects may best benefit from this work of design, empowering the designer as a co-researcher, alongside the historian, curator or other humanities scholar.

Keywords

Data visualization; Design methods; Design research; Prototyping; Externalization; Digital Humanities

Introduction

Our concern in this paper is with the contribution of *designing*, considered as an activity with associated experience and skills, to information visualization. In this paper, when we use the term *designer*, we are referring to someone taking on a particular role within projects – perhaps combined, as here, with other roles such as software development – not someone with a particular disciplinary pedigree. Within the many aspects of designing that might be discussed we will focus on one: the devising of early mock-ups, prototypes and examples as a means of progressing the design process. (In this article we use these terms loosely, referring to artifacts from low to high fidelity and of different media (Rudd, Stern & Isensee 1996)). We will treat such activity as one of *externalization*, the instantiation in visible or tangible form of ideas that might otherwise be internal to the minds of the designer and other participants. We will note several characterizations of this process that have been discussed by other authors (including in some key early texts from the time when information design and design research were emerging as identifiable fields) and describe, with recent practical examples, our own processes of designing with a range of cultural organizations – museums and archives – focusing on the role of such early-stage designing in the refinement and development of a range of data-visualization solutions. If it perhaps seems superfluous to discuss the roles of visual externalization for readers of this journal, we believe it is important to anatomize and reflect on such roles – not least because of the implications for how projects should best be conceptualized and conducted, and to support the ambition that design should have as an equal contributor to research.

Our visualizations discussed here share two characteristics: they are concerned with *nominal data*, which names and describes (through cataloguing) a quantity of individual objects within collections; and we emphasize the interpretive power of organizing such

objects according to time, in chronographic visualizations or timelines: Dörk, Pietsch and Credico (2017:41) note how pervasive the time attribute is in cultural collections, while Kräutli (2016:22) elucidates differences between timelines used merely as devices for linear storytelling and as tools for visual analysis, prioritizing – as we do – the use of visualized time as a means of sense-making (p.70-75). We do not focus on quantitative change over time but on other factors. In the present article we use our own work to illustrate different uses of externalization. Whitelaw (2015) and Dörk, Pietsch and Credico (2017) should also be consulted, particularly in relation to the use of visualization to *open up* cultural data to a range of users, which we do not discuss further here. While our examples are confined to data visualization, we believe that our observations may help to illuminate designing in other fields while at the same time identifying the history of some key theoretical contributions to this topic.

Before proceeding we note also that design, at one time commonly regarded as concerned only with the form of artifacts, is now often concerned with intangibles such as systems, services, strategies and policies, and with a broad range of ethical and political imperatives; our concern here is with the relatively narrow question of the visual expression of data and concepts, set within a critical approach. Our enumeration of the purposes of *making* is relevant not just to the disciplines of information visualization and design, but also to the digital humanities. This last discipline increasingly recognizes artifacts, tools, technologies and the processes of their making as substantive intellectual interventions rather than mere mechanisms, questioning the historically “higher status of interpretation, analysis, and abstraction over fabrication, application, and production” (Thompson Klein 2017). This has been described as a “maker turn”, where “meaning is derived from thinking with objects” – “interpretive objects” – and where embodiment is “an integral part of how meaning is made” (Staley 2017). The visual, its production and use, always central concerns of the Information Design Journal, are increasingly recognized within other disciplines that have traditionally been dominated by the word. The present article may therefore serve as a useful bridge between disciplinary debates.

Externalization as self-expression

From the rise of romanticism in the early nineteenth century, artists have been encouraged to express their emotions, world-view and other internal states through their art, and in the twentieth century this privilege has been extended to a few star designers. However, for the vast majority of those engaged in designing, this is not an aim, perhaps particularly in fields such as data visualization, where the designer is normally expected to make themselves as inconspicuous as possible, memorably metaphorized in relation to typography by Warde in 1932 through the term “crystal goblet”, the vessel that presents rather than obscures or distracts from its content (Warde 2009). Nevertheless Jänicke (2016) discerns a perhaps increasing mismatch between the expectation of novelty in computer science visualization and the often modest demands of humanities scholars: the latter’s objective is interpretive power rather than technical virtuosity. In our own work, we do not set out to impress with complex visuals but rather to assist museums and archives to use the simplest possible visual means to discover new knowledge about their collections and/or to engage their visitors and other clients with such knowledge.

