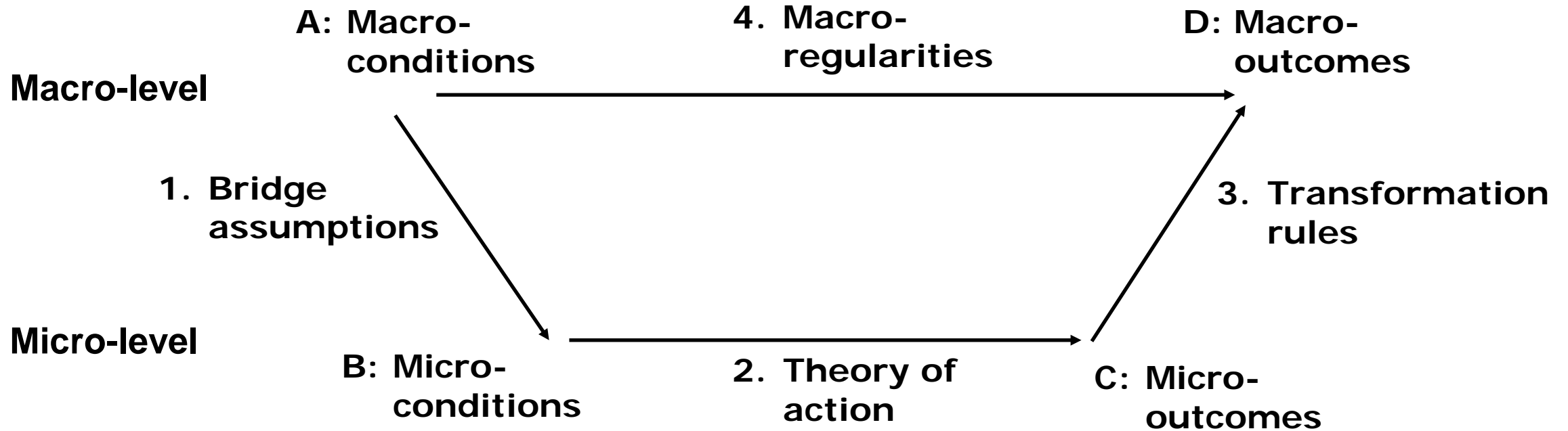# Coleman's Diagram: Some Comments

Werner Raub

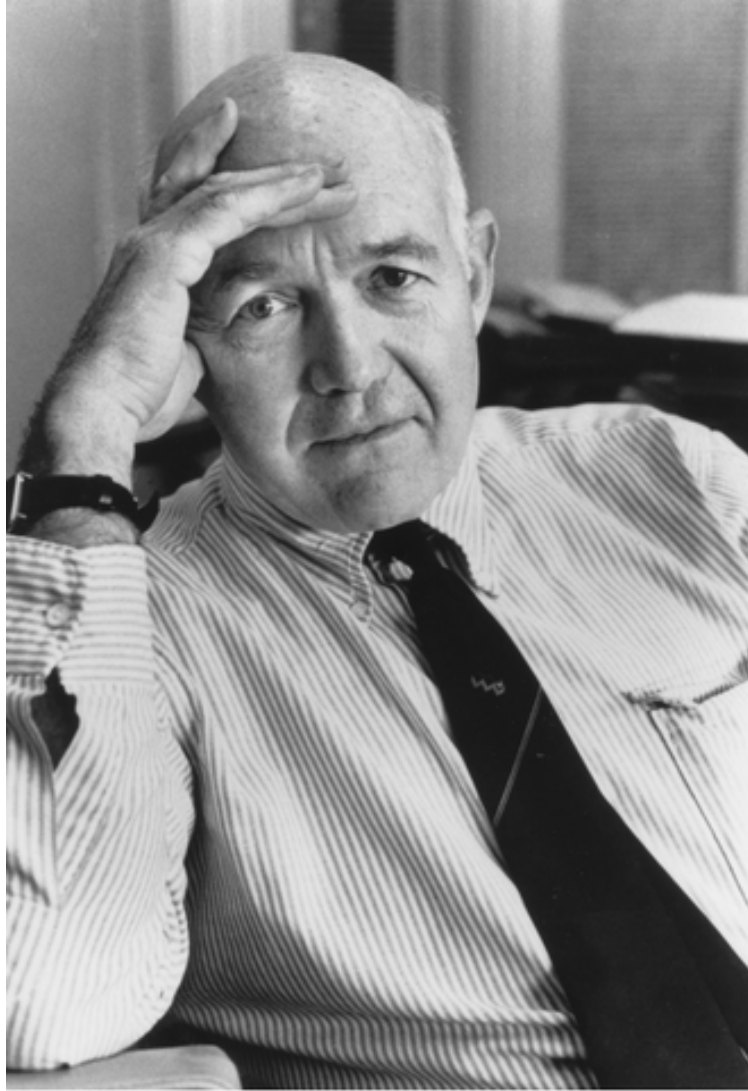Department of Sociology/ICS
Utrecht University

Workshop
'Analytical Sociology: Theory and Empirical Applications'
Venice International University, November 20–23, 2023

For starters...

