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LIGHT BULBS, CRICKET MATCHES, AND *Talk Softly Please*: ON THE SEMANTICS OF DIGITAL CONNECTIONS

To explain his far-famed maxim, »the medium is the message,«[1] Marshall McLuhan cited the example of a simple light bulb. A light bulb contains no content in the usual sense, yet it still conveys a message: It forms our environments and influences our actions, attitudes, schedules, and arrangements of everyday life. »Whether the light is being used for brain surgery or night baseball is a matter of indifference,« McLuhan claims. As a medium, however, it »shapes and controls the scale and form of human association and action.«[2] But what happens when this very light bulb enters the digital archive? Consider these three representations of bulbs (see Figure 1).

In the digital archive, the light bulb is deprived of its mediality. It neither lights up nor flickers; it no longer creates an environment. But it becomes the ›content‹ of another medium – the digital archive. How we make sense of the bulbs now depends entirely on the presentation in or through the archive. The first bulb is *represented* as a medical instrument of the early 19th century; on the second image, a set of bulbs is *described* in terms of their manufacture; and the Marconi radio valve is *introduced* as an instance of a certain bulb type. What McLuhan called »the matter of indifference«[3] suddenly comes to the fore: the context of the light bulb, i.e., how it is described and represented.

This brief exercise in media theory makes apparent that the order of the archive – the way it represents objects and gives them meaning – is a message, too. The digital archive displays and situates the object; it defines its relationships, assigns it to categories, frames it with words, descriptions, numbers, dates, and other artifacts. In so doing, it shapes the background and context of a thing, sets the framework for the user's interpretation thereof, and defines how the artifact in question relates to other objects in the archive.

1 Marshall McLuhan. *Understanding Media: The Extensions of Man*. New York: Signet Books, 1964, p. 1 (and the entire Chapter 1).
2 Ibid, pp. 23-24.
3 Ibid, p. 23.

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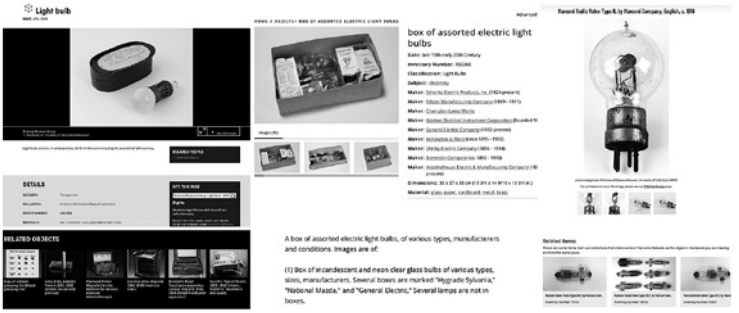

Figure 1: The representations of light bulbs in three digital collections: the Science Museum Group, the Collection of Historical Scientific Instruments (Harvard University), and the History of Science Museum at the University of Oxford. Courtesy of and copyright by the Science Museum Group, the Collection of Historical Scientific Instruments (Harvard University), and History of Science Museum at the University of Oxford. Screenshots taken by the author, January 2023.

This paper is concerned mainly with the latter point: connectivity and linkage.[4] The capacity to model and represent the connections between items is a hallmark of a digital collection, unlike the traditional archive. The digital archive owes this power to its technical *dispositif*, as detailed in Media Archaeology and Digital Memory Studies.[5] The traditional archive seeks to preserve things in their integrity and original form; the digital archive operates not with things in their entirety but with discrete bits and pieces, with zeros and ones, devoid of any semantics per se, yet open to manipulation. Digital collections thus sacrifice the alluring *goût de l'archive*[6] for creating unprecedented forms of access and modeling the past. The power to establish relations between objects is one of the manifestations of these new capacities.

