Flexing paper's muscle
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Despite being a computer scientist I have always had a weak spot for paper: pens over keyboards, books over computers, a "real" diary with barely intelligible scribbles over a precise, impersonal online one. Somehow a real personal letter dropping through the letterbox evokes feelings of pleasure much greater than an equivalent email. As a child one of my favourite puzzles was the hexahexaflaxagon. They are made by folding a strip of paper into a flat hexagon shape in a particular way and gluing the ends together. The neat thing about them is that they have only two "sides" visible but four more totally unobvious sides hidden in the folds. By folding and unfolding the hexahexaflexagon in a special way ("flexing" it) the hidden sides can be revealed in turn. The puzzle is to flex through all six sides in the shortest number of moves. Of course it is easy to write a computer version of a hexahexaflexagon to eradicate all that folding and flexing but that misses the point. The puzzle itself is logically trivial. The fascinating bit is that such a thing can physically be created just from folding paper and the surprising, magical, nature of the flexing. I've also always found that flexing a flexagon is physically very stress-relieving. They were only invented because of an annoying physical property of paper – the result of someone trimming the edges of American sized paper to fit an English sized file and playing about with the off-cuts.

There is certainly something about the physicality of paper. I've never really been convinced that just because computers can do something it means they are the most useful way of doing it. Am I just an out of date romantic, or is there anything at all in my quirky love of this several thousand year old technology for doing useful things like writing? After all I am writing this article on a laptop. You are undoubtedly reading it on a screen. It never has to touch paper at all to achieve its purpose.

Before I write further bear with me while I reorganize my desk. For the next bit I need the paper notes that I scribbled on a bus, the post-it note from my browsing with Google, and that book I was going to refer to. Where is the annotated printout of the earlier draft? Finally I need the article this essay is based on containing my highlights and scribbles. That's better. The article I am now looking at is about research on materiality: an investigation into the way people work when writing from multiple source documents. They observed people carrying out writing tasks done naturally as part of their job. The people studied used a mixture of paper and online versions of documents. Afterwards they were interviewed, using the video of their session to prompt explanation of what was going on. The data collected was analyzed by looking at how the material properties of the artifacts used affected the cognitive processes involved. Things related to materiality that were particularly significant were glances back and forth, document organization, scribbles on documents and use of both paper and electronic versions of the same documents.

Movement of attention was very important. When using paper versions of the source documents (though not electronic ones), the person's focus of attention rapidly switched back and forth. Such glances were used to evoke complex memories and previous trains of thought. The participants developed a familiarity with the structure of the paper documents that supported these quick glances. Documents were also arranged on the desk in a way that supported glances and their positions were used to quickly locate information with minimum effort. The layout was also adjusted as the task demanded it. There was frequent temporary lifting and dropping of documents that preserved the structure, as well as more major changes that modified that structure. The fact that all these activities were easy meant that there was little interference with the writing task. Paper was also preferred for source documents because it meant they were in a separate physical space from the composition, again supporting glances away from and back to the composition. Electronic documents were printed out specifically so they could be used in this way. Many of the participants used both paper and electronic versions of the *same* documents, but for different parts of the task. There was an implicit understanding that the physical characteristics of the different media supported different things.

The ease with which annotations could be made on paper was also important. They were used in a variety of flexible, informal and incomplete ways. They were used to make links between documents, though in a more convenient way than hyperlinks where the requirement of a complete link would be disruptive. Instead, only when combined with the writer's knowledge did they give complete links. They allowed thoughts that cropped up as a result of writing to be quickly offloaded in a way that also

minimized disruption. They were used to make points more salient but also to break the layout of the document and so support noticing and evoking from the writer's quick glances.

Because of its physical properties, paper supports a wide range of quick and flexible activities that do not impede the main task of writing. This has ramifications for the developers of technologies like e-books. They should be cautious of trying to directly emulate paper. It is unlikely to be bettered at the subtle things it is good at. That is why it is still the medium of choice for some parts of the writing task. Instead designers should be looking for new affordances of e-technologies that complement those of existing ones. An understanding of both the material properties of those technologies and the way people use them is vital. Similar considerations apply to the design of any new computer technology. Totally paperless offices may be possible, but studies such as this suggest that people working in them may be less able to do some parts of their jobs as efficiently. Personally, I hope I am never forced to work like that. I also hope I'll always have a paper flexagon around.

Further reading:
- M. Gardner (1959) "Hexaflexagons", Chapter 1of *Mathematical Puzzles and diversions*, Pelican.
- K.P. O'Hara, A. Taylor, W. Newman and A.J. Sellen (2002) "Understanding the materiality of writing from multiple sources" *Int. Journal of Human-computer Studies* 56(3): 269-305.
- A.J. Sellen and R.H.R. Harper (2001) "*The Myth of the paperless office*", MIT Press.
- Typing "hexahexaflexagon" into Google will also give you many links to sites on how to make flexagons.