# A Collective Approach to Inductive Inference & Causal Reasoning Using Simpson's Paradox

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Talk to me about this research during the poster session via: https://heiconf.uni-heidelberg.de/2knu-zrtw-y66j-ztef

## Introduction

- Drawing causal inferences is important in daily life, however, individuals struggle with integrating a potential third variable in their reasoning, that influences the contingency between a cause and an effect, e.g. Simpson's paradox (Fiedler et al., 2002, 2003; Waldmann & Hagmayer, 2001)
- **Simpson's paradox** describes the phenomenon, that the contingency on an aggregate level between two variables x and y can be inverted by conditioning on a third variable z (for an example of such a contingency reversal see Figure 1)
- Inductive causal reasoning can elicit **group advantage**, because the correct solution can be demonstrated by drawing inferences from available, presented information (Laughlin & Ellis, 1986; Schulze & Newell, 2016)

➔ Do groups elicit an advantage over individuals in a trivariate reasoning task depicting Simpson's paradox? (**Study 1**)

➔ Does such an advantage go beyond nominal group effects? (**Study 2**)

## Results

**Study 1**

- Individuals did not differ significantly from chance level, $t(98) < 1$, but groups performed above chance level, $t(30) = 2.53$, $p = .017$, 95% *CI* [.54, .87].
- A logistic regression, $\chi^2(2) = 10.62$, $p = .005$, Nagelkerke $R^2 = .11$, with the factors group and causal model shows an effect of group, $b = 0.97$ ($SE = 0.46$), $z = 2.12$, $p = .034$, $OR = 2.64$, with a 95% *CI* [1.11, 6.74], and causal model, $b = -0.94$ ($SE = 0.37$), $z = -2.51$, $p = .012$, $OR = 0.39$, with a 95% *CI* [0.19, 0.81], with groups performing better than individuals and more correct decisions in the mediator condition. Results are shown in Figure 2.

