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Pursuing a combinatorial habit of mind and machine

Willard McCarty

Introduction

Thanks to the development of tools and techniques, we can, after half a century of repeatedly questioning digital scholarship for revolutionary breakthroughs, begin to see 'evidence of value' in results not otherwise obtainable.[1] How and to what extent the academic mainstream has been affected is a matter for debate, discipline by discipline and (don't forget) culture by culture. Here, however, I want to pursue a different but related line of enquiry, one closely attuned to John Bradley's life in digital work. My question is this: at the low-tech end of scholarship, where most scholars spend most of their time, how have digital tools and methods affected habits of work and mind and processes of reasoning? Neurocognitive scientist Michael Anderson has observed that:

> when we invent scales, rulers, clocks, and other measuring devices, along with the specific practices necessary for using them, we are not merely doing better with tools what we were doing all along in perception. Rather, we are constructing new properties to perceive in the world . . . properties that actually *require* these tools to perceive them accurately (Anderson 2014, 181f.)

– or perhaps at all. But, he and many others have argued, cognition is not only or perhaps even primarily in the head; we need to look for it throughout the body, and not only there, but also in the whole person situated in a world of affordances, social interactions and physical consequences, where the digital machine has established a presence.[2] Thus, although there is some truth in the hype of a Digital Age, the

machine's 'evidence of value' for the humanities has been a long time emerging out of the infancy or *incunabular* period of the machine. In 1994 Paul Evan Peters announced 'the Dawn of the Meso-Electronic Period'. He was then an optimist; now I would be tempted to agree.

Part of the problem we have had lies in a pervasive disinclination to look for clues in what Philip Mirowski (following Donna Haraway) has called 'the cyborg sciences' (Mirowski 2002), especially those focused on cognition. But there's also the plain fact that the digestive powers of the less technoscientific disciplines and areas of life beyond the natural sciences work slowly. In 1971, in one of my favourite statements on such matters, historical sociologist W.G. Runciman wrote:

> No doubt the rewards of ingenuity, even if coupled with perseverance, are often meagre. They may indeed be particularly meagre in the traditionally less exact sciences. But this may mean that in due course the opportunities for spectacular advance will be all the greater. Every branch of science has had its false starts, its deluded hopes and its naively misapplied techniques . . . But it remains true that habits of mind usually take a generation to be overturned: wasteful techniques, unfruitful hypotheses and misconceived presuppositions are apt to fade out only with the deaths of the protagonists. We may have to wait two or three hundred years before we know what are the most rewarding applications of quantitative methods to the sciences of man, and meanwhile it is irrelevant if not positively unhelpful to carp at the lack of immediate success. (Runciman 1971, 943)

Historian Linda Colley, more optimistic than Runciman, has likewise observed that most 'major changes become apparent within the canonical span of a human lifetime: three score years and ten' (Colley 2018, 12) – a measure which matches almost exactly the period of humankind's cohabitation with the digital machine. So now is an apposite moment for these reflections.

Colley uses the modern derivative of the old Germanic *spann*, which in its modern spelling survived well into the nineteenth century: a distance measured by the hand when fully extended (*OED*). Like other common words in English that measure the world in human terms by relating it to the body, such as 'foot', 'hand' and 'fathom', 'span' is a clue to our physical intimacy inter alia with the machine, which was designed for hands to manipulate and structured (as machine-language programmers of my vintage will know) according to operations of the hand and body,

as with the abacus. It's about time, I say, that we looked critically inward, *to ourselves as embodied users of a bodily imprinted device*, for the answer to the big question of significance we keep asking ourselves, or should be.

But we must also look outward, specifically toward the often wild scattering of sources online, whose materials the scholar in interaction with the machine makes into an argument or description of something.[3] Thus the tendency, amplified from the movements characteristic of a physical library, toward Claude Lévi-Strauss's *bricolage*, the assembling of 'structured sets . . . by using remains and debris . . . "des bribes et des morceaux" . . . odds and ends' (Lévi-Strauss 1966/1962, 21f).[4] Similarly, at the turn of the millennium philosopher Richard Rorty (with no mention of anything digital) argued for a fundamental shift in emphasis, from regarding objects as having an intrinsic nature investigated by narrowly specialised techniques and theories, to the idea that 'to understand something better is to have more to say about it – to be able to tie together the various things previously said in a new and perspicuous way' (Rorty 2000, 24). Among other things, the prominent emphasis on interdisciplinary research, now made radically easier to pursue (though not to do well), would seem to follow.

