[MEtHodo]

Fiche technique

Causal cognitive mapping

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Definitions

Cognitive map is a "graphical representation of the mental representation that the researcher has made of a set of discursive representations expressed by a subject from his or her own cognitive representations about a particular object." (Cossette and Audet, 1992, p. 15).

Cognitive maps include two elements—nodes and arrows. Nodes represent concepts; arrows represent the relationships between the concepts (Cossette, 2002; Eden, 2004; Warren, 1995).

Weick and Bougon (1986, p. 106) differentiate between cognitive maps and causal cognitive maps. Cognitive maps consider all types of relationships among concepts; causal cognitive maps are limited only to causality relations.

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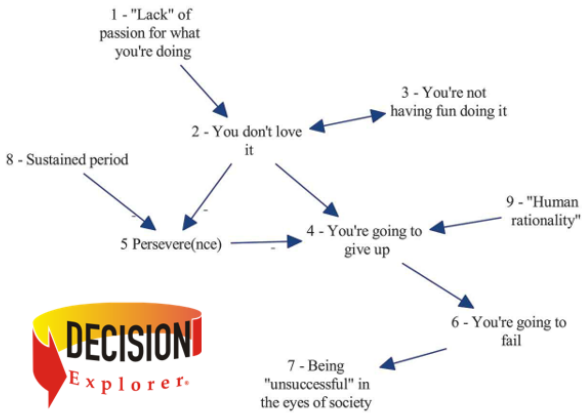
Two modes of causal cognitive mapping

Two methodological tools are commonly used for causal cognitive mapping (Swan, 1997). The first employs the visual graph method and Decision Explorer software (Cossette & Audet, 1992; Eden, 2004). The second tool employs the matrix-multiplication method with an adjacency matrix (Kosko, 1986; Weick & Bougon, 1986).

Visual representation of causal maps

Decision Explorer is computer software designed to capture and explore the cognition in terms of a causal graph structure (Eden & Ackermann, 2004). The cognitive use of an adjacency matrix can provide an alternative method to elicit the complexity of individuals' cognitions by using a matrix (Kosko, 1986; Weick & Bougon, 1986) in which C represents the map's concepts.

Visual graph method
(Cossette & Audet, 1992; Eden, 2004)



Adjacency matrix
(Kosko, 1986; Weick & Bougon, 1986, p. 106)

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	0	w_{12}	0	0	0	0	0	0	0
C2	0	0	w_{23}	w_{24}	w_{25}	0	0	0	0
C3	0	w_{32}	0	0	0	0	0	0	0
C4	0	0	0	0	0	w_{46}	0	0	0
C5	0	0	0	w_{54}	0	0	0	0	0
C6	0	0	0	0	0	0	w_{67}	0	0
C7	0	0	0	0	0	0	0	0	0
C8	0	0	0	0	w_{85}	0	0	0	0
C9	0	0	0	w_{94}	0	0	0	0	0

Conceptual centrality

The conceptual centrality score includes not only the direct but also the indirect causal-effect relationships among a map's concepts.

According to the visual graph method using the Decision Explorer software, this score is calculated as follows: The concepts directly linked to a map's concept receive a score of 1 (first level), the concepts linked to these concepts receive a score of 0.5 (second level), the concepts linked to these concepts receive a score of 0.33 (third level), and the process is repeated up to seven levels (Banxia Software Ltd, 2017, p. 78).

According to the second method, the indirect causal relationships among a map's concepts can be examined through adjacency matrix-multiplication (Swan, 1997) by using Mic-Mac (a matrix-multiplication software developped by Godet, 2000) by performing the following procedure (Manzano-Solís et al., 2019) :

Step 1 - Generating the matrix of indirect causality (MIC) : the adjency matrix (also called the matrix of direct causalities (MDC)), must be elevated to the n power until the concept classification according to their scores of indirect influences and dependences is stable.

