Obsessed by Lines

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Lines are everywhere. The lines of the streets and the buildings where we live. The lines of the shelves on which we place our books, dishes, towels. The lines we draw on the page. The lines we gesture in the air. Those lines are not always straight: the lines of the paths we take meandering in the woods, the lines of the curves of the body, the lines scribbled on a page. Lines, straight or messy, serve our behavior and our thought. Let's see how.

How do we think about things that don't exist? Where do new ideas come from? These are not new questions. Sometimes it seems impossible, yet we can think of things that don't exist and we can have new ideas. There are two ways to invent new things: bottom-up, by altering or combining or rearranging old things, varying concrete instances; or top-down, abstractly, by starting with desiderata, goals, principles, or properties, and instantiating them. The advantage of the bottom-up way is that it gives us instances to start thinking about. It's hard to think in the abstract. The disadvantage is that those instances constrain and limit thought; we don't stray far from them. The advantage of the top-down way is that it allows flights of fancy; the disadvantage is that it doesn't tell us where or how to begin. Evolution has only one way to create new things, bottom up, by altering or combining or rearranging old things. People can—and do—do both. They can create new ideas and new things by using perception and they can create new ideas and new things using conception. In actuality, people go back and forth between perception and conception, using one to augment the other.

Thinking is hard. When thoughts overwhelm the mind, the mind puts them into the world, and has since antiquity. We use fingers, tallies, abacuses, computers to count and calculate. We gesture maps and routes in the air or draw them in sand, in stone, on paper, on screens. An overwhelmed mind puts thought into the world; even simple means help—talk, sketch, gesture, model. These cognitive artifacts, externalizations of thought, expand the mind. They enable thought, guide variations, allow play, discovery, and invention. They seem to be uniquely human.

Each of these tools for thought has different properties with different consequences. Here, we focus on actions that are realized in sketches, gestures, and arrangements of space. We'll begin with sketching, and lines. Lines are among a set of simple forms that acquire a range of readily inferable meanings, abstract and concrete, in context. A line in a street map is a path between one location and another; a line in a knowledge network is a relation between one idea and another. One-dimensional lines connect, and indicate a relationship between the points, places in maps or ideas in knowledge networks. Arrows are asymmetric lines, and indicate asymmetric relations. A diagram of a bicycle pump or a car brake or a pulley system that doesn't have arrows is interpreted by students as a representation of the structure of the mechanical system. When arrows are added, students interpret the diagrams as representations of the causal operation of the system. Similarly, when asked to diagram descriptions of structure, students don't use arrows,

but when asked to diagram descriptions of causal operation, they use arrows. Just as lines show relations, boxes show containment, so that students interpret lines in graphs as trends whereas they interpret the same data displayed as bar graphs as discrete relations. These simple abstract forms—dots, lines, crosses, arrows, blobs and more—have context-dependent meanings related to their mathematical or Gestalt properties (Tversky, 2011; Tversky, Zacks, Lee, and Heiser, 2000). Ample research has shown that well-designed diagrams help people to learn complex information and to make inferences about it.

Intriguingly, gestures use analogous simple forms, points, lines, directed lines, containers. Gestures are used communicatively, to explain things to others. Not only is speech understood better when it is accompanied by gesture, but certain gestures have dramatic effects on the thought of those who view them. Children understand algebra better when the hands cup each side of an equation on the blackboard, like parentheses (Goldin-Meadow, 2003). Adults grasp cyclical concepts better when the explainer gestures each stage in an imaginary circle than when the explainer gestures each stage along an imaginary line (Jamalian and Tversky, in preparation). More surprisingly, it turns out that gestures aid thinking in those who produce them. When people sit on their hands, they have trouble finding words (Krauss, Chen, and Gottesman, 2000). When people are alone in a room trying to solve spatial problems, they often gesture the structure of the problem, and when they do, they are more likely to solve the problem (Kessell and Tversky, 2006; Jamalian, Tversky, and Giardino, in preparation).

So far, we've talked about neat and orderly lines. They are used, on paper or in the air, to convey the essence of neat and orderly ideas, and they succeed. But messy lines, as designers and artists know, also aid thought, exactly because they are messy. Messy lines are ambiguous, pre-categorical, so they allow many interpretations. Messy lines promotes discovery of new ideas. Making messy lines allows play and exploration. Designers and others comment that they have "conversations" with their drawings, that their drawings "talk to them" (Schon, 1983). How might this happen? And how can it be encouraged?

Several studies elucidate how designers and artists get new ideas from their own sketches (Tversky and Suwa, 2009). Experienced architects were asked to design a museum on a particular site, and later talked about what they were thinking as they drew. They reported getting new ideas when they regrouped elements in their sketches, as did designers and non-designers in follow-up laboratory experiments. Getting new ideas requires reinterpreting ambiguous sketches, but it also requires getting an idea. The first is a perceptual skill and the second a cognitive one. The perceptual skill is related to seeing smaller forms embedded in larger ones; the cognitive skill is finding meaningful relations in seemingly unrelated things. Together this process has been called "constructive perception," actively using perception, especially reorganization of perception, to innovate. It depends on messy lines.

Orderly lines, ideas that are ordered; unstructured lines, ideas that are awaiting structure. Lines on paper, lines in the air. Now to the lines in the world. Some are orderly, usually imposed by people: books in cases, dishes on horizontal shelves and in vertical piles. They, too, express neat ideas that others can uncover. Books are likely to be grouped by topic, fiction and non-fiction; they may be ordered by year or by size. Dishes are likely to be organized in categories, plates and glasses, and sub-categories, small plates and large; water glasses and wine glasses. The world has messy lines, too, the chaos of clouds that let us see changing forms and shapes, the meandering paths in the woods that let us get lost and make new discoveries.

References

Goldin-Meadow, S. (2003). *Hearing gesture: How our hands help us think*. Cambridge, MA.: Harvard University Press.

Kessell, A. M. and Tversky, B. (2006). Using gestures and diagrams to think and talk about insight problems. *Proceedings of the Meetings of the Cognitive Science Society.*

Krauss, R. M., Chen, Y., & Gottesman, R. F. (2000). Lexical gestures and lexical access: A process model. In D. McNeill (Ed.), *Language and gesture* (pp. 261-283). New York: Cambridge University Press.

Schon, D. A. (1983). *The reflective practioner*. New York: Harper-Collins.