Observing the conceptualisation of a complex task domain: The role of metaphors, gestures, and routine behaviour

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Embodied and situated approaches to concept acquisition have made a lot of progress in explaining where concepts come from and how they might be acquired initially. However, so far this progress is mostly restricted to (a) empirical concepts which might be derived directly from a combination of basic perceptual dimensions (e.g. shapes, colours, etc.), or (b) abstract concepts which might be linked to the aforementioned empirical ones by mechanisms such as conceptual metaphor (e.g. AFFECTION IS WARMTH, MOOD IS ELEVATION, ARITHMETIC IS OBJECT COLLECTION, etc.). More complex abstract concepts can then be derived from those basic ones, resulting in a kind of bottom-up bootstrapping of ever more abstract concepts [2].

In this contribution, I want to demonstrate by example that in reality the acquisition of complex concepts is more convoluted than this picture implies. In an exploratory case study, I investigated how pairs of participants slowly acquaint themselves with a complex task domain over the course of three days. Specifically, they had to work on a complex spatial transformation and problem solving task in the domain of iterated mental paper folding [1]. In this task participants have to understand the geometry of edges which occurs when repeatedly mentally folding a sheet of paper in alternating directions without being allowed the use of external aids. Faced with the difficulty of handling increasingly complex folds (Fig. 1), participants are forced to look for regularities in the folding process, such as repeating configurations of edges, common transformations between folds, etc. which help them represent folds more efficiently. In a qualitative analysis of video recordings of the participants' behaviour I have traced the development of their conceptualisation of the task domain over the course of the study, focussing especially on the use of gesture and the spontaneous occurrence and use of idiosyncratic metaphors in the construction of new representations.

Presenting an in-depth analysis of one particular case (which was selected for its participants communicating particularly well and thus having generated more verbal descriptions than other pairs), I will show how this pair's conceptualisation of the task domain developed, ranging from the use of iconic and deictic gestures in the beginning, over the emergence of figurative verbal descriptions, to finally re-representing the whole domain by use of a mnemonic metaphor and coining precise terminology (Fig. 2). While many aspects of this case are clearly idiosyncratic and cannot be generalised to derive a full-fledged theory of con-

cept acquisition, the case can still provide many interesting pointers for theory development.

Regarding such pointers, I will in particular discuss several potential extensions and directions for development for theories of problem-solving, metaphor production, and analogy-making – mainly focussing on: (a) The embedding of the memory retrieval process for potential source domains in its pragmatic, environmental, bodily, and social contexts, (b) the role of routine behaviour as a form of epistemic action, (c) the role of flawed (e.g. ambivalent) metaphors in the iterative refinement of target conceptualisations, and finally (d) the resultant weakening of the notion of static and encapsulated problem spaces.

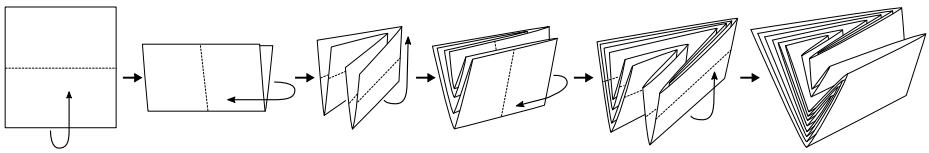

Fig. 1: Cross-folding a sheet five times by alternating between two perpendicular folding directions. While the geometry of edges produced by iterated cross-folding is governed by a simple set of recursive rules, this is not easy to see.

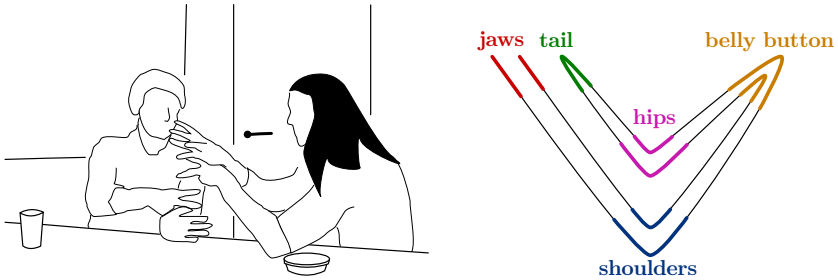

Fig. 2: *Left*: Reasoning about a cross-fold with a joint gesture in which fingers correspond to individual edges, *Right*: Mnemonic landmarks along a "doubly-folded crocodile", derived from blending generic anatomical knowledge and the shape-based "crocodile" metaphor (which originated in an idiosyncratic description of a "Victory" gesture.)

References

1. Angerer, B., Schreiber, C.: Representational dynamics in the domain of iterated mental paper folding. Cognitive Systems Research **54**, 217–231 (2019)
2. Lakoff, G., Núñez, R.E.: Where Mathematics Comes from: How the Embodied Mind Brings Mathematics into Being. New York: Basic Books (2000)