Externalization as cognitive support

A wealth of theory engages with this important activity. In this mode, external representations act as a kind of prosthesis for the mind, discussed by Norman (1991) in terms of the “cognitive artifact” and by Scaife and Rogers (1996) as “external cognition.” Such external support for mental operations is not limited to visualization in the generally accepted sense of the term: writing and text, as Ong (1982), Havelock (1986) and Goody (1987) make clear, also enable the mind to do work that would otherwise be difficult or impossible. The idea of computational media as mental prosthetic is fundamental to the innovations of Bush (1945), Engelbart (1962), Nelson (1974) and Berners-Lee (1989), as the title of Engelbart’s essay “Augmenting Human Intellect” implies. In the memorable phrase of Spivey (2007: 264), arguing a dynamic model of perception and cognition, “an environment is essentially doing some of the thinking for the person within it.” Noël (2014) advances the value of diagramming as such an external artefact, particularly in relation to complex issues, emphasizing the iteration of diagrams within a cycle of increased understanding. Cognitive artifacts are a special case of Vygotsky’s psychological tools, “physical objects made by humans for the purpose of aiding, enhancing, or improving cognition” (Hutchins 1999: 126). To mention Vygotsky is immediately to suggest that these external representations do not solely augment the abilities of the author, but are shared – and therefore social – representations, a point to which we return later in the article.

Externalization as feedback

Visser argues that the activity of designing is fundamentally concerned with cognitive artifacts since each tentative representation not only captures the current state of a design, but also implies directions for further development (Visser 2006: xvi). This recalls Arnheim’s descriptions of sketches as “guiding images” whose role as externalization facilitates the design process as much as being an end in itself. A sketch may be tentative, generic and vague but this is a strength, since these qualities mean that it “stands for a whole range of possibilities without being tangibly committed to any one of them” (Arnheim 1993). Arnheim built on the observations of Goldschmidt (1991) who had specifically highlighted the dialogical role of such representations; the designer makes, observes, remakes, in an ongoing loop of action and reaction. Glanville and Pak (2010) particularly argue the model of conversation – an interactive, developmental activity. Their work unites Glanville’s lifelong engagement with cybernetics (in particular its emphasis on the dynamic, productive, ever-changing interaction between people and things), Pask’s conversation theory (Pask, Kallikourdis and Scott 1975), and Schön’s reflective practice (Schön 1983).

Iterative externalization is so common in the design world that we tend take it for granted; it just seems to be part of what we do. In our own recent projects, the iterative feedback process between maker and artifact is exemplified in Figures 1 and 2. The visualization projects, from which these prototypes/mock-ups derive, aim to map individual items from cultural datasets at a large enough size to be inspected. Strategies to balance focus/legibility and context/scale were explored through a cycle of make-reflect-remake. This is a standard process within any competent designing, and one in which two overlapping activities typically take place: the designer improves the fit of the emerging design to various aspects of the requirements, but also uses the external representation as a jumping-off point for new ideas, perhaps simply to conceive and trial new solutions, but potentially also to reconsider the original “question”. We discuss this second vital aspect below.



Figure 1. Olivia Vane. 2017. Exploring spatial and other visual variables to articulate a range of attributes and relationships in London Medical Officer of Health Reports, Wellcome Library.

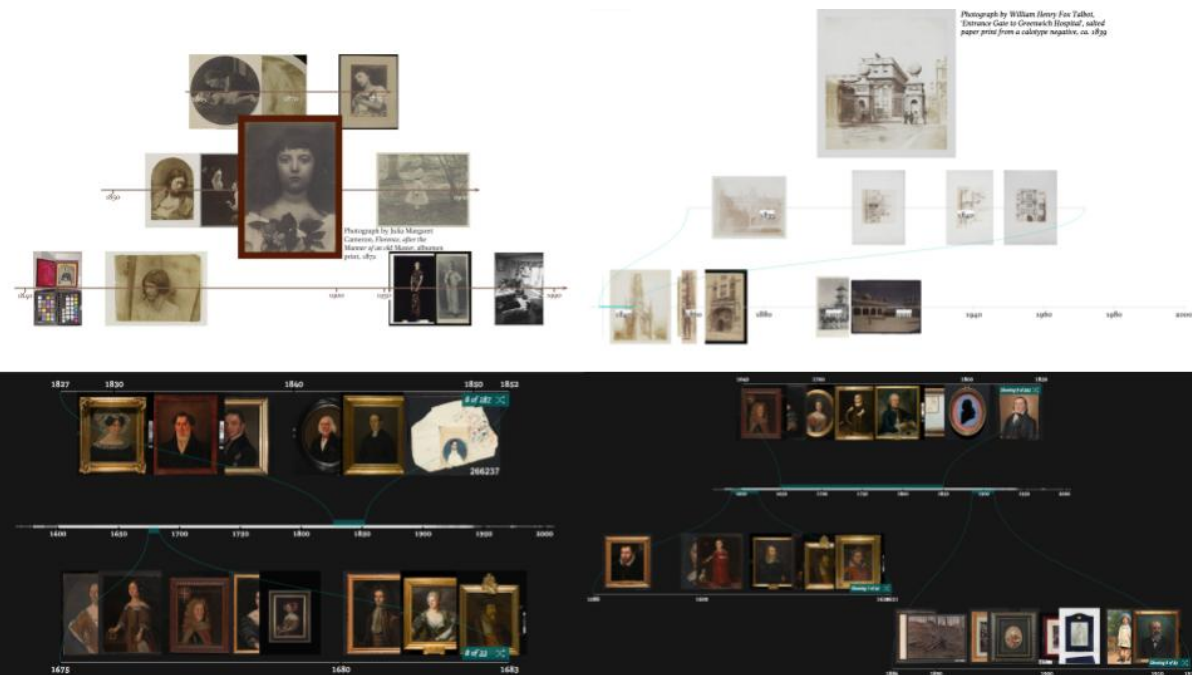


Figure 2. Olivia Vane. 2018. Exploring spatial and other visual variables to articulate a range of attributes and relationships in the Royal Photographic Society collection, Victoria & Albert Museum, London (above) and in portraits in the Nordic Museum, Stockholm collection (below).

