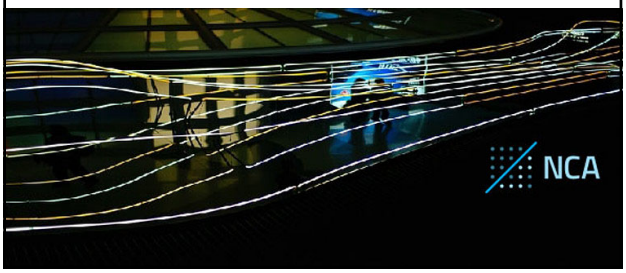
ACADEMY OF Management

Introduction
Necessary Condition Analysis

Jan Dul



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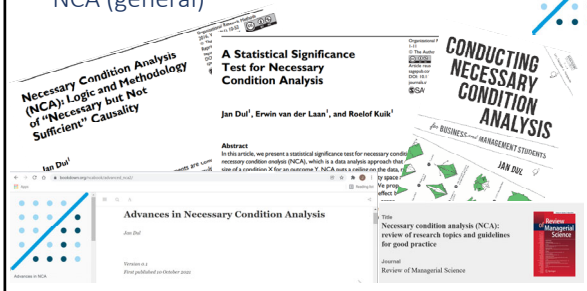
Key methodological publications on NCA (general)



- Dul, J. (2016). Necessary Condition Analysis (NCA): Logic and methodology of "necessary but not sufficient" causality. *Organizational Research Methods* 19(1), 10-52.
- Dul, J., van der Laan, E., Kuik, R. (2020). A statistical significance test for Necessary Condition Analysis. *Organizational Research Methods* 23(2) 385-395.
- Dul, J (2020). Conducting Necessary Condition Analysis (NCA). (Sage Publications).
- Dul, J. (2021). Advances in Necessary Condition Analysis. online book: https://bookdown.org/ncabook/advanced_nca2/
- Dul, J. Hauff, S. Bouncken, R. (2023). Necessary Condition Analysis (NCA): review of research topics and guidelines for good practice. *Review of Managerial Science* (published online).

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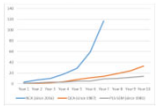
Rapid increase of NCA publications

217 publications since 2016 (source: website NCA)
Methodological publications: 20
Substantive publications: 194



- Psychology/Organizational Behavior (25)
- Entrepreneurship (21)
- Strategy (19)
- Operations/Supply chain management (19)
- Environmental sciences (15)
- Marketing (11)
- International business/management (10)
- Tourism & hospitality (10)
- Transportation (10)
- Medicine (9)
- Human Resource Management (7)
- Information systems (7)
- Public, Environmental & Occupational Health (6)
- Economics (6)
- Education (6)
- Technology (5)
- Public Administration (5)
- Finance (2)
- Human Factors/Ergonomics (2)
- History (1)
- Sport (1)

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Content

- Why NCA?
- Conducting NCA
- Example

- Discussion

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NCA

Focus on *single* conditions that are *necessary* ('critical') for the outcome

"You must have (a certain level of) X to have (a certain level of) Y"

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Historic roots of current causal thinking

David Hume (1756)
"Regularity theory of causation"

"… we may define a cause to be an object, follow'd by another, and where all the objects, similar to the first, are follow'd by objects, similar to the second: Or in other words, *where, if the first object had not been, the second never had existed."*

If X then Y (sufficiency)

If not X then not Y (necessity)

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Currently causal logics

Different logics/lenses:

Probabilistic sufficiency (Additive, average effects)
- If X then probably Y
- Used in regression: Y = b0 + b1*X1 + B2*X2 … + ε
- "X likely has an effect on Y" (on average). [e.g. X = smoking and Y = cancer]

Regularity sufficiency (combinations of X)
- If X then (always) Y
- Used in QCA: (X1,X2,X3) + (X3,X4) + … → Y
- Configuration (X1,X2,X3) or Configuration (X3,X4) ,.. is sufficient for Y"

Regularity necessity (single X)
- If not X then (always) not Y
- Used in NCA: Y < fc (X)
- "X is necessary for Y" (There must be (level of) X to have (level of) Y).