This book is a commemorative offering, a *Festschrift*, but for me and several other contributors it is also and more importantly a *liber amicorum*, a book written by a gathering of friends, stitched together in such a way as to suggest the larger significance of a particular life in the intersection of computing and the humanities. I take this as sufficient justification to write in an informal, personal mode rather than a sociological or media archaeological one, as the initial form of my question might suggest. But I have another reason for writing like this. In 'The Dilemma of Scientific Subjectivity in Postvital Culture', feminist historian of science Evelyn Fox Keller has written of the 'enduring and final erasure' of the knowing subject in scientific writings during the seventeenth to the nineteenth centuries. The individual scientist, she argues, was

> replaced by the abstract 'scientist' . . . who could speak for everyman but was no-man, in a double sense: not any particular man, and also a site for the not-man within each and every particular observer. By the beginning of the last century a hollow place had been carved out in the mind of every actual or virtual witness into which a machine could vicariously be placed. (Fox Keller 1996, 418–19)

Likewise, Nobel geneticist François Jacob has described his colleagues' routine weeding out of the fruitful but all-too-human, agonising

uncertainties and confusions he calls 'night science' so that an official 'day science . . . [can call] into play arguments that mesh like gears, results that have the force of certainty' (Jacob 1998/1997, 126).

Through painstaking examination of laboratory notebooks, cognitive-historical studies of experimentation have since the 1980s striven to reconstruct as much of this night science as possible in order to recover moments in which experimenters fashioned experience into communicable knowledge.[5] Perhaps we who are so much preoccupied by the great engine of our age need to pay particular attention to how we ourselves have come to know what we think we know by virtue of our own particular experiences – and to start keeping our own laboratory notebooks. Bruno Latour is on our side in this: he has argued for shattering the illusion of seamless, bullet-proof arguments, where results hold centre-stage, so that the sometimes messy processes by which we figure things out can become visible (Latour 2004). Obviously, such a programme could be carried too far, but the desirability of revealing philosopher Gilbert Ryle's 'knowing how' (Ryle 1945) in digital scholarship – manifested in particular over John's lifetime of puzzling out what to do with the machine – seems undeniable. Make no mistake in this: experimental practice *is* what many digital practitioners do. Even today that which can be learned from tool-use tends to vanish in the rush to display evidence of value to mainstream disciplines, to exhibit the up-to-date or nervously to worry the social organisation and proprieties of our young discipline.

So much for the prolegomenon. The rest comprises a narrative of my experiences and introspections on them, but these are not the gold for which I am panning.

A small *Bildungsroman*

In brief I am panning for the emergence of a combinatorial habit of mind (one that reasons about the world by sorting and re-sorting it) in order to match and harness the inbuilt processes of the digital machine that have urged us to think *combinatorially*. This is a very large subject that I can only hint at here.

Combinatorics is a branch of mathematics that studies *configurations*, that is, groups of objects 'distributed according to certain predetermined constraints. Cramming miscellaneous packets into a drawer is an example of a configuration' (Berge 1971/1968, 1). So is a certain arrangement of words in a text, colours in an image, cards in a hand of

poker or milfoil (yarrow) stalks in a *Yijing* divination.[6] Combinatorics 'counts, enumerates, examines, and investigates the existence of configurations with certain specified properties. With combinatorics, one looks for their intrinsic properties, and studies transformations of one configuration into another, as well as "subconfigurations" of a given configuration' (Berge 1971/1968, 2). Claude Berge – the most significant mathematician of the Oulipo (Motte 1998/1986) – goes on to note that 'this particular discipline has developed on the edge of, or away from, the mainstream of modern mathematics'. A playful devotee of such things, he expresses surprise. Unsurprisingly, attention to it has grown since the digital machine became commonly available to mathematicians.