As represented by Figure 1, the designer is working primarily alone, trying out a range of solutions. The central problem is how to squeeze as many time-ordered data-points into the display as possible, while also giving a sense of transparent access to the content of a large

number of texts, using snippets instead of resorting to mere dots for each occurrence. Dávila (2017: 25) has highlighted the poverty of the dot as a token for data. In that case, the motive is to articulate the human richness behind the dot, where our purpose is more prosaic: to enable the user to glimpse, in situ, the relevant content, combining detail and overview as far as possible (Cockburn, Karlson and Bederson 2009). Subsequent evaluations with academic historians confirmed that the evolved design made it seem possible to look through “all of the data at the same time” (Vane 2018: 156), but multiple iterations had been tried before a version suitable for exploring with historians was completed.

In Figure 2, the problem is similar, to support comparison of artworks from different times, while keeping the images large enough to make out. Here, example images from one period, and from different periods, can be viewed simultaneously on multiple timelines (Vane 2019). While the goal was again simplicity, many different algorithmic approaches to sampling the portraits were tried in an exploratory make-evaluate cycle. A distinctive feature of design-through-coding, as here, is that the results of changes cannot always be anticipated: feedback is not completely instantaneous. An implication of this iterative process is that the designer must be open to exploring an idea through a range of subtly or radically different representations. If, as is standard in information design and data visualization, the design is required to express a number of variables, such as date, degree of connection, certainty, category, etc., it is easy to exhaust the available graphic variables of hue, tone, texture, dimension, etc. (Bertin 1967, MacEachren 2001). Hard choices and compromises must be made, and new variations attempted. In the process the designer is highly attentive to the externalization, looking perceptively at, and reacting to, the emerging design, evaluating its effectiveness, seeking compromise between (and indeed re-balancing) requirements – “satisficing” (Simon 1956). It is this process that makes learning to see or to look a fundamental required skill in the designers’ education, whether formal or otherwise.