If the archive connects and disconnects, those connections and symptomatic absences must be traced, mapped, and explicated. As Geoffrey Bowker and Susan Leigh Star noted in their study of classification, »every link […] reflects some judgement about two or more objects: They are the same, or

4 This work was supported by the Fonds National Suisse (grant number P0ELP1_192402).

5 Cf. Wolfgang Ernst. *Digital Memory and the Archive*. Minneapolis: University of Minnesota Press, 2012; Bruno Bachimont. *Patrimoine et numérique: Technique et politique de la mémoire*. Paris: INA, 2020.

6 Arlette Farge. *Le goût de l'archive*. Paris: Seuil, 1997.

alike, or functionally linked, or linked as part of an unfolding series.«[7] So how and on what grounds do archives link items? What is the place of the connections among other forms of archival ›categorical work‹? How do these ties operate? And what are their implications for object representation?

1. Digital Archives of Scientific Residuals

This analysis relies on a special type of digital collection, namely, the archives of scientific residuals – collections that incorporate the by-products of scientific knowledge production, such as drafts, protocols of experiments, obsolete scientific instruments, photographs, and other outdated documentation of the laboratory routine. Left behind by science, they are crucial to the history of science, inasmuch as they bear testimony to certain facets of science in the making.

This paper forms part of a larger dissertation project exploring how the residuals of science get represented in digital collections and how to reengage them in producing knowledge. The project draws on a corpus of around 120 collections, which allows for making both qualitative and quantitative inferences. Without describing the corpus in detail,[8] this paper nevertheless draws on it as a basis for some generalizing reflections.

At the center of this essay lies a close reading of one particular archive, the Cavendish Laboratory Collection, displayed by the Cambridge Digital Library.[9] Featuring photographs and correspondence from the mid-19th century to the 1970s, the collection serves as the backstage area of the renowned scientific institution. The history of the laboratory, filled with Nobel prizes and groundbreaking discoveries, has been documented in some monographs and is quite well known. That makes it all the more interesting to see how it is refracted and imagined in the digital collection. The paper looks closely at how the connections in the Cavendish laboratory collection are arranged

7 Geoffrey C. Bowker and Susan Leigh Star. *Sorting Things Out: Classification and Its Consequences*. Cambridge: MIT Press, 2000, p. 7.

8 For the complete list of collections and the statistical data, see (https://zenodo.org/record/7853611#.ZELb8S9Bw_U, accessed 13 March 2023). The main criterion in selecting collections was the objects exhibited: I sampled only those collections that displayed neither scientific publications nor scientific data but the residues of scientific practices. The corpus encompasses various genres and types of collections of scientific residues from across countries and scientific disciplines.

9 The Cavendish laboratory collection/ Cambridge Digital Library (https://cudl.lib.cam.ac.uk/collections/cavendish, accessed 13 March 2023).

and then takes a broader perspective on how different links function in the digital archive.

2. Networking the Cavendish Laboratory Collection

Let us start with the bare structure of object relations in the digital collection.[10] The inquiry uses network analysis and its metrics to calculate various indices of influence, isolation, and connectivity. The technical language of network analysis allows for exposing the connections and ruptures within the collection, the degree of its cohesion (*connectivity*), the importance (*centrality*) of some of the objects (*nodes*), and the exclusion (*isolation*) of other ones.[11] Once one asks how the influence is distributed among the nodes and what the implications of this distribution are, this structural analysis turns into interpretation. As I show, the very structure of the collection is signifying and telling, indicative of how the institution's past is imagined, marked out, and expressed.

My analysis of the collection structure draws on two network visualizations (see Figure 2).[12] The ›subject network‹ displays relations between the subject categories and the objects they describe; this network exposes the

10 The collection does not make use of ontologies or controlled vocabularies. The metadata system – in particular, the subject categories and relations between objects – was developed manually in spreadsheets and subsequently converted to TEI elements. The records in the collection are described by means of a fairly common metadata grid, including physical location, place of origin, dates, creators, materials, format, and extent. In addition, one of the metadata fields used is »Note(s),« which specifies the so-called »associated images« for a particular artifact. The elaborated vocabulary of subject metadata as well as the »associated pictures« form the basis of this analysis.