The coming to prominence of combinatorics neatly coincides with the period 1978–84, during which I struggled to put together a large number of biblical and classical references for my PhD dissertation on the archetypal pattern of the Exodus in John Milton's *Paradise Lost*. (This happened at the University of Toronto, where John, two of the editors of this volume and I first met.) Faced by masses of data, I used 3x5 cards to keep notes, several thousands of them. To discover patterns in the scattered data I found myself using the floor or bed to lay out the cards, sort them into thematic piles, arrange these spatially, re-sort, re-group and so on. During this time I discovered that the great lexicographer Sir James Murray had done the same in putting together volumes of the *Oxford English Dictionary*, spreading his slips of paper 'out on a table or on the floor, where [the researcher] can obtain a general survey of the whole . . . [spending] hour after hour in shifting them about like the pieces on a chess-board, striving to find in the fragmentary evidence of an incomplete historical record, such a sequence of meanings as may form a logical chain of development' (Murray 1884, 510). Having constructed my own associational web of relations, the cards went back into boxes. On a hot July afternoon in 1984, frustrated by my inability to find among those cards a reference crucial to the bibliography, I realised that these many boxes comprised not a resource for further work but a graveyard of knowledge. To make sure I would never again have to dig in that graveyard, I wrote software to keep notes – but in later work continued to print out card-images so as to retain the kinaesthetics of sorting. At the time I was ignorant of Gibson's near-contemporaneous theory of affordances. This theory launched work which led to the now commonplace realisation that cognition happens 'beyond the brain', in and with the world (see note 2). I was finding this out by thinking with notecards.

Shortly afterwards, I joined forces with the similarly minded Geoffrey Rockwell in a software-design project to look into the question

of how academics take notes. Both the Macintosh and HyperCard, new that year, offered a ready-made platform for development. We interviewed a number of Toronto academics across several disciplines, expecting to find a common denominator easily translatable into a structure of menus and operations – a technologist's classic error (Carlisle 1976). After all, we thought, note-taking is largely mechanical if not algorithmically resolvable. To our surprise we discovered no consensus at all about how or indeed whether to take notes. Rather we found an ad hoc mixture of practices variable by project as well as by person, discipline, circumstance, even whim (Hellenist philosopher Brad Inwood, less riveted to the technology but quite familiar with it, pointed this out to me immediately when I told him about the interviews). So, liberated from the illusion of a methodological universal for scholarly research, even *in potentia*, I was thrown back to my own kinaesthetic use of notecards better to understand what was going on with sorting by means of the digital machine.

In the years that followed, the question of implementing Murray's method became part of a much larger enquiry into the relation between ourselves and our machines in the intimate moments of forming patterns from the (barely) constrained chaos of all that is available. This intimacy, I should point out, happens whether the scholar is working alone or in collaboration with others. Stressing the importance of thinking with others must not obscure the simultaneous need to think privately.

Tacit practices

For me, questions of implementation faded away with the growth of my work on the *Metamorphoses* of Ovid and attempts to understand the field we then called 'humanities computing'. Modelling was my primary focus. The methodological problem of shuffling notecards along with its implications went into hibernation, although my deep interest in modelling laid the groundwork for later work on combinatorics.

By the late 1990s, John and I both found ourselves on the other side of the Pond, at King's College London. He stayed with the question of how to implement note-taking. *Pliny* was the result.[7] Despite its felicity and the intelligence of its design, my own intellectual disorderliness and the infamous problem of 'screen real estate' drove me from *Pliny* back to paper slips and their manual sorting on table or floor. Years and several writing projects later, an invitation in 2018 to speak on annotation forced me to awaken that long-sleeping interest in notecards and consider their

sortition once again (McCarty 2020). This invitation came in the midst of the most complex and demanding project I have yet undertaken,[8] so I had a perfect opportunity to look again at that methodological problem under the most demanding circumstances. My conclusions take up the remainder of the paper.