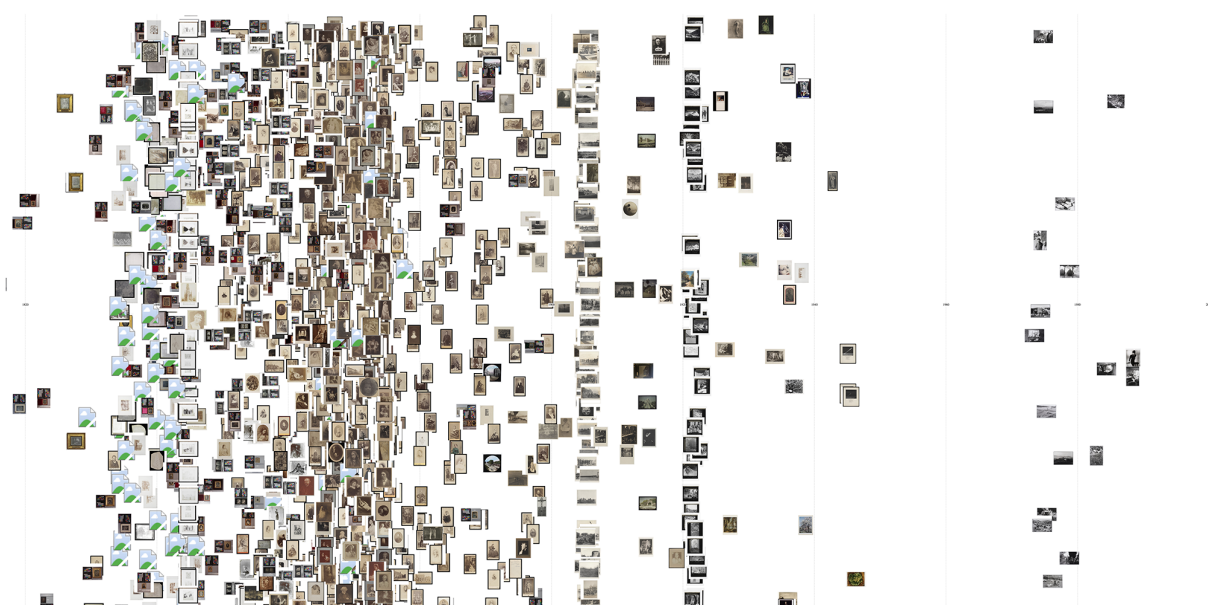
Externalization as conversation

The dialogic or conversational model of designing through tentative making can be conceived as a single, if powerful, feedback loop between the maker and the emerging artifact. But of course, rarely if ever is design an engagement by a solitary individual. Tentative designs will typically be subject to interactions involving colleagues, clients, manufacturers, programmers, end-users and a range of other stakeholders. In user-centered design, users may be consulted and tentative designs may be trialed; the emphasis will in some cases be on functionality, but increasingly on broader user experience. In participatory design, users have a significant role in the development cycle; their experience and opinions are valued beyond merely reacting to proposed designs; while in co-design, users are experts for whom designers may conceive their own role as that of facilitator, altering the balance of power in favor of the user. Not only are power-relations different in these three models – user-centric, participatory and co-design – there are also implications for how early the user is involved in the journey from initial ideation. In all these cases, the production of tentative designs is an essential component, and the communicative or provocative character of such artifacts extends more broadly. Specifically in data visualization, Lloyd & Dykes (2011) show how ‘data sketches’ (rapid prototypes made with real data) allow the designer to engage usefully with stakeholders. Stevens (2013) draws attention to the formative role of designs within the day-to-day activities and strategies of the *non*-designers with organizations; he builds on the work of Crilly et al. (2008) who had

earlier analyzed the multivalent role of artifacts as communicative objects. Kimbell (2011) calls for design to be re-characterized as a situated, contingent set of practices carried out between designers and those who engage with designers' activities – in other words as a profoundly social, non-solitary activity.

As we have indicated, making low-fidelity prototypes early in a project, even before the designer feels they fully understand the task, can help them better understand challenges in the space they are working; dialogue is elicited through making. Our example in this case concerns a project visualizing a historical photographs collection, The Royal Photographic Society (RPS) collection, at the Victoria and Albert (V&A) Museum, London. At the time of writing, the RPS collection is being digitized. Approximately 5,500 items had been digitally catalogued, and 2,500 had been photographed at the time of our collaboration.

We began our design process making rough plots laying out the collection data to get a better sense of what the collection consists of, how it distributes in time, and what attributes might be interesting to visualize. This came as a surprise to our partners at the museum, who had expected us to take our time familiarizing ourselves with the photographs rather than diving in to making. Our activity, almost instinctive at the time, mirrored the argument in the literature cited – that of defining and redefining the question, problem or issue through externalization. As is so often the case, the process of making these visualizations progressed through several of the stages we have described: in its earliest form it was a *cognitive support*, allowing the designer to visually explore the data and have ideas that would be difficult or impossible without making; later it was a node in the familiar *feedback* loop, where iterated variants of the emerging idea supported a cycle of making, thinking and re-making, probing different parts of the potential design-space, and then it became externalization *as conversation*, the aspect emphasized by van Amstel et al. (2016) when they argue the social production of design space as a socio-material rather than a cognitive process. We would suggest that externalization retains its early cognitive and feedback roles even when enmeshed in social, collaborative processes: it is a well from which the designer draws continuously as well as a location for dialogue. The externalization affords multiple actions and interactions.



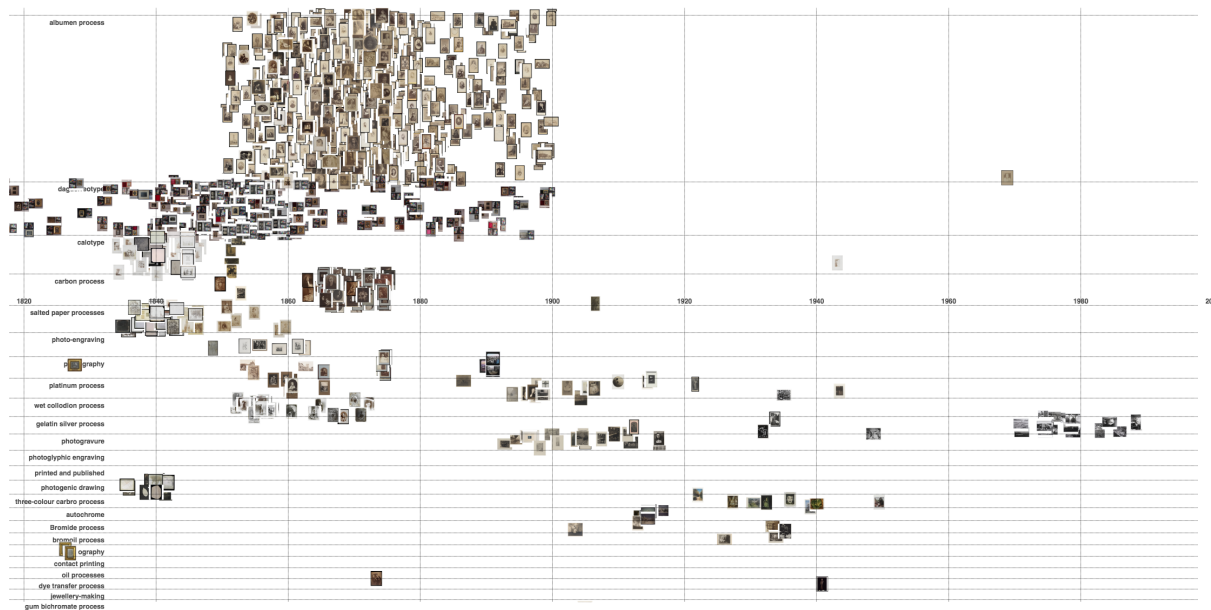


Figure 3. Olivia Vane. 2018. Rough prototypes visualizing Royal Photographic Society collection at the Victoria & Albert Museum by a range of attributes.