Coleman's diagram

Macro-level

A: Macro-conditions

4. Macro-regularities

D: Macro-outcomes

1. Bridge assumptions

3. Transformation rules

Micro-level

B: Micro-conditions

2. Theory of action

C: Micro-outcomes
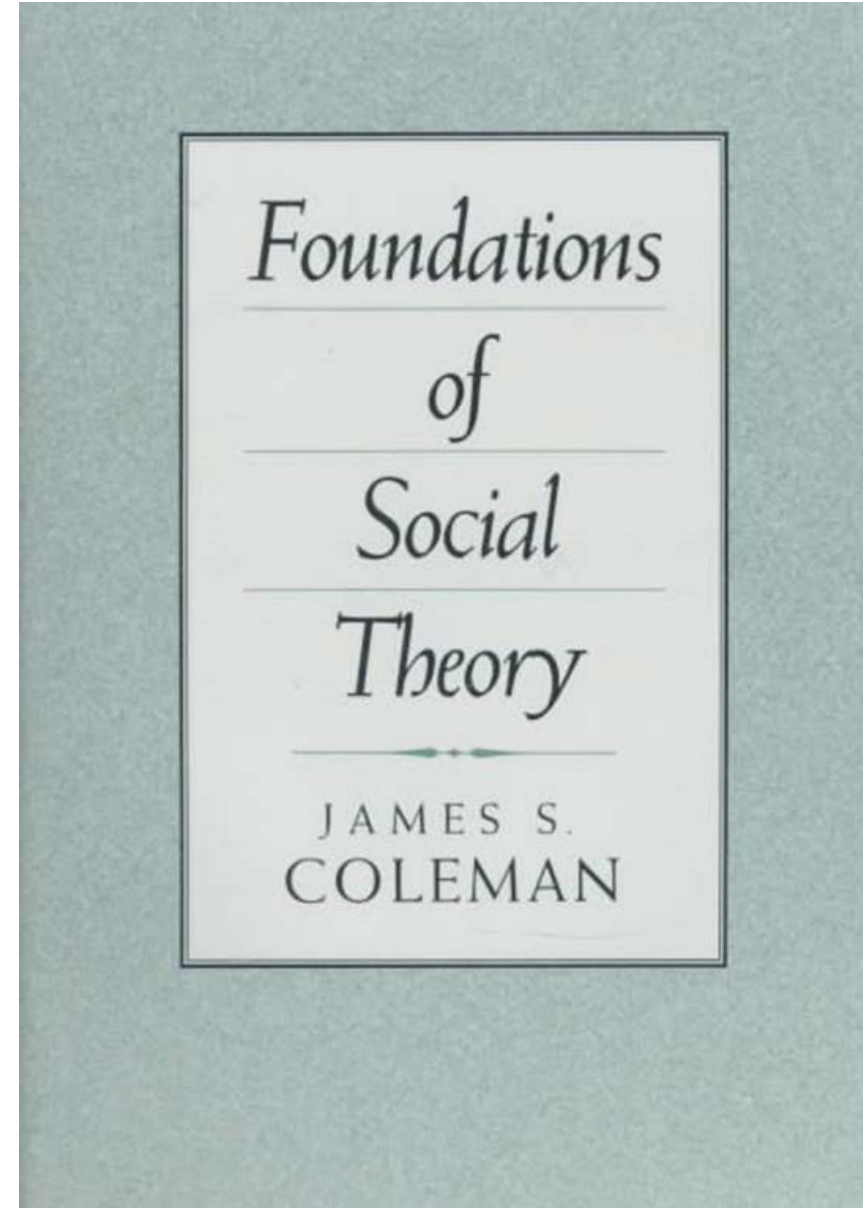
James S. Coleman

James S. Coleman

'Quantitative impact' of *Foundations...*

Google Scholar citations (as of October 16, 2023):

- To *Foundations of Social Theory* > 47.000

- Citations to other 'programmatic work'
  - G. Becker (1976) *The Economic Approach to Human Behavior* ≈ 11.000
  - P. Hedström (2005) *Dissecting the Social. On the Principles of Analytical Sociology* ≈ 2.200

'Impact': textbooks

Hartmut Esser

Soziologie
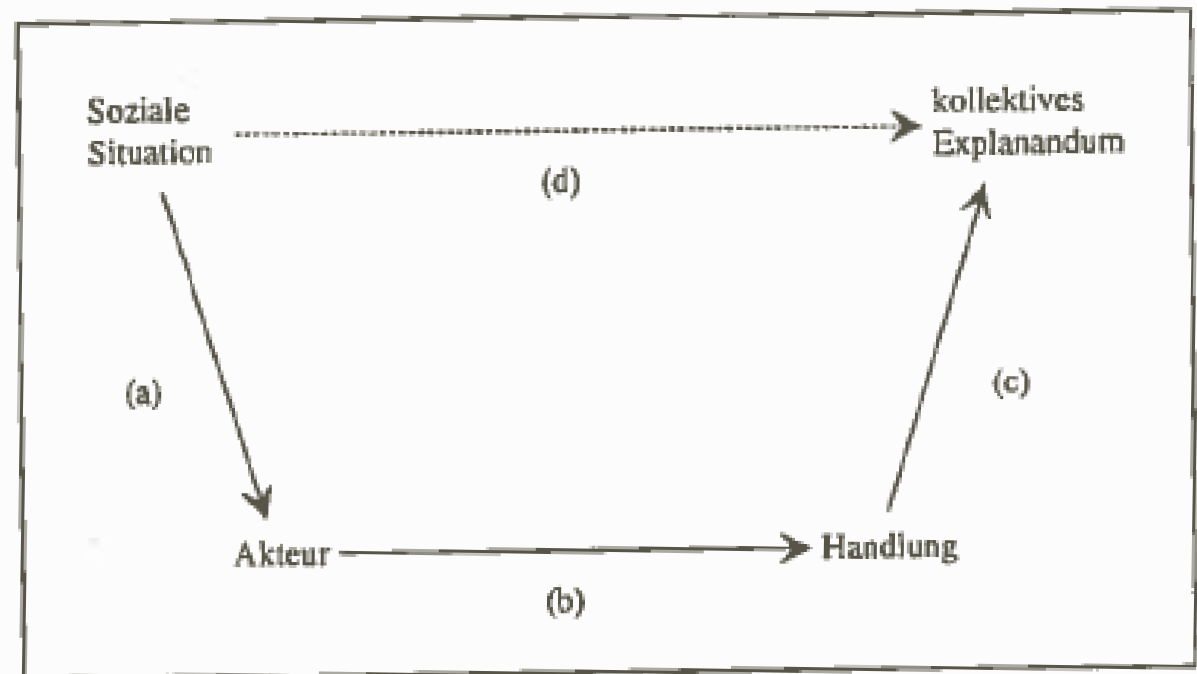
Allgemeine Grundlagen

Campus Verlag
Frankfurt/New York

Abb. 6.1: Das Grundmodell der soziologischen Erklärung

'Impact' in demography

Integrating macro- and micro-level approaches in the explanation of population change