A note-maker's account of actual note-making

Nowadays the note-maker, wanting the benefits of the machine, perhaps looks for and finds an app, then gets to work. In my experience the note-maker who pays close attention to the demands of the sources finds it exceedingly difficult to fit them to the assumptions of the app. Paradoxically, the more facilities an app provides, the greater the chance these limitations will loom large, inducing intellectual claustrophobia, bewilderment or both. For me, at least, the place of the app is invisibly in the background – while I am making notes, that is.

Seeing an opportunity, but before reaching for the toolbox, the properly educated systems designer will consider what's been done and what's available, then talk to many note-makers about their practices, likes and dislikes. As I have already recounted, experience has suggested to me that such anthropological fieldwork and time spent with the relevant literature will *not* converge on a single, one-size-fits-all design, and that the elusiveness of such a design is fundamentally *not* due to the shortcomings of current technologies. The basic problem is that note-making is not itself singular nor does it tend to settle down for good. Indeed, it is not an 'it' but a fluid mode of thinking-by-doing realised in a coupling with one or more of the world's affordances, taken up then abandoned as suits the occasion. Note-making is *not* invariant across research projects, the individuals who pursue them, their subject areas and the physical media and circumstances involved. It may vary, possibly for no identifiable reason, even from one day to the next. The point is not at all that the means are irrelevant – they are indeed essential in their concrete particulars – rather that couplings of human and machine (both being polymorphically perverse) are impermanent, answerable to the variable situations of note-making, not to any particular implementation.

The technologically minimalist style I am about to use in describing how I went about research for the project is not how I always take and use notes, but I have often worked in this way when the project is large in scope and complex. Again, experience has taught me that no one size or even a discrete range of sizes will fit all circumstances or even a majority of them.

We must begin with specific examples, of which this is one. But my point is to exemplify the coupling, *not* promote a particular method or tool.

Cultural and media historian Markus Krajewski comments in *Paper Machines* that despite the undeniably transformative effects of digital technologies, things also 'remain the same': the card-index continues to surface, as it does with me, again and again. As I will demonstrate, it is undoubtedly laborious, but when used well it is nevertheless marvellously efficient (Krajewski 2011/2002, 143). Krajewski cites Niklas Luhmann's account of his card index system, 'the furnace in which the texts are forged'. In an interview for the *Frankfurter Rundschau* in 1985, Luhmann described how his ideas came from a card-box of notes, by sorting and combining them:

> The new ideas . . . arise from the different combinations of the notes to the individual terms. Without the notes, so by reflection alone, I would not come to such ideas. Of course my head is required to write down the ideas, but it cannot be held responsible for them alone. In that sense, I work like a computer, which can also be creative in the sense that by combining input data, it produces new results that were not predictable. (Luhmann 1987, 144f., my translation)[9]

The card-index is 'like a computer' because both are fundamentally combinatorial, hence creative not only within but also *because of* their constraints. 'When ideas are combined in all possible ways,' mathematician Martin Gardner has observed, 'the new combinations start the mind thinking along novel channels and one is led to discover fresh truths and arguments' (Gardner 1958, 17). But the combinatorial apparatus does more than start the mind in a new direction; it also provides a different style of reasoning, as Lévi-Strauss and Rorty have suggested. The question to ask of both digital and paper machines is where and how their *künstliche Intelligenz* arises (the German term for 'artificial intelligence' is a good reminder that 'artificial' means 'made by art', that is, by artisans, and that the result is artisanal). Yes, this AI arises in the coupling with the enquirer, but *what happens there*? Currently we do not have an answer, or not much of one, but we can proceed by not underestimating the power of knowing-by-doing and so pay attention to what changes, especially what is lost when the observable actions of note-making are translated into software. We can draw on those cognitive-historical studies of experiment, among other things. We can ask, for example, what happens when the inchoate, shifting relationships expressed spatially by

a desk strewn with piles of cards, with the memory of strewing them, is rendered by screenicons with named links between them?

Much more needs to be known about the space between brain and card, mind and the worldly affordances to mindfulness. The examples I am about to give should help. But note: once again, there is nothing canonical here. I provide only an example. Again, what matters is that we pay attention at a fine-grained level to individuals' actions and experiences on particular occasions, for specific projects.

Typically I do more or less the following.