As the RPS visualization developed, we plotted the data by time and a range of other relationships offered by the dataset – separating the data by photographer, by photographic technique, and by theme (Figure 3). Through discussing these rough plots with staff at the museum, we quickly realized the shapes revealed by visualizing the collection this way were greatly skewed by what items had been prioritized for digitization. Only about 2% of this collection had been digitized at the time and the biases in those choices were overshadowing larger historical trends. These plots also revealed that some plentiful but similar types of photographs, such as widely-produced portraits, were overwhelming other content. The tendency for visualization to reveal as much about the internal practices of the institution, as about the collection considered in the abstract, is discussed by Kräutli (2016:147 fol.). In the words of Bailey and Pregill (2014), “visualization serves to place the individual item within the context of both the larger collection and the evolution of the institution itself.” Kräutli went on to use visualization explicitly to analyze the museum processes to which collections have been subject, making visible the internal transactions of the museum that are so often occluded (Kräutli 2016:215-217). A key aspect is absence. Priestley was perhaps the first maker of visualizations to note how the “thin and void places” in a chart are significant in their own right (Priestley 1764: 24; Boyd Davis 2019). Trouillot (2015:25) identifies the multiple opportunities for invisibility in relation to historiography, while Klein highlights the importance of such “archival silence” in visible records (Klein 2013). She particularly argues the need to use the visible as merely a starting point for contextualized inquiry that may include actively seeking lost data, lost connections and the forces that may have produced them. This is an important way that visual externalization can become a motive force, rather than merely a mechanism, in humanities research.

Through gaining a better understanding of the V&A RPS dataset’s qualities with quick prototyping in conversation with stakeholders at the museum, we were prompted to shift direction in the project. Since our focus for this project was to highlight the photographic

content rather than institutional practices, we explored visualization design that deliberately did *not* emphasize the overall shape of the collection.

If one extreme of the feedback loop is not a single individual, neither does the emerging artifact exist in isolation: the designer (and other participants) can be considered as interacting with – and altering – a surrounding culture. Part of this contextual environment is their own ongoing experience: designers “learn a repertoire of concepts, schemas, and strategies,” and draw from this repertoire “to design representations and action for unique situations” (Argyris 1985: 81). Second-order cybernetics accounts for this in terms of nested loops which each inform the other (Glanville 2007, Sweeting 2016). In some cases, the interactive context includes the intellectual frameworks, questions and assumptions of academic inquiry. This is the domain of *critical making* (Ratto 2011) in which “the site of knowledge creation is the process in conversation with a discipline’s scholarly research” (Hunter 2018:173); the application of these ideas to data visualization is discussed in Boyd Davis and Kräutli (2015). This brings us to the final category in our overview of the roles of the external artifact in the design process, which we have already alluded to several times.

Externalization as research

There is an ever-growing literature of design-as-research. We mention here some key earlier interventions in this field, not always acknowledged. Rust et al. (2000: 403) highlighted the way design and production of artifacts might be “instrumental in eliciting knowledge”; earlier, Frayling (1993) offered an often-cited triad of relationships between “research into art and design”, “research through art and design” and “research for art and design”. Though he described his triad as “derived from Herbert Read” he was also building on the work of Archer (1995) who distinguished “research about practice”, “research for the purposes of practice” and “research through practice”. Of this last, Archer claimed that “It is when research activity is carried out through the medium of practitioner activity that the case becomes interesting. There are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test it.” We have discussed elsewhere the turn-around in Archer’s thinking (Boyd Davis and Gristwood 2018); given its relevance to our argument, we summarize it here again briefly.

Archer was originally ambitious to turn design into a kind of science. Given his conception of science at the time, he assumed that one begins designing by gathering all the data and the requirements and assigning them appropriate weights. Designs are then developed and tested in a rigorous iterative process leading to a more or less successful solution answering the original requirements. The original problem, question or issue is not however reconsidered. As a result of his experience of complex, multi-stakeholder projects at the intersection of multiple requirements and disciplines, he radically altered his view, now summarized in some key phrases: he notes that “during the course of the problem solving activity new objectives may tend to form and re-form” (Archer, 1968: §2.29). These are not minor adjustments in the light of changing circumstances, rather, “any effective design procedure must therefore permit *radical reappraisal* of the problem *at any stage*” (Archer, 1968: §6:17, emphasis added). The requirements to which the designers thought they were responding may be subject to revision at almost any point. These changes in his thinking later led Archer to propose a then radical idea: that design is a unique means of

interrogating the world, on a par with, and different from, the textual humanities and the sciences (Archer 1979).