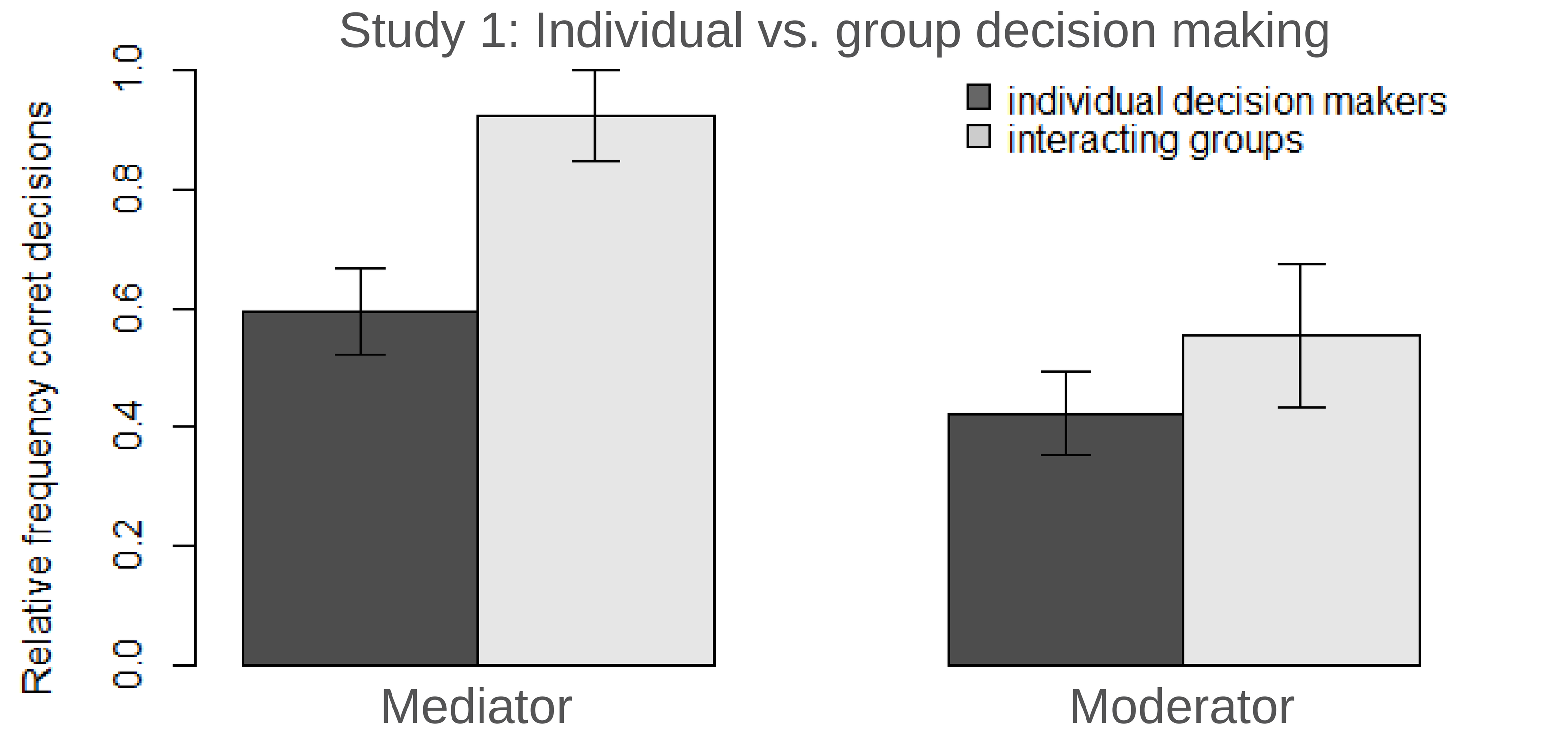


*Figure 2*. Performance of interacting groups vs. individual decision makers split into mediator and moderator condition. Relative frequencies of correct decisions with 95% CIs.

**Study 2**

- Individual decisions before group interaction were pooled **within the same group** using a) the majority rule and b) the most confident rule; results are compared to the **actual joint group decision**.
- 2 groups had to be excluded from the nominal decisions by applying the majority and most confident rule due to technical error in recoding the individual decisions of the group members (N=29).
- Interactive groups were not able to solve more decisions than nominal groups using either aggregation rule, $\chi^2(3) = 6.56$, $p = .087$. Results are shown in Figure 3.