1. If I am reading a book (which I prefer to do with the codex in hand), I take very brief notes on paper slips to record ideas, keywords and references to other sources I want to come back to later for more detailed note-making. The highly variable circumstances under which I read and the sheer convenience of taking notes in this way while reading a codex make it a very effective procedure. (Figure 11.1)
2. Later I return to the book and make more detailed notes in software from the book,[10] which if at all possible has been digitised and is accessed on screen. For digitised books and articles, I take notes, mostly by cut-and-paste. (Figure 11.2)
3. Once I have finished an episode of note-taking, I print index cards from these notes, four to a page, then cut the sheets into individual cards and stack them for sorting. (Figure 11.3)
4. I then take the stack of cards, sort and resort the cards (as Murray describes) until satisfied with the resulting topical piles, label and clip them together. (Figure 11.4)
5. From each individual pile, I attempt to construct a narrative by writing out summary notes by hand on sheets of paper. (Figure 11.5)
6. If, as sometimes happens, I find that the attempted narrative lacks coherence, or that particular notes require rearrangement, I cut up the offending sheets, paste the resulting strips on blank sheets in revised order, scan and print the replacements. (Figure 11.6)

Writing the paper then follows.

The labour and time involved should be painfully obvious. But note: equally important to the product is *what is not and cannot be shown*: the intellectual-kinaesthetic work of sorting out a highly complex subject and producing that proto-narrative. Perhaps the painful physical work does its cognitive work by distracting the conscious mind so that the rest of the mind can go on with what it does so well? In my experience such labour and the invisible intellectual operations are inseparable.

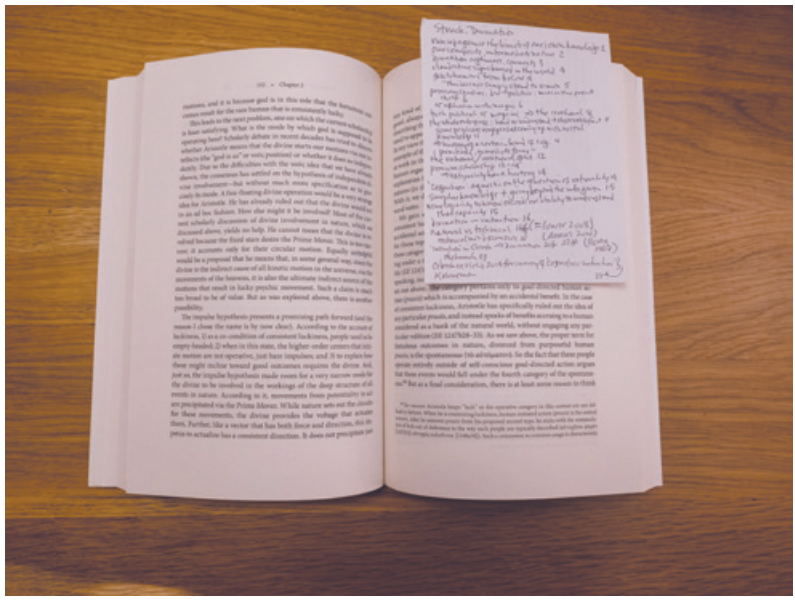

Figure 11.1 Notes written on a 3x5 paper slip while reading a book.