Francesco C. Billari
University of Oxford

Demographers study population change across time and place, and traditionally they place a strong emphasis on a long-range view of population change. This paper builds on current reflections on how to structure the study of population change and proposes a two-stage perspective. The first stage, discovery, focuses on the production of novel evidence at the population level. The second stage, explanation, develops accounts of demographic change and tests how the action and interaction of individuals generate what is discovered in the first stage. This explanatory stage also provides the foundation for the prediction of demographic change. The transformation of micro-level actions and interactions into macro-level population outcomes is identified as a key challenge for the second stage. Specific instances of research are discussed.

Keywords: demographic research; theory; life course; micro–macro; discovery; explanation

Introduction

Demographers study population change across time and place, and traditionally they place a strong emphasis on a long-range view of population change. In this paper, I address two questions about the strategy of studying this phenomenon. First, should the study of population change be anchored solidly at the macro level of populations as located in time and place? Second, should we consider the micro level of individual actions and interaction that bring about demographic change to be outside the core realm of demography? Building on current and

the production of demographic evidence is grounded in formal demographic measurement, which at times might require spatial or temporal statistical modelling, or both. 'Discovering' population trends and patterns is a macro-level challenge, albeit ultimately based on the collection of micro-level data.

Informed by evidence produced in the first stage, the second stage in demographic inquiry should be aimed at explaining population change and predicting its future development. For this second, *explanation*, stage, a micro-level 'life-course' theoretical and empirical framework is essential in order to explain what has been discovered. The use of the

events or the prevalence of demographically relevant behaviour among individuals or couples) is studied as a function of macro-level factors (Entwisle et al. 1984, 1986; Entwisle 2007). Action-formation mechanisms have implicitly been invoked in life-course analyses of demographic behaviour, in which micro-level outcomes are studied as a function of the past history of individuals (embedded in a macro context), and in event-history analysis (Hobcraft and Murphy 1986; Courgeau and Lelièvre 1992), generalized to outcomes that are more general than the timing of events as life-course analysis (Billari 2003).

Transformational (micro→macro) mechanisms in demography

Mortality

The formidable improvement in survival triggered by the demographic transition and its aftermath has contributed to a renewed interest in the determinants of age patterns of mortality and their changes over time. In this area, the study of mortality and longevity through the lens of 'frailty' is an important example
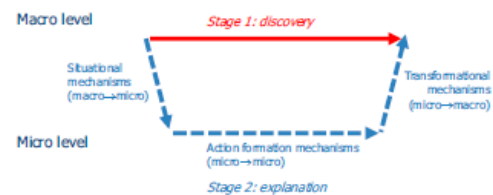

Macro level — *Stage 1: discovery*

Situational mechanisms (macro→micro) / Transformational mechanisms (micro→macro)

Micro level — Action formation mechanisms (micro→micro)

Stage 2: explanation

Figure 1 The two-stage view of demography (adapted from Hedström and Swedberg 1998 and the original diagram by Coleman 1986)

'Impact' in political science

Process-Tracing Methods

Foundations and Guidelines
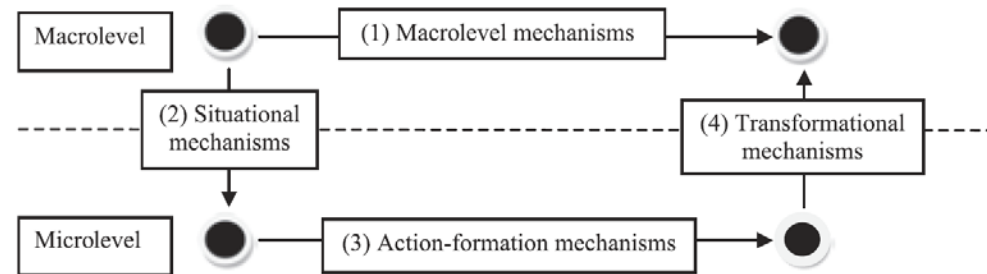
Derek Beach *and* Rasmus Brun Pedersen

The University of Michigan Press
Ann Arbor

What Are Causal Mechanisms? 41

Fig. 3.6. Levels of causal mechanisms. (Based on Hedström and Swedberg 1998: 22.)

Caution!

Given that there is so much attention for the diagram: keep in mind that *Foundations of Social Theory* is about much, much more than the diagram and that Coleman has contributed much, much more to sociology than the diagram

Foundations... ≠ diagram

Rest of presentation

Some comments on…

- …key features of the diagram

- …how the diagram relates to sociology as a science in line with methodological individualism ('rigorous sociology'; 'analytisch-empirische Soziologie')

Comment #1

A useful interpretation of the diagram: nodes and arrows represent key assumptions and implications of sociological explanations
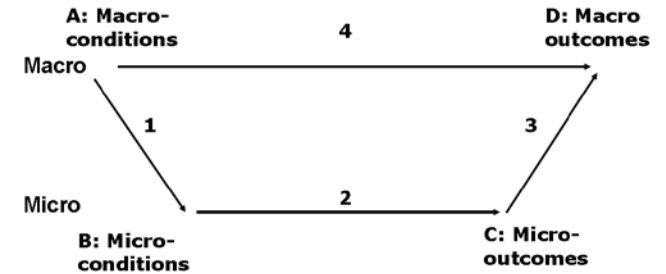
Comment #1

A useful interpretation of the diagram: nodes and arrows represent key assumptions and implications of sociological explanations

Interpretation seems obvious but...