11 The technical terms from the network analysis are given in parentheses. For a more detailed discussion of these, see, for example, Robert A. Hanneman and Mark Riddle. Introduction to Social Network Methods. Riverside, CA: University of California, 2005. (http://faculty.ucr.edu/~hanneman/nettext/, accessed 13 March 2023).

12 The networks were built in the Gephi software based on data harvested from the collection website (raw data can be found at the link above – see footnote 6). Both cases used the Force Atlas layout algorithm. On the network visualizations and below, I indicate the serial number of the artifacts starting with »P.« All the items can be accessed via Cambridge Digital Library (https://cudl.lib.cam.ac.uk/view/PH-CAVENDISH-P-00000, accessed 13 March 2023), where the ending zeros are to be replaced by the corresponding number.

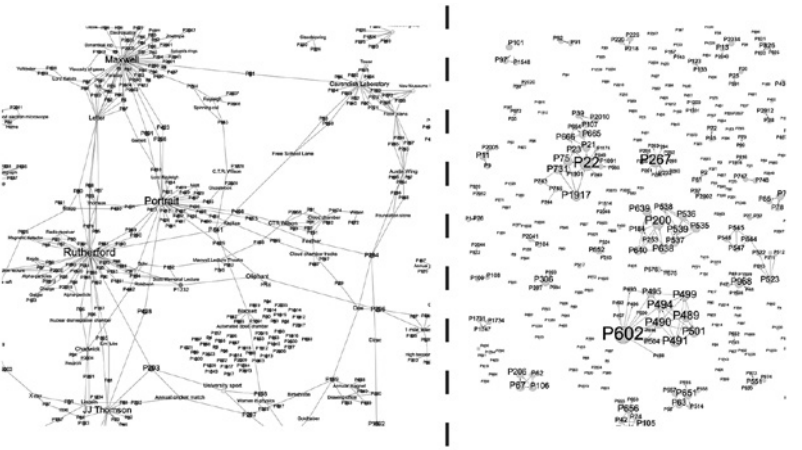

Figure 2: The fragments of the subject and object networks. The subject network (on the left) shows how the collection artifacts are interconnected through subjects (the categories used to classify the collection). In the visualization, subjects and objects are nodes, and edges represent their relationships. Objects are labeled with their ordinal number in the collection. The size of the nodes reflects the betweenness centrality: The larger the node and its label, the more important it is for the cohesion of the network. The object network (on the right) reflects the direct links between archival objects as mapped in the archive. The size of the nodes again reflects the betweenness centrality.

mediating function of the subject classification of the collection.[13] It shows how archival markup bridges, binds together disparate archival items, and makes sense of them.

Regarding the overall structure, the ›subject network‹ comprises one big, interconnected hub that consolidates most of the nodes, several separate clusters grouped by one or more subjects, and isolated standalone nodes without ties. Statistically, more than two-thirds of archival artifacts are defined by one or two relationships, about 15 percent are described by 3 connections, and about 10 percent have no ties at all. More often than not, the object in the collection is described by only one or two categories, which can be interpreted as a tendency toward stabilization of the artifact's meaning and interpretation.

Regarding the importance of individual nodes, I rely on the so-called »betweenness centrality,«[14] which shows how important a particular node

13 Only subjects that link at least two artifacts are included in the network.

14 Linton Freeman. »A set of measures of centrality based on betweenness.« *Sociometry*. 40 (1), 1977: 35-41.

is for the cohesion of the network. The top-ten list of the nodes with the highest betweenness centrality includes as many as seven subject categories representing proper names:[15] »Rutherford« (29334), »Maxwell« (22249), »Thompson« (20151), »Cockcroft« (10431), »Aston« (8810), »Oliphant« (7230), »Dee« (5820) (the three remaining entries being »Portrait« (27587), »Letter« (7530), and »Cavendish Laboratory« (7484)). The network thus perfectly captures the lens chosen to represent the history of the Cavendish Laboratory. It is framed as a personalistic history of the ›great physicists.‹ A proper name – as opposed to an instrument, a discovery, an institution – serves as the main reference point of that history.