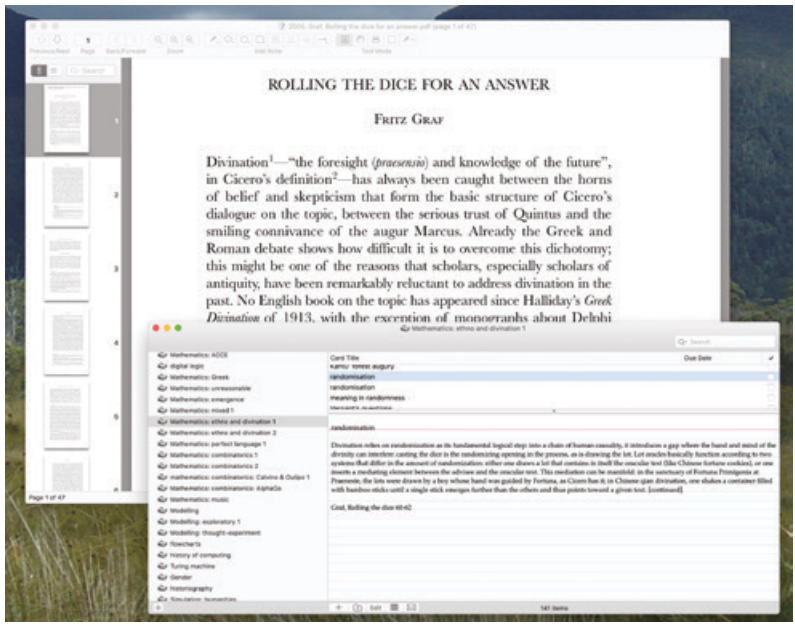

Figure 11.2 Notes copied from a digitised article into NoteCards.

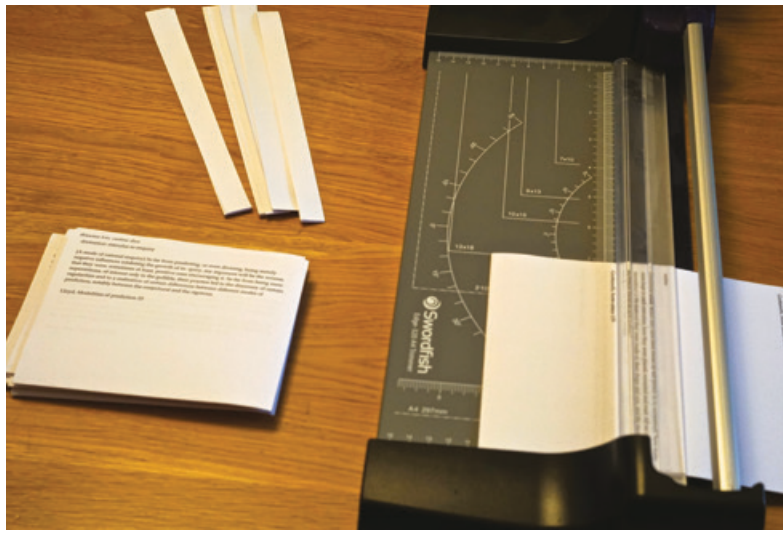

Figure 11.3 Printed notes cut into 3x5 slips.

Figure 11.4 Slips sorted and gathered into thematic groups.

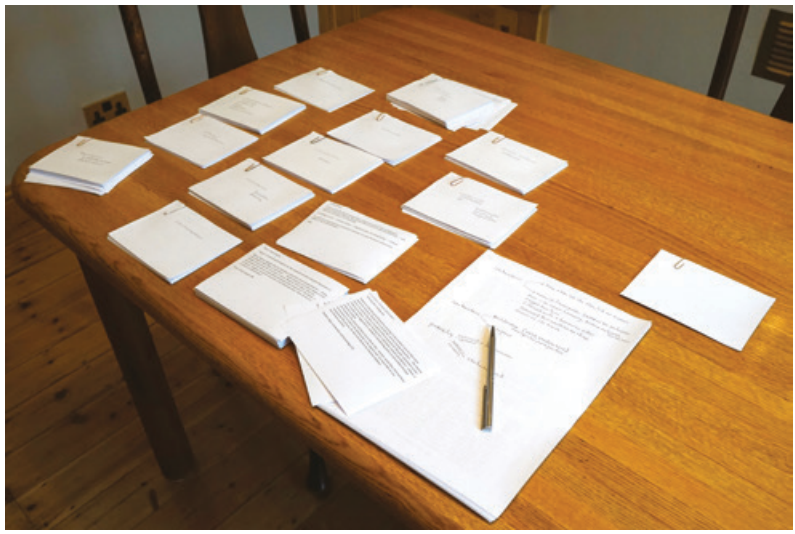

Figure 11.5 Transcription of groups onto pages.

