Measuring design behavior: Analysis of networks of links among speech units in design sessions

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Capturing Design Behavior

Design behavior usually refers to designers' activities while engaged in work towards producing a design proposal. This may mean team or individual work, at any phase of the design process. Capturing and documenting design behavior necessitates evidence from the process itself, i.e. design sessions, which can be collected by observation and recording (audio/video), and post hoc interviews with participants. Data thus collected, along with by-products of design sessions (sketches, notes) can be submitted to analysis. In the design thinking research literature a prevalent research methodology is what might be by now termed 'classic' protocol analysis, along the lines proposed by Ericsson and Simon more than two decades ago [1]. Many of the studies undertaken pertain to short-term design sessions (not exceeding two hours), in the early stages of conceptual design. In 'classic' protocol analysis verbalizations are analyzed: they are recorded and transcribed into a protocol which is then parsed into speech units. Those units which may be short or somewhat longer – depending on the nature of the study – are then coded, using schemes of categories that befit the aims of the study. Various statistical tools may be used to analyze the quantitative results the coding yields. In a design session in which an individual designer works alone, verbalization is prompted by asking the person to think aloud. Cross et al. [2] published a collection of protocol analysis studies using protocol analysis variants, all pertaining to the same two design protocols.

Linkography

Linkography was developed as a notation and analysis system based on protocols, see e.g., [3]. Unlike 'classic' protocol analysis, it concerns itself not with coding but with links among the speech units into which a protocol is parsed (by extension, it may also deal with other units or longer sequences of speech. For example, ideas extracted from a protocol). In many studies the unit of speech is a design move – the smallest step made by a designer, as a result of which the state of the design situation is at least somewhat transformed. In conceptual design the duration of a move may be a few seconds and the analysis is accordingly at the cognitive level. Since design problems are generally ill-defined and ill-structured, protocols of conceptual design phases reflect a search for a solution in which moves cannot be predicted ahead of time. Links among speech units (moves for the most part) therefore reflect the process of reasoning the designer is engaged in, as he or she endeavors to synthesize the primary concepts of a design solution.

Links between every pair of speech units are notated in a Linkograph, which is a diagram derived from a matrix. To do so, every unit is paired with every one of the preceding units and for every pair we ask: is there a link between the two units? A link pertains to the contents of the units, and is established using (expert) common sense. Thus for unit n the question is asked $n-1$ times, to check for links between n and 1, 2, 3… $n-1$. The total number of checks, and therefore of potential links is $n*(n-1)/2$. The system is binary in the sense that only a yes or no answer is given. Further coding of links is possible but no mandatory. Because of the large number of checks the process is labor intensive and therefore this method is suitable only for relatively short sequences of speech units. A typical Linkograph is shown in Figure 1, where links are represented by dots in a network.

Linkographs allow us to visualize the pattern of links among speech units and measure its properties in the form of a number of variables. The main variables are:
Link index: the ratio of links per speech units/moves.

The number and proportion of critical speech units/moves. A critical unit is one with a relatively high number of links associated to it; the threshold number of links used to determine criticality is arbitrary and is established per study relative to the grain of the study. We distinguish between criticality due to backlinks and criticality due to forelinks. Backlinks are links between a unit and previous units: in generating a Linkograph only backlinks are established. Forelinks are the virtual links between a unit and subsequent units. Such links can only be established post factum; in a Linkograph they have the same status as backlinks. Every link is counted once as a backlink of a particular unit, and once as a forelink of the other unit in the pair of linked units. The sum of all back and fore links is therefore twice the total number of links in the Linkograph.

Other variables pertaining to link distribution and positioning are also measured in Linkography and attest to the structure of design reasoning..

Linkography is particularly useful in comparisons, e.g., between processes by different designers in the same task; different phases in the same process; different predefined groups of designers, for instance experts and novices. It has also been used to compare communication parameters such as interactivity in tutorial conversations between teachers and students in studio sessions; the ratio of idea generation by students in a studio setting; creativity in idea-generation sessions of design teams; and the effect of different sources of inspiration on creativity and fixation. Linkography variables have been correlated with design productivity and creativity and appear to be useful in micro studies of cognitive behavior and reasoning processes in the context of design and design education. We presume that this method has the potential of illuminating matters of verbal communication in general, particularly in creative problem solving.

References

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