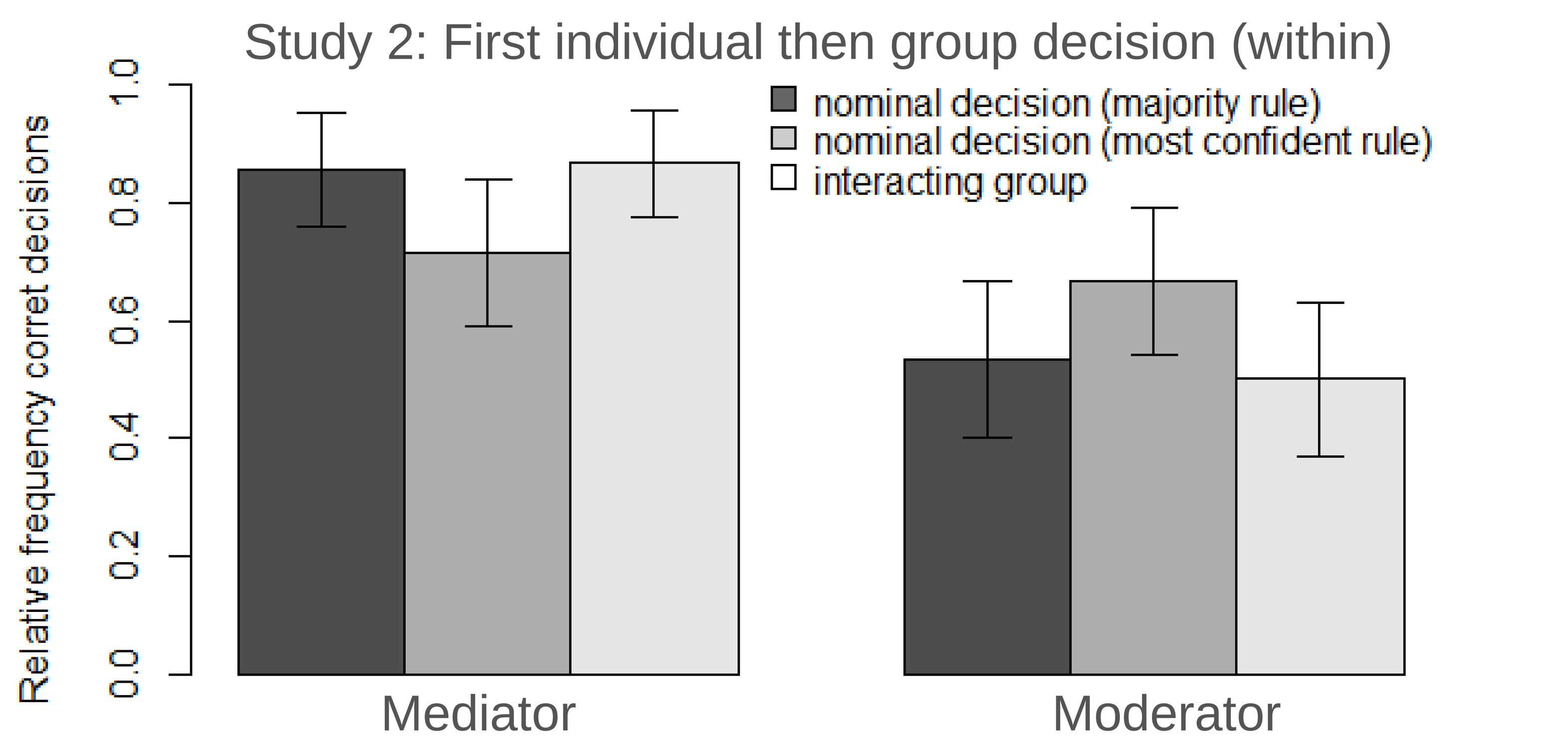


*Figure 3*. Performance of interacting groups compared to nominal groups pooled from the individual decisions of the group members before interaction. Two nominal decisions by applying two different aggregations rules (majority vs. most confident). Split into mediator and moderator condition. Relative frequencies of correct decisions with 95% CIs.

## Method

- Participants received two contradicting articles on two fictitious drugs designed to prevent heart attacks **by regulating blood pressure** (i.e. blood pressure is a mediator)
- Information was presented as icon arrays and in text
- Article 1 showed aggregated data (Figure 1, upper table) and article 2 showed disaggregated data (figure1, lower tables) conditioned upon one of two third variables (blood pressure vs. family predisposition) indicating two different underlying **causal models** (Figure 1, diagrams)
- Participants had to chose between the two drugs; correct choice was indicated by the causal model (mediator → aggregate data → Drug B in Figure 1 and vice versa for moderator)

**Study 1 – Individual vs. group decision making**

- 2 group (individuals vs. groups) x 2 causal model (mediator vs. moderator) between-subject design
- N=192, 99 Individuals & 31 groups of three

**Study 2 – First individual then group decision (within)**

- Only the group condition with group members making individual decision before group interaction and making a consensus group decision; material and between-factor causal model as in Study 1
- N=93, 31 groups of three

Causal models


Aggregated data

| Total | HA | No HA | Percent HA |
|---|---|---|---|
| Drug A | 26 | 16 | 62% |
| **Drug B** | **16** | **26** | **38%** |

Disaggregated

| Family predisposition | HA | No HA | Percent HA |
|---|---|---|---|
| **Drug A** | **26** | **8** | **76%** |
| Drug B | 8 | 0 | 100% |

| No family predisposition | HA | No HA | Percent HA |
|---|---|---|---|
| **Drug A** | **0** | **8** | **0%** |
| Drug B | 8 | 26 | 24% |

*Figure 1*. Overview of experimental scenarios. Different causal models used as between-subject factor in the studies. Contingency tables show aggregated (upper) and disaggregated (lower, here with family predisposition as third variable) data that was presented in articles using icon arrays and text. The data structure depicts a Simpson paradox as contingency is inverted between aggregation levels (better option highlighted in bold green for each aggregation level).

## Discussion

- Effect of causal model, i.e. mediation was solved more often than moderation. This might be due to lower processing effort associated with the correct answer as it requires focusing on the aggregated data level.
- Groups have an advantage over individuals (at least in tasks with lower processing effort).
- The advantage of group interaction seems to be similar to nominal groups pooled via majority rule or by selecting the most confident member. However, the procedure in Study 2 did differ from Study 1 by splitting decision time into first individual then group decision.
- Processes associated with the advantage of groups might be demonstrability of the correct solution and an increased epistemic vigilance (Sperber et al., 2010) due to critical interaction. However, these accounts require further investigation.

## References

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