Using big names for classification is quite a straightforward strategy. On the one hand, it orients the user in their navigation through myriads of machines, faces, and artifacts; on the other hand, the association with great scientists is also a form of legitimization and valorization of the artifacts in the collection. Representing the lab history through names inevitably obscures other facets of the story: that of instruments, of institutions, of the science-in-the-making. But, perhaps most importantly, it relegates the history of the laboratory as a collective endeavor to the background, rendering untraceable the very communal laboratory practices. Even the most generic of the statistically significant categories, »Cavendish Laboratory,« is used to describe building plans instead of, for example, group photographs of the laboratory staff.

Another curious effect of the personalized markup is that the most influential objects in the archive are those photographs that depict several ›influential names‹ together. In terms of structure, the most important object of the archive turns out to be a photograph of Rutherford and Thomson at a cricket match (P203). Its exceptionally high betweenness centrality (12029) is explained by the fact that it brings together three statistically important categories at once: »Rutherford« (29334), »Thomson« (20151), and »Annual cricket match« (4173) (see Figure 3). Yet, despite the statistical significance, this artifact is hardly a key to the history of the Cavendish Laboratory.

Let us now turn to the network representing the direct connections between objects.[16] Whereas the ›subject network‹ does link most of the collection, here the ties between objects fail to even form a central interconnected cluster. 44 percent of the network nodes are completely isolated, meaning they have

15 Hereinafter in parentheses are the values of betweenness centrality, rounded to whole integers.

16 In the digital archive, the connections between objects are identified in the metadata field »Note(s): Associated images.« I followed those in constructing this network.

Figure 3: Photographs from the Cavendish Laboratory Collection. The image on the left is »Rutherford and JJ Thomson at the annual cricket match (1936)« (P203); on the right is »Talk Softly Please« (P184). Courtesy of and copyright by the Cavendish Laboratory, University of Cambridge.

no connections with other objects, while another 21 percent have connections with one object and 16 percent with two objects. Consequently, the network does not represent a single coherent whole but a multitude of disparate fragments, sometimes forming small regions of meanings and relationships.

The logic of connecting nodes in this network has nothing to do with the personalistic order we observed in the ›subject network‹. The history of ›big names‹ here is substituted by microconnections between devices. The archive connects either the photographs of the same apparatus, for instance, multiple images of Maxwell's color wheel; or various parts of one apparatus, such as Van de Graaff's ion source, its base, its vacuum pump gauge, its magnet and its target room, or apparatuses located in close proximity to each other, such as in the same room. Two circumstances are of interest here: First, none of the connections trace persons; only the instruments are related and relatable, leaving the person – if at all – in the picture merely to serve as a background for the devices next to them. The second observation is just how static and rigid the established relations are. They register only some adjacency or proximity of the two instruments or their parts. In neither case does the connection allow for an amplification, unfolding, development, tracking changes, or tracing continuities, for instance, between different machines.

This is even more evident in the famous photograph *Talk Softly Please* (see Figure 3), one of the symbols of the laboratory. Taken in 1932 by C.E. Wynn-Williams, the photograph shows Ernest Rutherford and J.A. Ratcliffe

talking in the drawing engineering office. A panel saying »Talk Softly Please« is lit above them, and a machine for detecting and counting particles, the so-called Wynn-Williams-Ward amplifier, is situated on a cart in front of them. In the network, the photograph is linked directly to the three objects: photographs of the annular magnet (P639) and the drawing office (P200, P253). Therefore, the connection is predicated on two grounds: either the setting, the drawing room, or the magnet, a small fragment of which can be discerned in the bottom right corner of the picture. That is the only tie made. Not one additional connection, not one additional meaning, not one additional context is traced.