Note: NCA allows exceptions ("X is almost always necessary for Y")

Dul, J. (2024). Necessary Condition Analysis - NCA. Principles and Application. Chapman and Hall/CRC (in preparation)

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Theory-method fit

The method must fit the theory:

	Theory with probabilistic sufficiency causal logic	Theory with regularity sufficiency causal logic	Theory with regularity necessity causal logic
Regression	**Fit**	Misfit	Misfit
QCA	Misfit	**Fit**	Misfit
NCA	Misfit	Misfit	**Fit**

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Necessary conditions are everywhere

- Traveling to Boston is **necessary but not sufficient** for attending this PDW. (If you do not travel in Boston you will not attend this PDW).
- A high GMAT test score is **necessary but not sufficient** for admission to a PhD program. (If you do not have a high GMAT test score you will not be admitted to a PhD program).
- Senior management commitment is **necessary but not sufficient** for successful organizational change. (If there is no senior management commitment there will be no successful organizational change).

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Necessary conditions in academia

Examples from Academy of Management Journal

- "Managerial ties is **necessary, but not sufficient** for business success" (Peng & Luo, 2000).
- Social relationships are **necessary but not sufficient** for promoting high-performing cross-BU collaboration." (Martin & Eisenhardt, 2010)
- "Emotion recognition may be a **necessary but insufficient** ability involved in the performance of transformational leadership behavior." (Rubin, Munz, & Bommer, 2005)
- "Organizational commitment may be a **necessary but not sufficient** condition for low absenteeism". (Hausknecht, Hiller, & Vance, 2008).

Goertz' first law:
"for any research area one can find important necessary condition hypotheses."

(Goertz, G., & Starr, H. (2002). *Necessary conditions: theory, methodology, and applications*. Rowman & Littlefield)

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Necessary condition formulations

Enablers The presence of X …	Constraints The absence of X …
• X is necessary for Y • X is needed for Y • X is critical for Y • X is crucial for Y • X is essential for Y • X is indispensable for Y • X is a prerequisite for Y • X is a requirement for Y • X is a conditio sine qua non for Y • X is a pre-condition for Y • X allows Y • X enables Y • There must be X to have Y • Y requires X	• X constrains Y • X limits Y • X blocks Y • X bounds Y • X restricts Y • X is a barrier for Y • X is a bottleneck for Y • Without X there cannot be Y

Adapted from: Dul, J., Hak, T., Goertz, G. & Voss, C. (2010). Necessary condition hypotheses in operations management. *International Journal of Operations & Production Management* 30 (11), 1170-1190

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Relevance for research and practice

- If the necessary condition is not in place, there is **guaranteed failure**
- This absence of a necessary condition **cannot be compensated** by other conditions/determinants

- *The necessary condition works in **isolation**, independently of the context*

If not X then not Y (Hume)

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Why NCA?

- Because many phenomena include factors that are *necessary conditions* (that can stop the outcome)
- To better understand these phenomena
- Results are practically useful

Publication opportunities!

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- Discussion

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Conducting NCA

Stage 1
Formulate the necessary condition hypothesis

"X is necessary for Y"
(parsimonious theory)

Stage 2
Collect the data

Good data for X and Y
(good sample, good measurement, no new requirements)

Stage 3
Analyse the data

NCA's data analysis

In exploration studies
Stage 1 must be done after Stage 3

Stage 4
Write up the study

Dul, J. (2020) *Conducting Necessary Condition Analysis*. Mastering Business Research Methods Series, London: Sage Publications.