- ...helps to avoid misunderstandings

- ...has some noteworthy implications

Sociological explanations

- Sociological explananda: macro-outcomes (Node D) and macro-level regularities (Arrow 4)

- Macro-level: assumptions (Node A) and implications (Node D) on collective phenomena, i.e., properties of social systems (e.g. dyad, triad, family, city, business firm, school, society)

- Micro-level: assumptions (Node B) and implications (Node C) on properties of individuals (e.g. preferences, information, behavior)

- Macro-explananda are derived from assumptions on...
  - ...macro- and micro-conditions (Nodes A, B)
  - ...regularities of individual behavior (Arrow 2): theory of action
  - ...bridge assumptions (Arrow 1) on how macro-conditions are related to 'independent variables' on the micro-level
  - ...transformation rules (Arrow 3) on how actors' behavior generates macro-outcomes

Comment #2

A simple but noteworthy implication

Implication...

- The diagram is *not* a 'causal diagram' representing relations between variables
    - Nodes ≠ variables; arrows ≠ causal relations
- Note: Simplified 'keyword summaries' (such as Coleman's own keyword summaries) misleadingly suggest the 'causal diagram'-interpretation
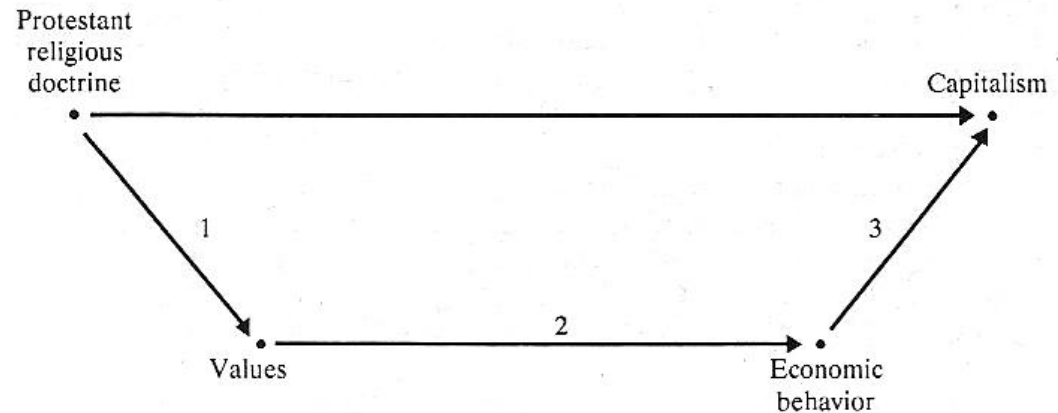

Figure 1.2 Macro- and micro-level propositions: effects of religious doctrine on economic organization.

Comment #3

An example: group size effects on collective good production – Volunteer's Dilemma

Comment #3

An example: group size effects on collective good production – Volunteer's Dilemma

- Aim: highlighting the difference between the diagram as a visualization of key assumptions and implications of explanations *versus* the 'causal scheme-interpretation'

- 'Technicalities' are less important but it's important to see that there *are* technicalities

Diekmann, A. (1985) Volunteer's dilemma. *Journal of Conflict Resolution* 29: 605–610

Raub, W. (2020) Sozialwissenschaftliche Erklärungen als rationale Modelle, in: A. Tutić (ed.), *Rational Choice*, Berlin: De Gruyter, 26–58

Group size effects on collective good production

- 'Classic' contribution: Olson, *Logic of Collective Action* (1965)
- Group size: macro-condition
- Individual contributions to collective good: micro-outcome
- Collective good production: macro-outcome
- 'Group size – collective good production': macro-relation
- Formal model: Volunteer's Dilemma-VOD (other models: Collective Good Game, *N*-person PD, etc.)

A formal model: Volunteer's Dilemma – VOD

- Non-cooperative *N*-person game (*N*≥2); binary choice: contribute (CONTR) – don't contribute (DON'T); simultaneous decisions; collective good is produced iff at least one actor contributes

- Cost of contribution *K*; (individual) gains from collective good *U*; *U*>*K*>0

- ==> normal form of VOD (note: *interdependence*):

	Number of other actors choosing CONTR				
	0	1	2	...	$N-1$
CONTR	$U-K$	$U-K$	$U-K$	...	$U-K$
DON'T	0	U	U	...	U

Fig. 2: Diekmann's (1985) Volunteer's Dilemma ($U > K > 0$; $N \geq 2$).

Game-theoretic analysis of VOD

	Number of other actors choosing CONTR				
	0	1	2	...	$N-1$
CONTR	$U-K$	$U-K$	$U-K$	...	$U-K$
DON'T	0	U	U	...	U

Fig. 2: Diekmann's (1985) Volunteer's Dilemma ($U > K > 0$; $N \geq 2$).

- N equilibria in pure strategies: one actor (a 'volunteer') chooses CONTR with probability 1, all others choose DON'T with probability 1
  - ==> asymmetric equilibria in a symmetric game
- Unique symmetric equilibrium in mixed strategies such that each actor chooses CONTR with

$$0 < p^* = 1 - \left(K/U \right)^{1/N-1} < 1$$

  - ==> plausible solution for VOD
- Implication: micro-probability p^* _declines_ with N

Group size effect on collective good production in VOD

	Number of other actors choosing CONTR				
	0	1	2	...	$N-1$
CONTR	$U-K$	$U-K$	$U-K$	...	$U-K$
DON'T	0	U	U	...	U

Fig. 2: Diekmann's (1985) Volunteer's Dilemma ($U > K > 0$; $N \geq 2$).