Others have developed this theme, all emphasizing the role of the emergent design(s) as instantiation – and elicitation – of knowledge. As Rittel put it, “the irritating thing is that, depending on the state of solution, the next question for additional information is unique and dependent on the state of solution you have already reached” (Rittel 1972:392). For Schön (1983:18), “professional practice has at least as much to do with finding the problem as with solving the problem found”. Problem *setting* is Schön’s alternative to the conventional emphasis on design as problem *solving*. For him, “problems do not present themselves to the practitioner as givens.” It may fall to the designer to “make sense of an uncertain situation that initially makes no sense” (p.39). This problem-setting may be judged by “the quality and direction of the reflective conversation to which it leads” (p.135), echoing the conversational model discussed above. For Buchanan (1992:17) “A quasi-subject matter is not an undetermined subject waiting to be made determinate. It is an indeterminate subject waiting to be made specific and concrete.” Lest this be seen as a problem peculiar to the humanities, Tukey noted forty years ago that “Science ... DOES NOT BEGIN WITH A TIDY QUESTION.” (p.24, original capitalization)” (Tukey 1980:24). His plea for exploratory data visualization is echoed in MacEachren’s (2001: 29) advocacy of visualization as a means to explore data, and through that exploration to *generate hypotheses*, not simply to develop solutions to problems, and to construct knowledge. Mirel and Allmendinger (2004: 141) rightly emphasize this capturing of the *emergent* – the unexpected possibilities that can arise at any point of the problem-solving process, while Pontis (2014: 118) highlights the recursive interpenetration of conceptual design and prototype design: the stages are not linear, but overlap or go back to previous states if emerging content requires it. Dorst and Cross (2001) characterize the key role of feedback into the original brief or problem: “design is not a matter of first fixing the problem and then searching for a satisfactory solution concept.” Instead it involves “constant iteration of analysis, synthesis and evaluation processes between the two notional design ‘spaces’ – problem space and solution space.” The problem space and the solution space co-evolve together, with interchange of information between the two.

To design through the production of artifacts may seem at first sight to be working in the *wrong order*: surely the question should be pinned down before the answer is attempted? But a key contribution of designing may be to transform or subvert the original question: it may make apparent new possibilities that could not have been foreseen without instantiation through visualization. A tentative design acts not only as a corrective, allowing a poor question or specification to be improved, but also as a provocation – even an inspiration – to further questions. Nowhere is this more true than in the visualization of cultural data, where some questions are obvious because they are traditional, but others may be new because the means to ask them were not previously available. This gives the emerging design a key role in research, by provoking or advancing new issues or questions.

In our own practical work, we use externalization in this way – for thinking through the issues and challenges around a project, informing the direction of our work and engaging with stakeholders, and generating new research questions. In a visualization project with the Cooper Hewitt Smithsonian Design Museum, New York City, we were interested to trace

themes through time across their digitized collection. One project produced another, because the first made apparent what might be possible in the second. Initially our attention was drawn to tagging in the collection data: informal, descriptive labels used thematically at Cooper Hewitt. To begin with, we experimented with visualizing tags in collection data against time, testing ideas through mock-ups and prototypes (see Figure 4). For instance, we trialed various ways to map the data by time, which was a challenge in this dataset as much of the historical date information was uncertain and/or imprecise (as it so often is (Kräutli and Boyd Davis 2013; Cottrell 2017)).

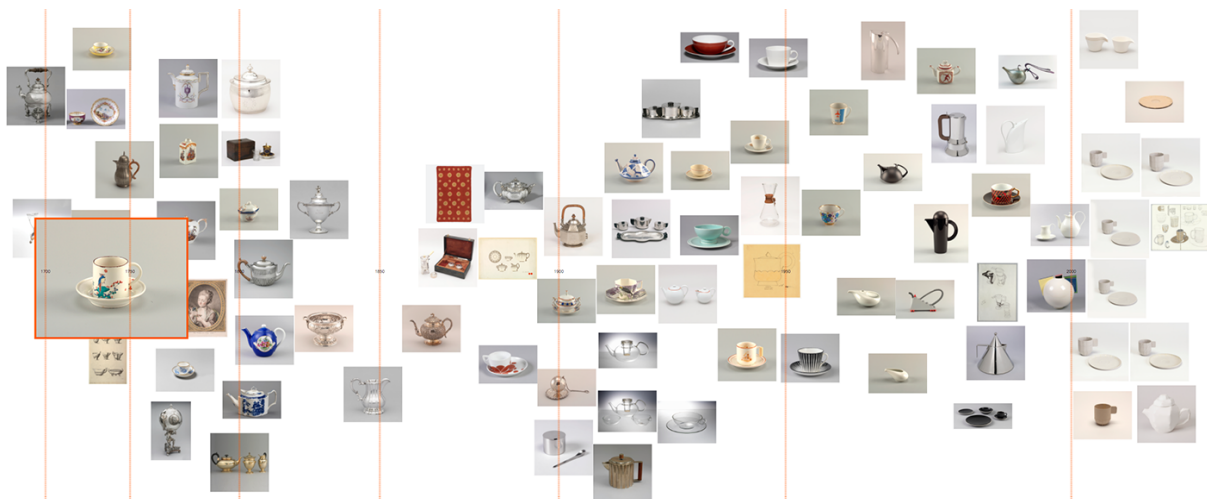


Figure 4. Olivia Vane. 2017. Prototype visualizing items tagged 'coffee and tea drinking' in the Cooper Hewitt Smithsonian Design Museum collection horizontally by date.