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Stage 3: Analyse data

Principles of NCA:

- Evaluates bivariate XY data patterns (e.g., scatter plots)
- Searches for empty spaces
- Draws ceiling lines
- Calculates NCA parameters (e.g., effect size, p-value)

"geometric analysis" rather than "statistical analysis" (no assumptions about distribution of data)

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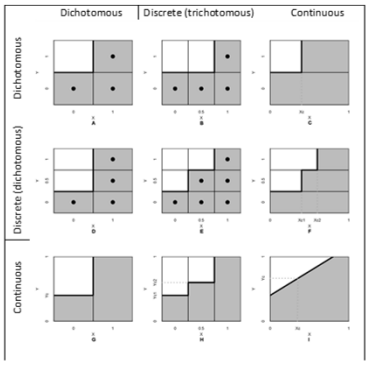
Stage 3: Bivariate XY data patterns



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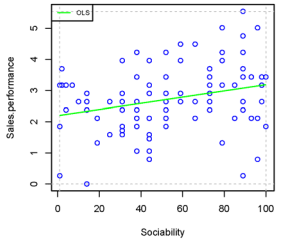
Conventional data analysis

"Probabilistic cause"
("generic cause", "contributing cause", "average effect")

$Y = f(X) + \varepsilon$



Data from: Hogan Personality Inventory (HPI) (Hogan, & Hogan, 2007).

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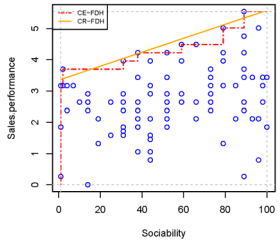
NCA's innovative data analysis

"Necessary cause",
("enabler", "constraint",
"bottleneck")

$Y \leq f_c(X)$



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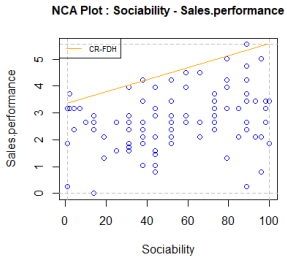
NCA parameters

Empty zone: Ceiling zone (C)
Total zone: Scope (S)
Effect size d=C/S (0≤ d ≤1)
p value: randomness of effect size (e.g., p < 0.05)
Ceiling accuracy: percentage of observations on or below the ceiling



Effect size: 0.19
Ceiling accuracy: 97%

Effect size	Classification
d < 0.1	"small effect"
0.1 ≤ d < 0.3	"medium effect"
0.3 ≤ d < 0.5	"large effect"
d ≥ 0.5	"very large effect"

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Deciding about support for a necessary condition

Necessary condition "in kind":

1. Empty space: Practical significance (e.g., effect size d > 0.1)
2. Statistical significance (e.g., p value < 0.05): no random effect of unrelated variables
3. Theoretical support (the necessity theory of Stage 1)

(Three necessary but not sufficient conditions for deciding that an empty space represents a necessary condition)

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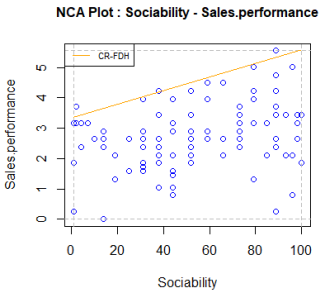
Bottleneck table

Necessary condition "in degree":

Sales Performance	Sociability
0	NN
1	NN
2	NN
3	NN
4	29
5	74
5.5	98



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Bottleneck table

Sales Performance	Sociability
0	NN
1	NN
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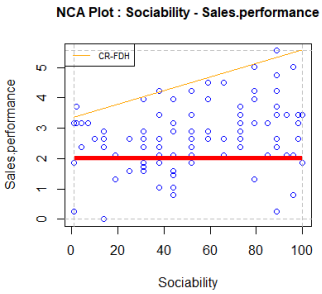

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Bottleneck table

Sales Performance	Sociability
0	NN
1	NN
2	NN
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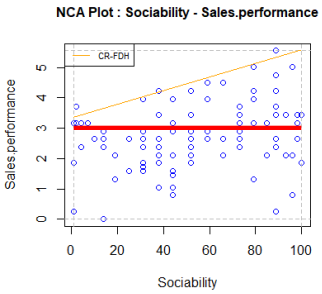