- Two opposite group size effects on macro-probability *P* of collective good production:
  - Positive effect: increase in number of players choosing CONTR with positive probability
  - Negative effect: each player's $p*$ decreases
- Macro-probability of collective good production in the symmetric equilibrium:

$$0 < P^* = 1 - \left(K/U \right)^{N/N-1} < 1$$

- Total effect: macro-probability *P** declines with *N*

VOD: summary of assumptions and implications in terms of the diagram I

Macro-level

- *Node A: assumptions on macro-conditions*
  - Actors involved in a collective good problem – VOD
  - Noncooperative game: binding agreements infeasible ('institution')
  - Group size: *N* actors
  - Information condition: normal form of VOD is 'common knowledge'
- *Node D: implication for macro-outcome*
  - Probability of collective good production
- *Arrow 4: implication for macro-regularity*
  - Association between group size and probability of collective good production

Bridge assumption (Arrow 1)

- Normal form of VOD shows how an actor's (expected) payoff depends on macro-conditions, own behavior, and behavior of other actors

VOD: summary of assumptions and implications in terms of the diagram II

Micro-level

- *Node B: assumption on micro-conditions*
  - (Expected) payoffs (see normal form of VOD)
- *Node C: implication for micro-outcome*
  - Individual probabilities of contributions
- *Arrow 2: theory of action*
  - Symmetric equilibrium as solution of VOD

Transformation rule (Arrow 3)

- Normal form of VOD shows how macro-probability of collective good production depends on individual probabilities of contributions

VOD: 'keywords-summary' in terms of the diagram
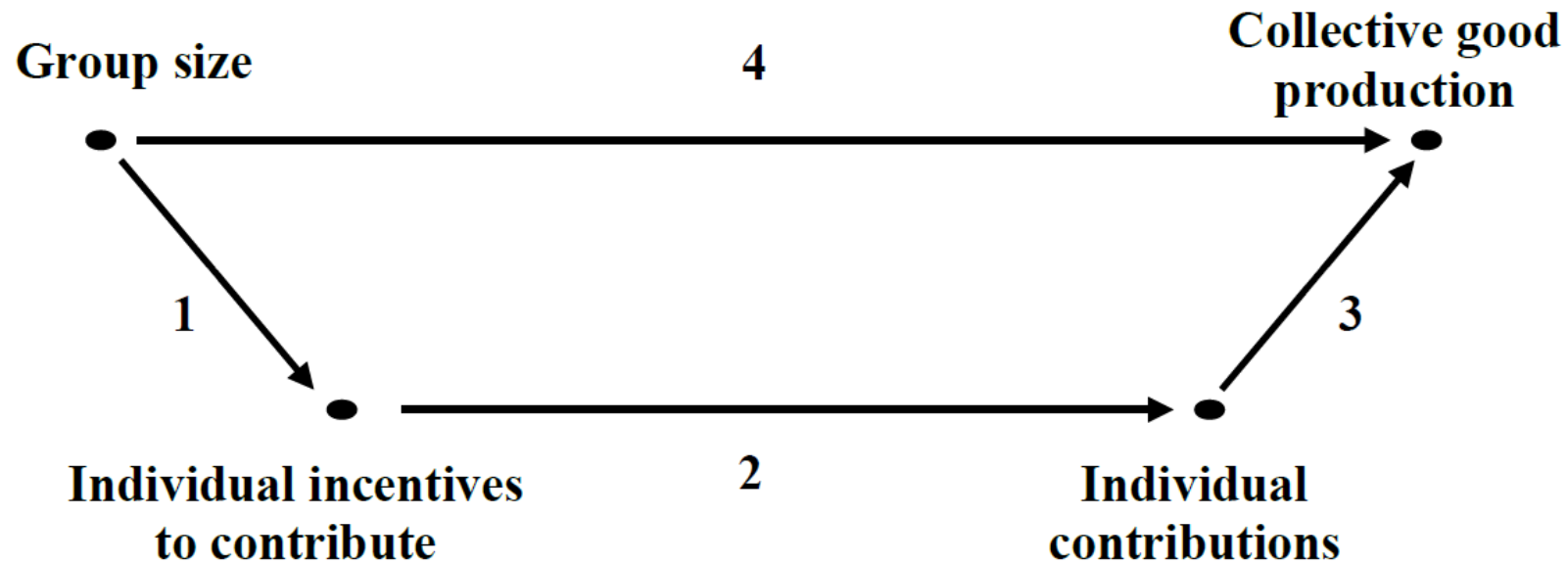
Some further remarks on the VOD example I

- Misleading simplicity of 'keywords-summary': assumptions and implications remain 'hidden'

- The keywords-summary misleadingly suggests a 'causal scheme'
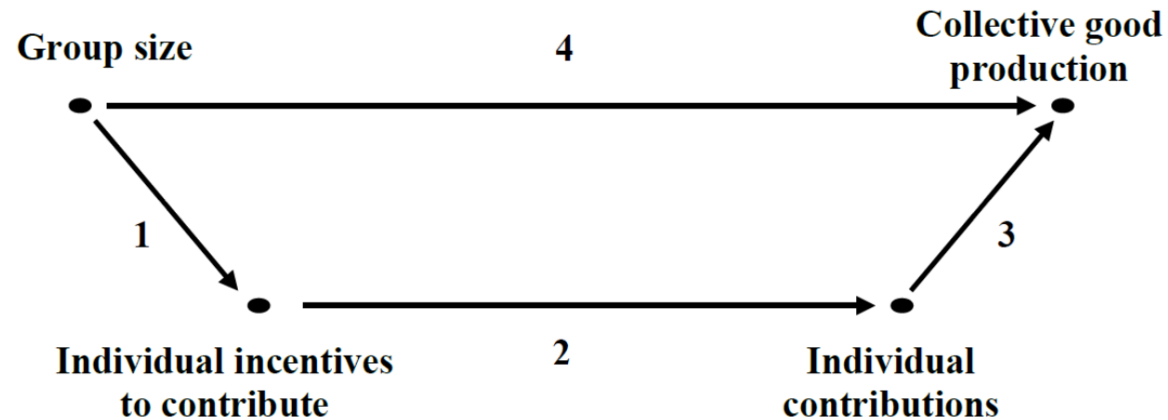
Some further remarks on the VOD example II

- The diagram as a visualization of _kinds_ of key assumptions and implications ('heuristic device') _versus_ a full-fledged model (such as our summary of assumptions and implications of the VOD-example)

- Focus of our example on _theory_. For _empirical tests of implications_, further assumptions are needed: specification of an experimental design, specification of a statistical model, etc.