Throughout this project, we worked closely with staff at the museum. Discussing our timeline prototype with the curators prompted them to suggest that the template we had developed could work well for visualizing the collection by color. Adapting the visualization to color could facilitate tracing color trends and innovations through history. Changing the direction of the project in response to this new area of interest, we developed an interface exhibited by the museum that works with a color search (see Figure 5). We believe the curators would have been unable to foresee the potential for such an interface if they had not been inspired by the earlier prototype.

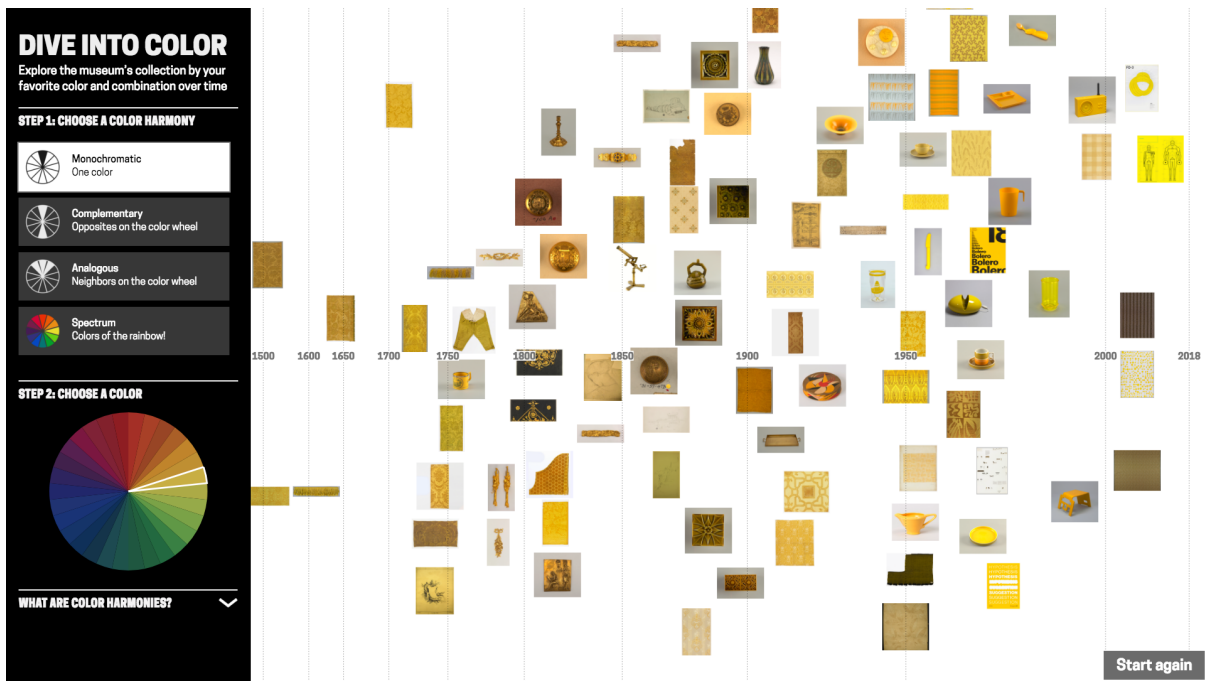


Figure 5. Olivia Vane. 2018. 'Dive into Color', visualizing the Cooper Hewitt Smithsonian Design Museum collection by color and date.

The new color theme to the project demanded new elements in the user interface design, including a way to select colors to search by. We experimented with mapping an extensive palette of colors to a color wheel, to use as a search input. We trialed various ways to do this: mapping color values as dots round a radial hue map; or drawing circle sectors divided concentrically for the different colors (see Figure 6).