The fact that the implicit links between cards and piles of cards are left implicit – changeable if not fluid, if not tacit, intertwined with inchoate feelings that an idea or cluster of ideas 'belongs with' or 'is far away from' or 'is quite unlike' another, or is a right-handed or left-handed sort of thing – is in my view essential, though I cannot say why. *As a note-taker, I do not need to understand why the procedure works or what is going on cognitively at each step*. I just let it do what it does, then observe that it has somehow worked. But students of note-taking do need to investigate.

On the horizon

For digital humanists attracted by the potential yield from digging into relations of mind, subject matter, machine and note-taking, there is much to be done. Several fields – cognitive history and psychology to begin with – offer valuable help. On the answer(s) to the question of what happens when we take notes turns the design of better software for doing it, and as John, the designers of *NoteCards* and others have shown, writing this software raises new and exciting questions. In a sense I have gone in the opposite direction from those writers of software, to straightforward use of a minimalist app to generate piles of notecards, and as that person am now very close to concluding that I should simply let happen what happens and not fall prey to the centipede's dilemma, of stopping

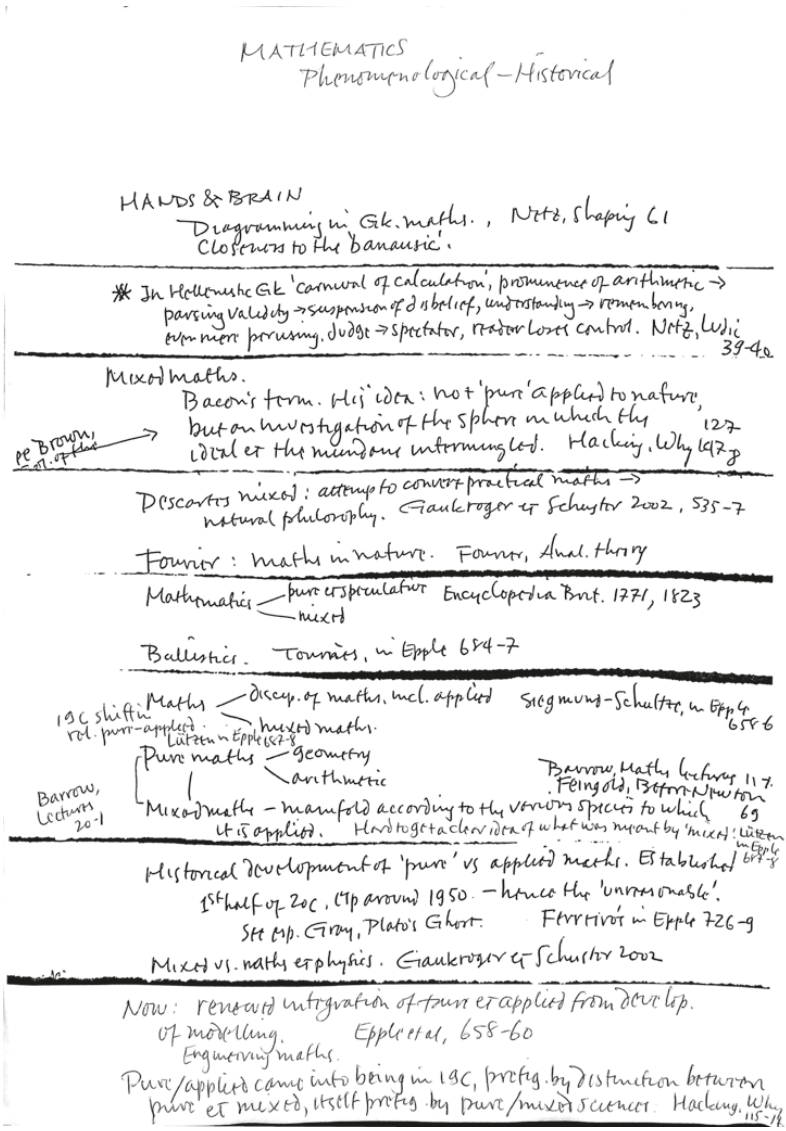

Figure 11.6 Transcribed notes physically reorganised, photocopied and printed.

to figure out how it is that she does what she does, and as a result fall 'exhausted in the ditch / Not knowing how to run'.[11] But having become a digital humanist *circa* 1984, I am also their fellow traveller. The very paper whose making provided me with the evidence for the note-taking practices I've presented here is in fact a prolonged meditation on the

artisanal potential of the machine to become a more intelligent collaborative affordance in the web-amplified work of tying 'together the things previously said in a new and perspicuous way' (Rorty 2000, 24).