- Note: 'theory + further assumptions' may _imply_ a causal scheme – but the causal scheme as an implication should be distinguished from the assumptions used for deriving the causal scheme

Other examples of 'detailed reconstructions' in terms of nodes and arrows of the diagram

- Boudon's competition model of relative deprivation
- Effects of dyadic embeddedness on trust and cooperation
- Network effects on trust and cooperation
- Emergence of status hierarchies

(Raub 2020; Buskens, Corten & Raub 2022)

Comment #4

The diagram is 'neutral' with respect to different micro-level theories of action

The diagram and theories of action

- VOD-example: standard noncooperative game theory as theory of action ('Arrow 2')

- The diagram allows for using _other_ theories of action: methodological individualism ≠ rational choice theory ≠ standard game theory

- Alternatives to rational choice theory: 'dual-process theories', other theories and assumptions from cognitive and social psychology, etc.

Comment #5

The diagram is a useful but imperfect device

Useful but imperfect…

- *'Useful':* the diagram visualizes _kinds_ of assumptions and implications that are key for sociology (roughly: 'necessary ingredients' of sociological explanations)

- *'Imperfect':* the typology of kinds of assumptions is _not exclusive_. Example: 'common knowledge assumption' in game-theoretic models – a macro- and/or micro-condition?

- *'Imperfect':* sometimes, the diagram needs to be 'extended': e.g., more than two levels (macro-meso-micro); dynamic processes ('fleet of "boats"')

- *'Imperfect':* the diagram itself does not specify the methodological status of the various assumptions (general laws? initial and boundary conditions? empirical regularities? definitions?…?)
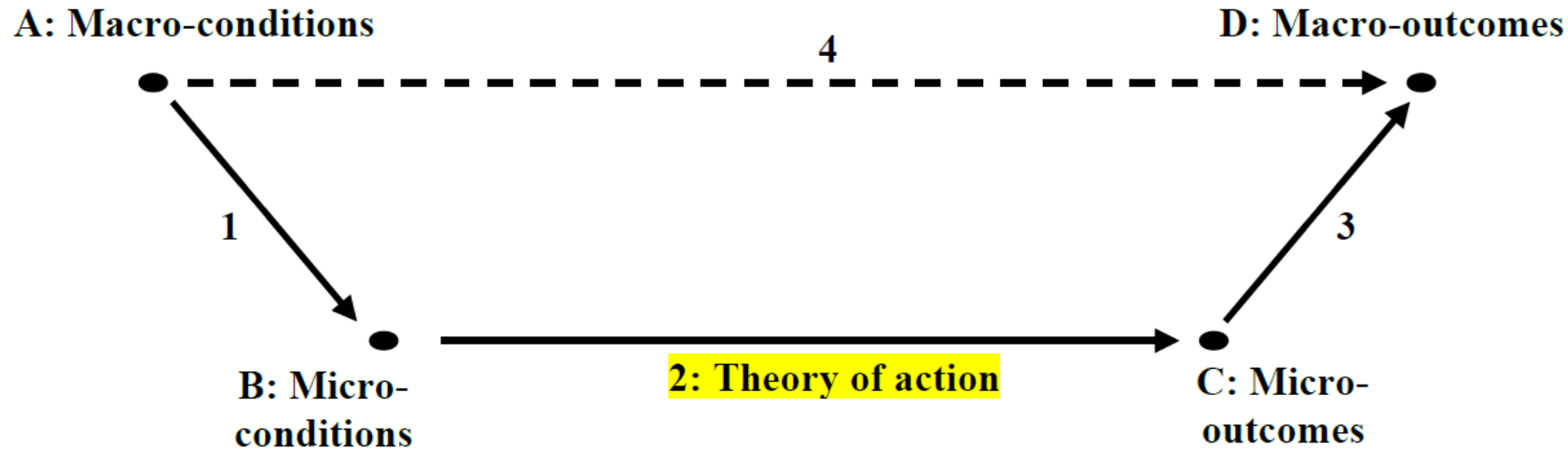
Comment #6

The diagram and middle-range theory

The diagram and middle-range theory I

- Middle-range theory à la Merton: 'we have social structures constraining individuals' action and cultural environments shaping their desires and beliefs (arrow [1]), and we have individuals choosing their preferred courses of action among the feasible alternatives (arrow [2]), and various intended and unintended outcomes of these actions (arrow [3]).' (Hedström & Udehn 2009; see Stinchcombe 1975)

- ==> the diagram visualizes key assumptions and implications of middle-range theories à la Merton

- ==> *middle-range theory* is perfectly compatible with employing a *general theory of action* (such as RC or others)

The diagram and middle-range theory II

A: Macro-conditions

D: Macro-outcomes

4

1

3

B: Micro-
conditions

2: Theory of action

C: Micro-
outcomes

- ==> *middle-range theory* is perfectly compatible with employing a *general theory of action* (such as RC or others)

- Employing the same general theory of action across several middle-range theories allows for theoretical integration and 'family resemblance' (Diekmann & Voss 2004)

Comment #7

The diagram and 'social mechanisms'

The diagram and 'social mechanisms'

- The diagram provides a simple and clear explication of the vague notion of 'social mechanisms' in analytical sociology

- Assumptions on 'social mechanisms' in terms of the diagram:

  - Bridge assumptions (Arrow 1) specify 'situational mechanisms'

  - Theory of action (Arrow 2) specifies 'action-formation mechanisms'