Mapping the missing connections could be a worthwhile exercise in history-of-science analysis. At this point, I wish to note only a few of the most significant omissions. First and foremost, none of the links associates the photograph with Rutherford or his interlocutor. Further, the magnet that binds several items together was in fact used to study alpha particles by the four physicists,[17] each of whom had something to do with the photograph. Rutherford, Wynn-Williams, and B.V. Bowden designed the »Talk Softly Please« panel, and Lewis wrote a detailed essay based on this photograph.[18] Next, the Wynn-Williams and Ward amplifier invites one to trace both the history of its invention and modification and the history of its use, vital to counting practices in nuclear physics. Following the same adjacency logic, one can establish many more ties, connecting the photo with the images of James Chadwick's laboratory, where the open door on the left side of the picture leads, with the researchers who worked in this notorious drawing office and further with the machines they worked on and their actual research. Finally, the context of the photograph itself as well as the history of its reproduction and citation history are also worth considering. I outline these overlooked and neglected contexts to point to numerous perspectives and ways of making sense of the item, which might alternatively have been applied in the digital archive. Instead, the archive contextualizes such an iconic object as the »Talk Softly Please« by drawing on spatial and object proximity, using location and a piece of magnet.

17 Cf. Ernest Rutherford et al. »Analysis of α-Rays by an Annular Magnetic Field.« In: *Proceedings of the Royal Society of London*. Series A, 1933, 139:839, pp. 617-637.

18 Wilfrid B. Lewis. The development of electrical counting methods in the Cavendish. In: John Hendry (ed.) *Cambridge Physics in the Thirties*. Bristol: Adam Hilger, 1984, pp. 133-136.

3. Between Subject and Object Connections

The two networks were constructed following the logic of the archive: Subject metadata and direct object links seemed to be the major forms of creating archival order, of linking and detaching objects. These two types of networking echo the two facets of order as defined by Michel Foucault:

> Order is, at one and the same time, that which is given in things as their inner law, the hidden network that determines the way they confront one another, and also that which has no existence except in the grid created by a glance, an examination, a language.[19]

Subject relations are produced in language, through words, and by assigning objects to categories, while direct object relations describe things through their confrontation, connection, and association with other things. Subjects fix the ›aboutness‹ of things, while object relations only grasp some associative connection between two artifacts.[20] Subjects generally represent a much more common way of semantizing an archive than direct links between objects. Out of the 119 collections in the corpus, 80 percent are structured through subject relations, while only 30 percent establish ties between items. As seen in the Cavendish example, these ties do not always add much meaning to the objects they describe. Yet, establishing ›related objects‹ seems to be a special power of digital collections, as they describe an object beyond language through its relationship with other objects. From the perspective of media theory, as a medium, the digital archive is equipped with the power of interactive hyperlinks that allows generating and reproducing effective (or operational) connections and ties. As Wolfgang Ernst noted, the digital archives bring to the fore the relations between objects, while the archival material itself becomes less important: »The new archive's task is to meaningfully link up different information nodes – a veritable archive art.«[21] That said, the inquiry through link-making, of course, predates the digital.[22]

Returning to the light bulb example introduced above, consider the first light bulb and its medical context. Neither the formal description of the bulb nor the subject headings nor even its photographs give such an insight into the

19 Michel Foucault. *The Order of Things: An Archaeology of the Human Sciences*. New York: Vintage, 1994, p. xx.

20 Relationships that are specified within ontologies are not considered at this point.

21 Ernst, *Digital Memory and the Archive*, p. 83.

22 Some examples are addressed by Markus Krajewski in *Paper Machines: About Cards & Catalogs, 1548-1929*. Cambridge, Mass: The MIT Press, 2011.

being of a thing, as a selection of the related objects does. The fact that the bulb is assigned to the »Therapeutics« category (see Figure 1), is made of brass and glass, that it belongs to the »electricity« type, was owned by Dr. R. Wallace Henry, and was used in the 2nd half of the 19th century is less of a clue than seeing it amidst the related objects. This metadata captures information about the bulb through categories but does not associate it with its natural habitat – the world of things. It is its juxtaposition with the »hypodermic syringe,« »magneto-electric machine for nervous diseases,« »ivory dildo,« »Blundell's blood transfusion apparatus,« and other devices that marks the horizon of its use and meaning. Although some connections are quite controversial and their grounds not quite explicit, nevertheless the context of things allows us to imagine the light bulb in use. Through its encounter with other things, the object becomes part of some material order – instead of a self-sufficient and self-valuable monad, as the archive often portrays.