Here I must stop. I leave you with three suggestions regarding further explorations. The first is to pay critical attention to the sciences of mind and machine, including the anthropology of human–machine interaction (Suchman 2007; Duguid 2012). The second is to turn from mimesis to alterity in thinking about *künstliche Intelligenz*, that is, from imitation of human intelligence to exploration of intelligence differently constituted, not to match ourselves when taking notes but to provide a worthy and not always agreeable interlocutor. My third, last and most adventurous suggestion is to seek analogical help from uses of combinatorial enquiry wherever it is to be found: close at hand culturally, in the natural sciences and mathematics, and further afield, from other people, in other times, places and cultures. What have people done with counting and sorting when, unassisted by computers, they were at a loss to proceed? My title gives a hint of one rather unexpected place to look.

Notes

1. On the phrase 'evidence of value' see McCarty 2012, 117–19.
2. For the extensive literature on embodied cognition and related areas of research, begin with Gibson 2015/1979, especially the Preface and 'The Theory of Affordances', 119–35; Anderson 2014; Anderson et al. 2016; Cowley and Valée-Tourangeau 2013; Chemero 2009; Clark 2008.
3. The same has always been true of the research library, indeed is of its essence. But seen in the context of the web, the library of codices imposes a classification physically in the arrangement of stacks, even of separate buildings, and hence radically slows down and so limits its recombinatorial potential.
4. Thus the *OED*: 'The process or technique of creating a new artwork, concept, etc., by appropriating a diverse miscellany of existing materials or sources.' In Lévi-Strauss's terms, the scholar, like the artist, is midway between the scientist and the *bricoleur* (Lévi-Strauss 1966/1962, 22).
5. See: Gooding 1990; Steinle 2016/2005; Nersessian 2008; Rheinberger 2010/2006; cf. McCarty 2020 and esp. 2021.
6. I make the argument for the relevance of ancient, cross-cultural divinatory practices in McCarty 2021.
7. To my mind, *Pliny* shares with the much earlier *NoteCards* the honour of the most thoughtful and suggestive software environment for note-taking devised to date. Neither *NoteCards* nor *Pliny* made it to market. On *NoteCards* see Halasz et al. 2001; Brown 1985; and Halasz, Moran and Trigg 1987; on *Pliny*, Bradley 2008, cf. 2012; for a survey of annotation systems, Hunter 2009. See also DeRose 1989. For Vannevar Bush's *Memex*, grandfather of all, see Nyce and Kahn 1991 and Engelbart 1962, 48ff.
8. I refer to an ongoing series of workshops at Cambridge, 'Science in the Forest, Science in the Past' (2019–), for which see Lloyd and Vilaça 2019; McCarty, Lloyd and Vilaça 2022. A third workshop was held in June 2022, proceedings of which are to be published in *Interdisciplinary Science Reviews* (forthcoming, 2024).
9. 'Die neuen Ideen ergeben sich dann aus den verschiedenen Kombinationsmöglichkeiten der Zettel zu den einzelnen Begriffen. Ohne die Zettel, also allein durch Nachdenken, würde ich auf solche Ideen nicht kommen. Natürlich ist mein Kopf erforderlich, um die Einfälle zu notieren, aber er kann nicht allein dafür verantwortlich gemacht werden. Insofern arbeite ich

wie ein Computer, der ja auch in dem Sinne kreativ sein kann, daß er durch die Kombination eingegebener Daten neue Ergebnisse produziert, die so nicht voraussehbar waren'.

10. The software I happen to use for the above steps is QwikCards (https://www.qwikcards.com/), which I prefer for its elegant simplicity – precisely for its minimalist restraint. But any program that makes printing out cards on paper would leave my description more or less unchanged.
11. From a poem attributed to Katherine Craster (1841–74), https://en.wikipedia.org/wiki/The_Centipede%27s_Dilemma (accessed 6 September 2022).

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