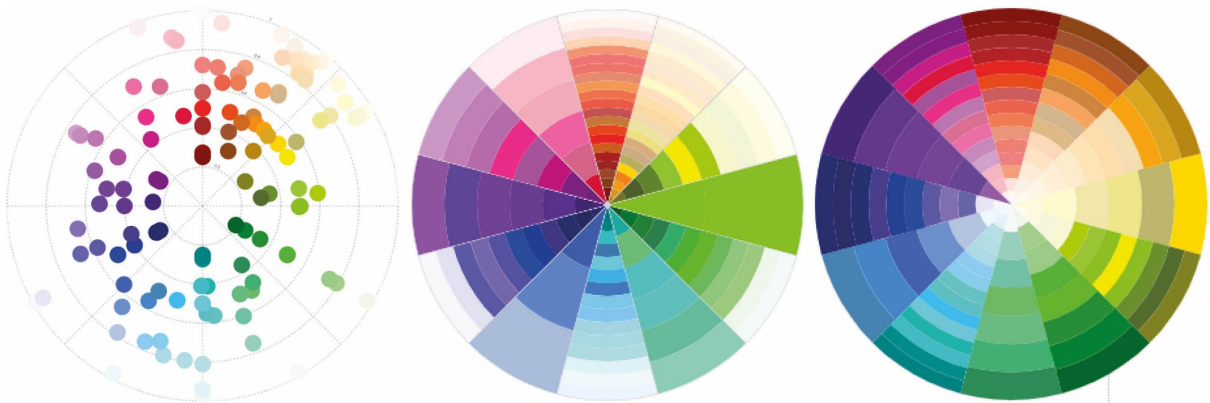


Figure 6. Olivia Vane. 2017. Prototypes mapping a wide color palette to a color wheel

While creating these visual examples, we realized the sector technique could be applied to an individual item's color palette. Rather than serving as an input, this would be purely informational: the graphic reveals the color wheel relationships between the colors present in the item's palette (see Figure 7). These relationships (for example opposites or neighbors) determine the color relationships exploited in the design – for most users a new way to understand color data in the collection. It was also topical, as the museum curators were working towards an exhibition around color theory and design: the stimulus of the earlier

tag-based design and the timely opportunity for novel interrogation and presentation of the collection together had produced a new brief and a new set of research questions.



Figure 7. Olivia Vane. 2018. Graphic mapping an item's color palette to a color wheel. Cooper Hewitt Smithsonian Design Museum collection. In the upper example, users can clearly see the use of complementary colors, on opposite sides of the color circle, while in the lower example a very different color harmony arises from the use of adjacent colors.

The color wheel graphic for an individual item's palette became part of the final design, while the original search-input experiments were abandoned for a standard color wheel design. Externalization had prompted us to identify new possibilities by connecting the visual forms we had created for one element of the design to a different element.

Implications

Among the implications from the theory and practice outlined above, we focus on the designer-as-researcher and the consequences for the overall conceptualization of the design role, including the project specification and skills required.

We noted earlier how the visual has tended to be excluded from debates on digital humanities. The value of externalization is obvious to most readers of this journal but, until recently, the world of digital humanities has been dominated by concerns over relations between just two disciplines – computing and the humanities – and the idea that design may have a fundamental role to play has been neglected. An exception is Drucker, who has highlighted the interpretive role of the visual along her career (eg. Drucker 1984; 2014) including in collaboration with Nowviskie, where they described their task as to “overcome humanists’ long-standing resistance (ranging from passively ignorant to actively hostile) to visual forms of knowledge production” (Drucker and Nowviskie 2004:431). Their demand that “The computational processes that serve speculative inquiry must be dynamic and constitutive in their operation, not merely procedural and mechanistic” (ibid) can be considered definitional for our category *externalization as research*.

Clearly, software development is vital to the life of digital humanities projects, but as Biemann et al. (2014) note, there can be mutual incomprehension between programmers and humanists; designing is not a key part of Biemann’s argument, but the potential for designs to act as common ground between the other disciplines, both enhancing mutual understanding and surfacing new questions, is clear. But designing must be integral to the development of projects from the outset, if the advantages of its contribution to the problem definition or research question are to be realized with full effectiveness. The present authors are well aware that they have been privileged: our projects over several years have used public funding to support extended collaborations with cultural organizations from small university museums to national archives, from the works of single individuals to large heterogeneous collections. In the U.K, museums are increasingly inclined towards university research, in part because public funding for collaborative doctoral awards has over recent years been made directly available to them, but the appetite to engage with both visual methods and research goes beyond the merely pragmatic – an exceptional opportunity to demonstrate the research value of design.

Coding of course has its own valid claims to be an intellectual driver. Endres (2017) remarks that “Code underpins digital scholarship and affects what can be known, its reliability, and what can be envisioned as possible” (the emphasis on vision is noteworthy). He argues the necessity of the “literacy of building” – beyond mere competence in programming, this recognizes “knowledge of coding [...] for envisioning and assessing current possibilities, analyzing and critiquing digital structures, understanding digitally generated ontologies, and apprehending the epistemic principles enmeshed in layers of code.” Alvarado (2012) feared that it would be almost impossible for anyone to combine the necessary deep understanding of the humanities and the required competence in programming and other relevant technologies (p.53), but there are signs of emerging cross-disciplinary individuals who, even if they do not excel in all the necessary domains, have the necessary language and awareness to cross discipline boundaries, especially as part of a multidisciplinary team. Our own projects have exploited this combination of design and coding within the skillset of individuals. Both Endres and Alvarado, like so many, neglect the design function: we would argue that, given the power of visual externalization outlined above, designing has a particular potential to act as the site of dialogue and collective progress – but as designers

we need to have both the intellectual and practical arguments to hand, if we are to make that case effectively.

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