Another issue is the nature of the relationship between objects as established within the archive. In the case of the Cavendish Laboratory, we could recognize the connection between objects as metonymic, connecting things by their adjacency and proximity. This logic applies to most of the collections in the chosen corpus. The archives typically seek to identify similarities by establishing object relations instead of putting things into a dialogue. They are likelier to associate two images of the same instrument than two instruments used in the same experimental set-up. In the collections, this semantic practice is referred to as »similarity« or »relatedness«: Users are prompted to inspect »similar« or »related« objects to the object being viewed. The Oxford History of Science Museum defines »similar objects« as having »the same name, a similar description or [which] are from the same place.«[23] In nearly 80 percent of the collections from the present corpus featuring »related objects,« this similarity is interpreted and calculated algorithmically based on metadata. In practice, it means that, for example, Marconi bulbs from the Oxford History of Science Museum are doomed to remain neighbors exclusively with the typologically similar Marconi bulbs. For things that have no counterpart, the logic of the algorithm becomes even more convoluted: Sigmund Freud's clock from the Library of Congress collections[24] is displayed alongside his Greek statue (dating back to B.C.), simply because both artifacts belong to the same part of the collection called »Artifacts and Paintings.«

23 See Oxford History of Science Museum (https://hsm.ox.ac.uk/collections-online#/item/hsm-catalogue-15553, accessed 13 March 2023).

24 Sigmund Freud Papers/ Library of Congress (https://www.loc.gov/item/mss 3999 001828/, accessed 13 March 2023).

The archive hence seeks sameness rather than differentiation. Meaning is imparted on a thing by embedding it into the networks of similar objects. One problem with this approach is that, since algorithms control the boundaries of this similarity, the result is often either a multiplication of the exact same things or, conversely, an artificial linking of items too remote from each other. Another problem concerns the attitude toward an archival object which stands behind such an approach: In this logic, the archival artifact is treated mechanistically as motionless, replaceable, and inert. This approach fails to recognize the agency of a thing, such as its involvement in different contexts, its participation in social relations, or its influence on other agents.

4. Conclusion

A close observation of how the digital archive draws links and ties reveals the implicit semanticity of the archival order. It confers meaning to objects, builds hierarchies, and establishes certain contexts. It determines what is visible and what is hidden, sets connections and creates discontinuities, and thereby prefigures the way we encounter the past.

As we saw, one can endow a light bulb or a portrait of scientists with meaning in many ways. This signification zone appears to be especially sensitive where special knowledge is needed to interpret an object, as is the case with scientific objects. Preserving such artifacts means not only keeping them physically intact, but also framing the horizons of their meaning, uses, relationships, and interactions with other objects. Making connections in this sense appears as a distinctive power of the digital archive to remodel and reimagine the past.

The realization of this power, however, may not always be fruitful. Digital archives do not always fully utilize their semantic capabilities, offering somewhat rigid adjacent or hierarchical relations. It seems that we should rethink these meaning, context, and connection-making mechanisms and no longer regard the digital archive as a collection of unambiguous testimonies that lead to nothing but the only ›correct‹ picture of the past. Instead, we should reconceptualize it as a medium capable of accumulating histories, modeling relationships and associations, and mediating our experiences of the past. Then, perhaps, we will see in the archive not only hierarchies and metonymies but also »perspective-switching,« »background-building,« and »complicating links.«[25]

25 For detailed classifications of links see Marie-Laure Ryan. *Avatars of Story*. Minneapolis: University of Minnesota Press, 2006.