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Bottleneck table

Sales Performance	Sociability
0	NN
1	NN
2	NN
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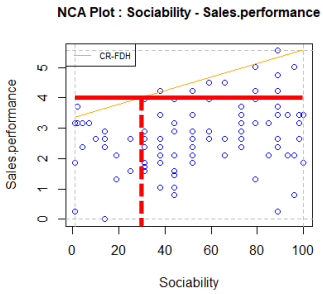
4	29
5	74
5.5	98



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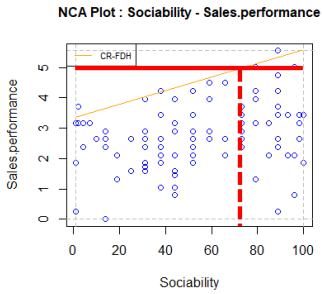
Bottleneck table

Sales Performance	Sociability
0	NN
1	NN
2	NN
3	NN
4	29
5	74
5.5	98



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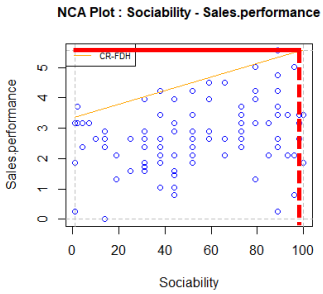
Bottleneck table

Sales Performance	Sociability
0	NN
1	NN
2	NN
3	NN
4	29
5	74
5.5	98



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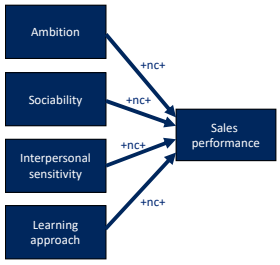
Example: multiple necessary conditions

Pure necessity causal theory



Bokrantz, J. and Dul, J. (2023). Building and testing necessity theories in supply chain management. *Journal of Supply Chain Management*, 59:48–65.
Example from: Dul, J., Hauff, S., and Tóth, Z. (2021a). Necessary condition analysis in marketing research. In Nunkoo, R., Teeroovengadum, V., and Ringle, C., editors, *Handbook of Research Methods for Marketing Management*, pages 51–72. Edward Elgar Publishing.
Data from: Hogan Personality Inventory (HPI) (Hogan, & Hogan, 2007).

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Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98

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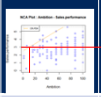
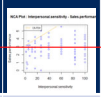
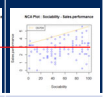
Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98

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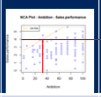
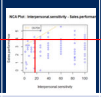
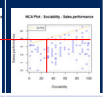
Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98

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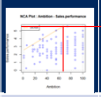
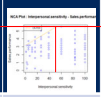
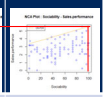
Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98

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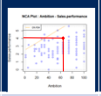
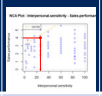
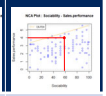
Example: multiple necessary conditions (example case)

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4 (4)	33 (65)	18 (28)	21(57)	29 (59)
5	55	40	52	74
5.5	67	52	68	98

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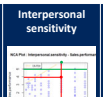
Example: multiple necessary conditions (example case)

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4 (4)	33 (65)	18 (60)	21(57)	29 (59)
5	55 (65) ✓	40 (60) ✓	52 (57) ✓	74 (59) ✗ Bottleneck !
5.5	67	52	68	98

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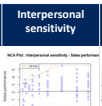
Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98
d	0.18	0.11	0.14	0.19	
B	0.19	0.01	-0.19	0.26	Adj. R^2=.10

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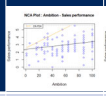
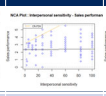
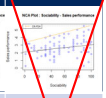
Example: multiple necessary conditions