Step 2 - The MIC must be standardized by dividing the values (wij) of the cells by the highest value contained in the MIC. The resulting matrix, which is called the matrix of standardized indirect causalities (MSIC), contains cell values that range from zero to one.

Step 3 - The MSIC must be summed with the MDC. The resulting matrix, which is called the matrix of total causalities (MTC) contains not only the direct but also the indirect causal links among the map's concepts.

Step 4 - Then new scores of total influences (the sum of the values in a row) and dependences (the sum of the values in a column) can be calculated on the basis of the MTC.

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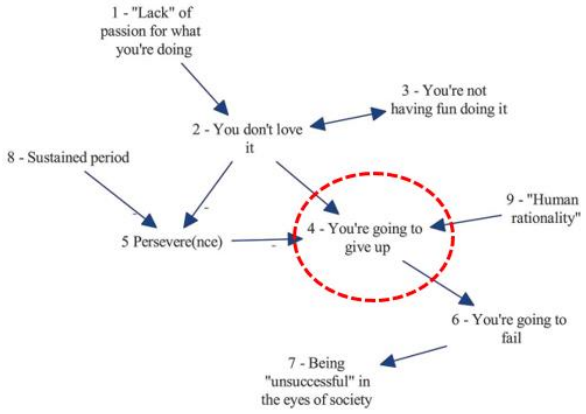
Visual graph method
(Cossette & Audet, 1992; Eden, 2004)

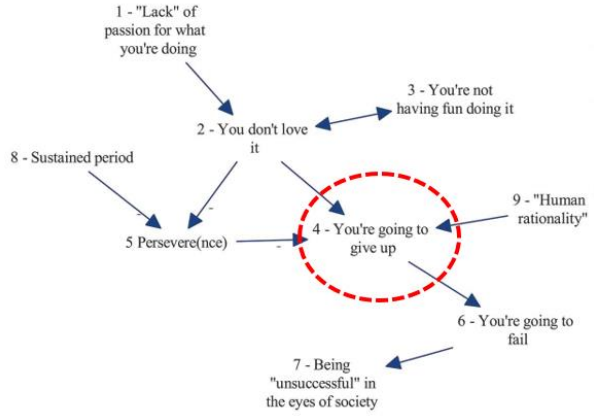


MTC
(Kosko, 1986; Weick & Bougon, 1986, p. 106)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	Outdegree
C1	0	1	1	1	1	1	1	0	0	6
C2	0	1	1	2	1	1	1	0	0	7
C3	0	1	1	1	1	1	1	0	0	6
C4	0	0	0	0	0	1	0	0	0	1
C5	0	0	0	1	0	0	0	0	0	1
C6	0	0	0	0	0	0	1	0	0	1
C7	0	0	0	0	0	0	0	0	0	0
C8	0	0	0	0	1	0	0	0	0	1
C9	0	0	0	1	0	0	0	0	0	1
Indegree	0	3	3	6	4	4	4	0	0	24

The MTC shown that the concept "C2—You do not love what you are doing" is the most central concept with a score of 10; a completely different score is given by the Decision Explorer software. The adjacency matrix multiplication method provides a more realistic "conceptual centrality" score without weighting the indirect causalities.

Visual graph method
(Cossette & Audet, 1992; Eden, 2004)