  - Transformation rules (Arrow 3) specify 'transformational mechanisms'

 (Hedström & Swedberg 1998 and earlier Esser 1993)

Comment #8

The diagram and 'social dynamics'

The diagram and 'social dynamics'

- An 'extension' of the diagram to visualize processes over time: a 'sequence' of diagrams such that macro-outcomes (Node D) at time t are macro-conditions (Node A) at time $t+1$

- Note the similarity to 'genetic explanations' (Hempel 1965; Stegmüller 1983)

- Example (Raub, Buskens & Frey 2013; 2019): endogenization of (networks of) repeated interactions that foster trust and cooperation

    - t_1: actors can invest in establishing (networks of) repeated interactions

    - t_2: (networks of) repeated interactions established in t_1 affect trust and cooperation t_2

Social dynamics: a "fleet" of diagrams

t_1 t_2 t_3 ...
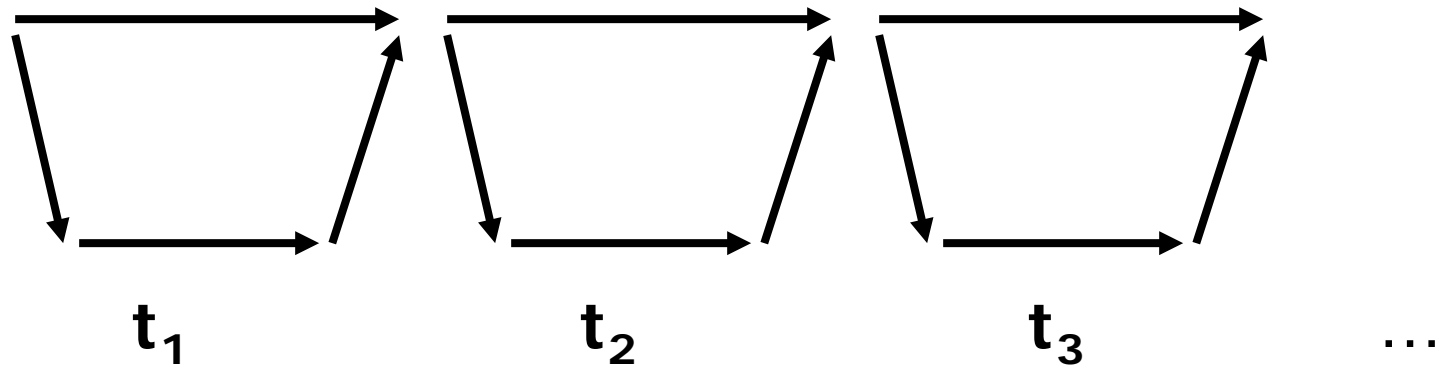
Comment #9

A comment on 'formal' and 'informal' explanations

Raub, W. & A. van de Rijt (2023) Methodological individualism and formal models, forthcoming in N. Bulle & F. Di Iorio (eds.) *Palgrave Handbook of Methodological Individualism*, London: Palgrave Macmillan

'Formal' and 'informal' explanations

- Examples mentioned are typically 'formal' models

- Formalization is often useful for deriving implications from assumptions (see already Hummell 1973; Ziegler 1972)

- But: formalization is *not an aim* in itself. It is a '*tool*' for achieving other aims: when clear informal reasoning suffices to derive conclusions, time and effort spent on formalization can better be invested otherwise (see Raub & Van de Rijt 2023)

- The diagram is a useful visualization for *both* formal and informal explanations

Formal theoretical models: the VOD example

- Note the 'complexities' that become apparent when implications are to be derived explicitly and, hence, assumptions must be made explicit.

- Examples from VOD-model:
  - RC assumptions versus assumptions on preferences and beliefs
  - Equilibrium behavior versus assumptions on equilibrium selection
  - What are the equilibria of the game?
  - What is the 'net effect' of increasing group size on the probability of collective good production?

Comment #10

A note on bridge assumptions and transformation rules

Bridge assumptions and transformation rules

- Coleman recommended explicit and careful specification of transformation rules (Arrow 3) and bridge assumptions (Arrow 1) as key assumptions in sociological explanations. He criticized that sociology is often deficient concerning such specification

- Note: the strategic as well as the extensive form of a game includes explicit specifications of transformation rules and bridge assumptions (see the VOD model)

Comment #11

Some misguided criticism of the diagram

Some misguided criticism…

- Simplified 'keywords-versions' of the diagram and interpreting the diagram as a variant of a 'causal scheme' (see Ylikoski 2021; Mäs 2021 for such interpretations) lead to misguided criticism:
  - 'Interdependencies and interactions between actors are neglected'
  - 'Heterogeneity of actors is assumed away (the diagram is based on a representative-agent approach)'
  - 'The diagram can only account for "simple aggregations" of individual behavior (and thus neglects unintended macro-consequences of behavior)'
- Note: examples such as VOD show that the nodes and arrows of the diagram *can* represent assumptions on interdependencies and interactions as well as on heterogeneity, and *can* allow for deriving macro-outcomes that are not merely 'simple aggregations' of individual behavior

Comment #12

By way of conclusion: 'predecessors' of the diagram

Raub, W. & T. Voss (2017) Micro-macro models in sociology: Antecedents of Coleman's diagram, in: B. Jann & W. Przepiorka (eds.), *Social Dilemmas, Institutions, and the Evolution of Cooperation*, Berlin: De Gruyter, 11–36

Raub, W. (2021) Analytical sociology and its lesser known antecedents: Structural individualism in European sociology, in G. Manzo (ed.), *Research Handbook on Analytical Sociology*, Cheltenham: Edward Elgar, 80–99

'Predecessors'

- The diagram has various 'predecessors', specifically in 'structural individualism' and 'explanatory sociology' that emerged in European sociology (Germany, Netherlands, France) in the 1970s: Hummell & Opp 1971; Lindenberg 1976, 1977; Boudon 1979 and Hernes 1976