Sales Performance	Ambition	Interpersonal sensitivity	Learning approach	Sociability
				
0	NN	NN	NN	NN
1	NN	NN	NN	NN
2	NN	NN	NN	NN
3	10	NN	NN	NN
4	33	18	21	29
5	55	40	52	74
5.5	67	52	68	98
d	0.18	0.11	0.14	
B	0.28	0.01	-0.15	Adj. R^2=.05

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Strengths of NCA

- Parsimonious theory (no confounders, control variables)
- Simple data collection
- Straightforward data analysis
- Practically relevant
- Opportunity for interesting publication

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Weaknesses of NCA

- Theory not about presence of outcome
- Possibly sensitive to outliers
- Inferential statistics not fully developed

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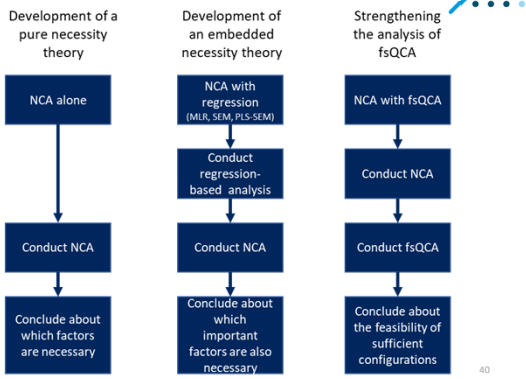
Three possible uses of NCA



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Recent methodological developments

Published (online book):

- Outlier indentification
- Robustnest checks
- Power analysis

Expected:

- NCA's causal theory ("indeterminsitic regularity")
- New fit measures (veracity, solidity)
- Recommendations for formulateng necessity theory (combining literature, researcher's expertise, generative AI and thought experiments)
- STATA package for NCA (volunteers Beta testers?)

Dul, J. (2021-now). Advances in Necessary Condition Analysis (online)
Dul, J. (2024). Necessary Condition Analysis - NCA. Principles and Application. Chapman and Hall/CRC (in preparation) .

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Recent general reviews and guidelines

Published:

- General overview of NCA publications + guidelines
  Dul, J. (2023) Necessary Condition Analysis (NCA) and its diffusion. *Oxford Encyclopedia of Business and Management*.
- Overview of topics in business and management + guidelines
  Dul, J., Hauff, S., Bouncken, R. B. (2023). Necessary condition analysis (NCA): review of research topics and guidelines for good practice. *Review of Managerial Science.*

Expected:

- NCA guided QCA
  Rubinson, C., Dul, J.
- Extended guidelines for using NCA with PLS-SEM
  Dul, J. Ringle, C.M. , Richter, N.F., Hauff, S., Sarstedt, M.

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Support for NCA users - 1

- Website (www.erim.nl/nca) (including Discussion Forum)
- Online beginners course (https://www.coursera.org/learn/necessary-condition-analysis)
- R-package (NCA version 3.3.2)
  Quick start guide quick start guide: http://repub.eur.nl/pub/78323/ or https://ssrn.com/abstract=2624981
- Calculator (on website)
- "How to" book (Sage)
- Guidelines-publications (https://doi.org/10.1007/s11846-023-00628-x)
- Advanced on line book (online: https://bookdown.org/ncabook/advanced_nca2/)
- Social media (Facebook, LinkedIn)
  Facebook : http://facebook.com/NCA.community
  LinkedIn : https://www.linkedin.com/groups/13664044/
- Newsletter (subscribe on website)

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Support for NCA users -2

Next online courses:

- Necessary Condition Analysis NCA: Foundations and Applications: 6-9 September 2023. INSTATS (www. instats.org)
- Paper Development Workshop: November 2023 (contact: stefan.breet@ru.nl)

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Conclusion

NCA:

- Has become a broadly accepted method
- Uses a different (*not better!*) paradigm for theory and practice ("must haves")
- Gives new insights and publication opportunities

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