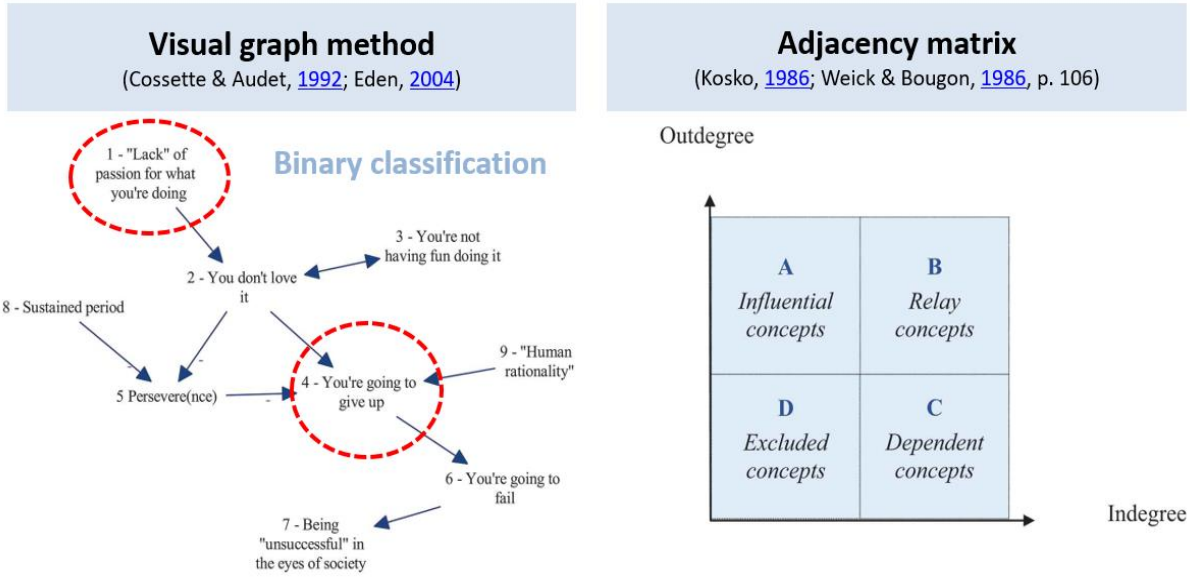


Adjacency matrix
(Kosko, 1986; Weick & Bougon, 1986, p. 106)

	Outdegree	Indegree	Centrality
C1	6	0	6
C2	7	3	10
C3	6	3	9
C4	1	6	7
C5	1	4	5
C6	1	4	5
C7	0	4	4
C8	1	0	1
C9	1	0	1
Total	24	24	48

Conceptual clustering

The visual graph method that uses Decision Explorer software reduces the complexity of an individual's cognition by focusing on the most "relevant" map concepts, which thus leads to a binary classification that opposes the "relevant" with the "irrelevant" concepts, whereas the adjacency matrix method provides a more nuanced classification by differentiating among the "relevant" concepts—the "influential," "relay," and "dependent" map concepts



Hidden concepts

The matrix multiplication method allows scholars to disclose "hidden" concepts that were previously classified as "excluded" but that play important roles in individuals' cognition because of their indirect causal links among the map's concepts. Such "hidden" concepts could remain undetected if scholars were to consider only the direct relationships among the map's concepts. Delineating this "excluded" concept may distort the cognitive map analysis.

This finding was observed by comparing the map's concept classification that resulted from the MDC (which considers only direct causalities) with the map's concept classification that resulted from the MTC (which considers both direct and indirect causalities) (Godet, 2000). For example, the MDC reveals that the concept "C3—You're not having fun doing it" was classified as "excluded" with a score of 2, but the MTC reveals that this concept is "central" with a score of 9

Classification that resulted from the MDC

	Outdegree	Indegree	Centrality
C1	1	0	1
C2	3	2	5
C3	1	1	2
C4	1	3	4
C5	1	2	3
C6	1	1	2
C7	0	1	1
C8	1	0	1
C9	1	0	1
Total	10	10	20

Classification that resulted from the MTC

	Outdegree	Indegree	Centrality
C1	6	0	6
C2	7	3	10
C3	6	3	9
C4	1	6	7
C5	1	4	5
C6	1	4	5
C7	0	4	4
C8	1	0	1
C9	1	0	1
Total	24	24	48

Loops analysis

As schown above, the adjacency matrix method allows scholars to disclose the "hidden" concepts among the "excluded" concepts, that is, the concepts that appear to be "central" in an individual's cognition considering the indirect causalities and loops. Decision Explorer can be used to identify the loops and consequently represent the "causal scheme" for which individuals do not necessarily have a "discursive awareness." Hence, the complementarities between these two methods for causal mapping.

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