- Key ideas underlying the diagram have been developed in this intellectual movement, often much earlier than elsewhere (also earlier than in Coleman's own work)

A _very_ early predecessor: McClelland 1961

McClelland (1961) _The Achieving Society_, New York: Free Press, p. 47
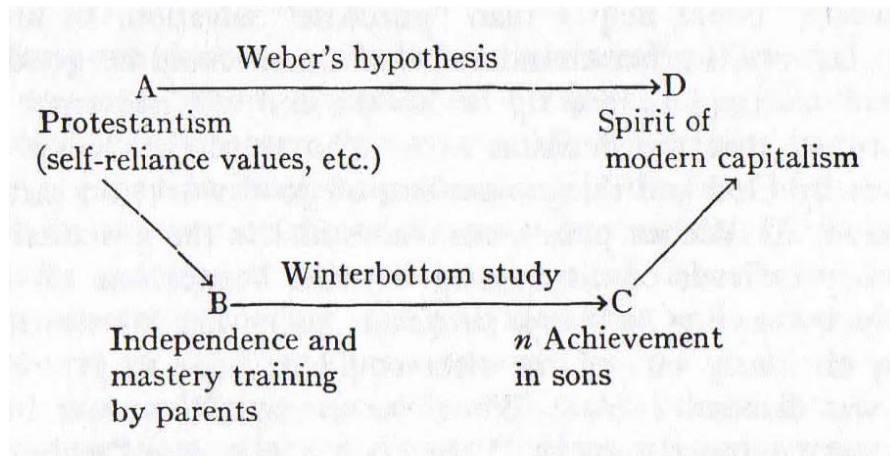
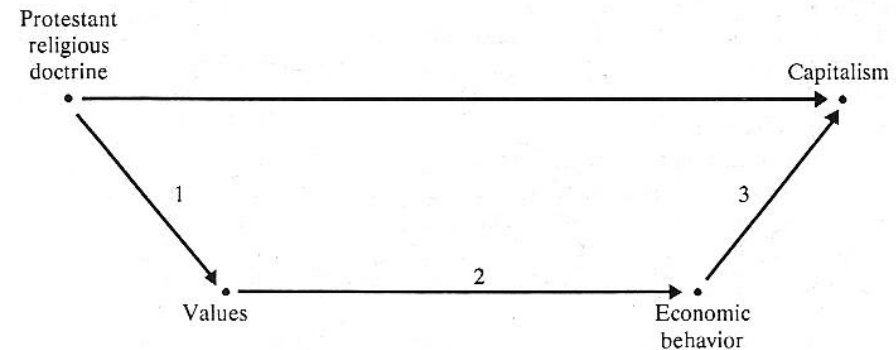**Coleman 1990: 8 (see also 1984, 1986, 1987)**

Figure 1.2   Macro- and micro-level propositions: effects of religious doctrine on economic organization.

(Brüderl 2004; Diekmann & Voss 2004; Opp 2011)

Another 'predecessor': Lindenberg 1977
'Two-step version' of H-O model of explanation

Propositions on individuals (micro-conditions; Arrow 2)

Bridge assumptions (Arrow 1)

Initial conditions
- **Macro-conditions (Node A)**
- **Micro-conditions (Node B)**

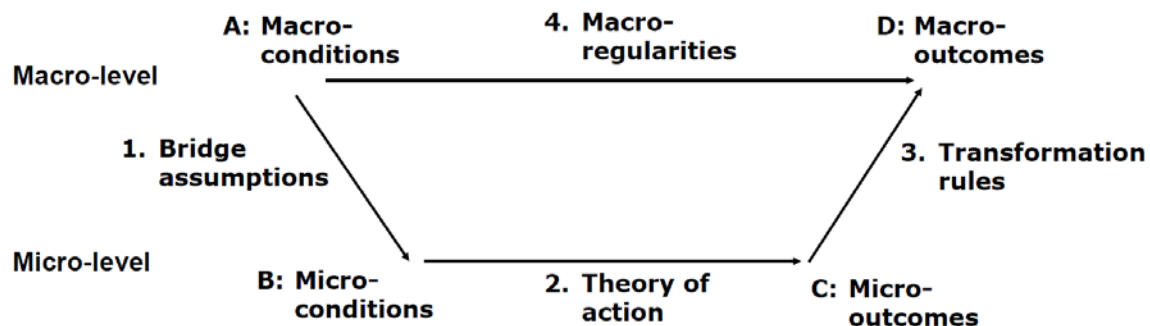**Individual effects (micro-outcomes; Node C)**

Transformation rules (Arrow 3)

Additional boundary conditions

Individual effects (micro-outcomes; Node C)

Collective effects (macro-outcomes; Node D)

Macro-level — A: Macro-conditions — 4. Macro-regularities — D: Macro-outcomes
1. Bridge assumptions
3. Transformation rules
Micro-level — B: Micro-conditions — 2. Theory of action — C: Micro-outcomes

Thanks for your attention!

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Further reading

- Raub, W. & T. Voss (2017) Micro-macro models in sociology: Antecedents of Coleman's diagram, in: B. Jann & W. Przepiorka (eds.), *Social Dilemmas, Institutions, and the Evolution of Cooperation*, Berlin: De Gruyter, 11–36

- Raub, W. (2020) Sozialwissenschaftliche Erklärungen als rationale Modelle, in: A. Tutić (ed.), *Rational Choice*, Berlin: De Gruyter, 26–58

- Raub, W. (2021) Analytical sociology and its lesser known antecedents: Structural individualism in European sociology, in G. Manzo (ed.), *Research Handbook on Analytical Sociology*, Cheltenham: Edward Elgar, 80–99

- Gërxhani, K., N.D. de Graaf & W. Raub (eds.) (2023) *Handbook of Sociological Science,* paperback edition and Open Access for all chapters