Evaluation of the validity of ALE meta-analytic contrasts

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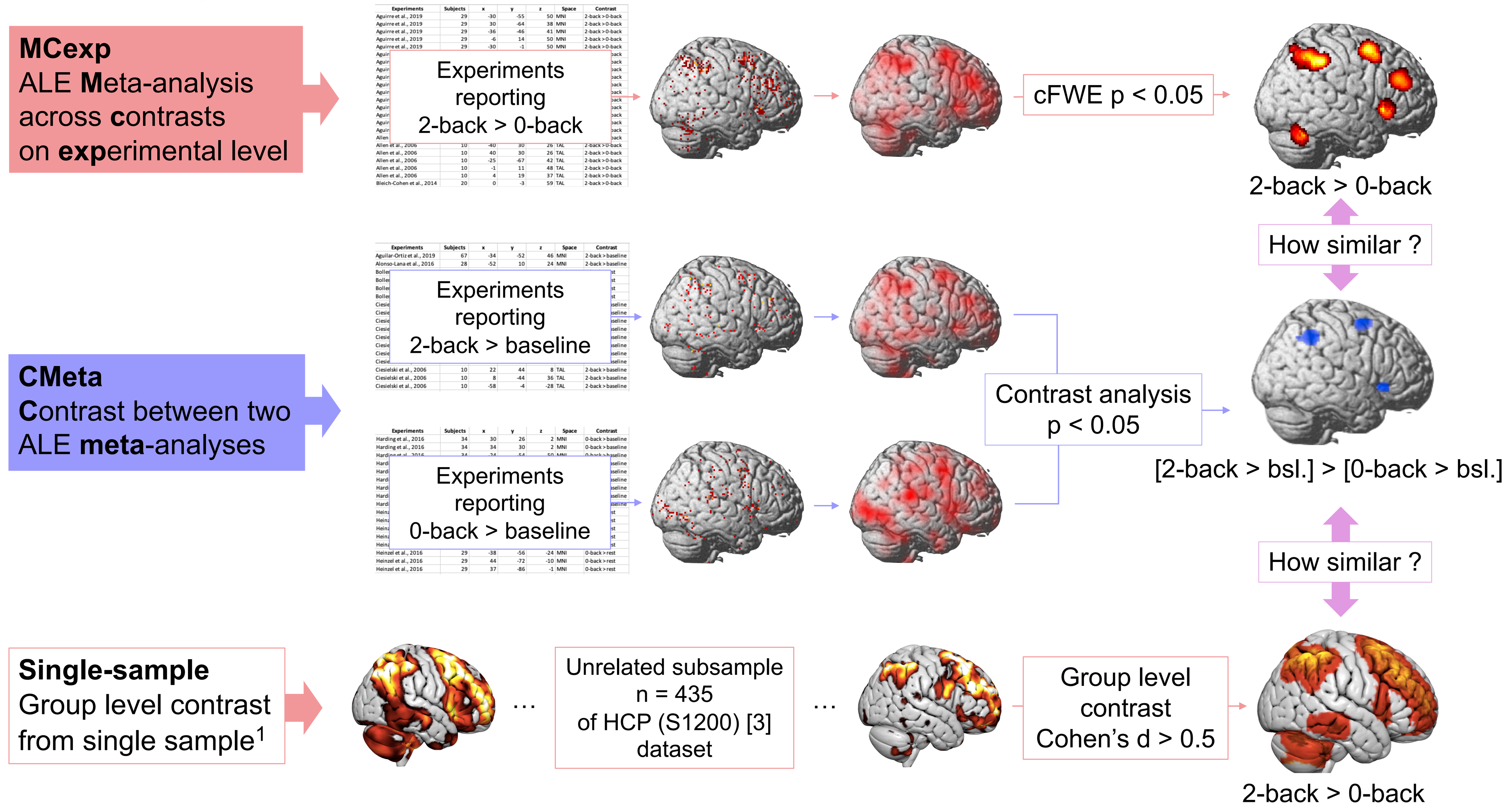
Background

- Activation Likelihood Estimation (ALE) meta-analyses of neuroimaging studies are key to overcome spurious findings, low power, analytical and experimental flexibility in individual fMRI studies
- ALE Meta-analytic contrasts [1] are statistical comparisons between the results of two individual meta-analyses, showing significant stronger convergence of one meta-analysis in comparison to another
  - Use-cases: e.g., dissect larger cognitive concepts (cognitive emotion vs. cognitive action regulation [2]); Testing new hypotheses (not yet investigated/ difficult to investigate in individual studies)
  - However, it remains unclear what exactly meta-analytic contrasts reflect
- AIM: investigate the validity of meta-analytic contrasts

Approach

- Two different cognitive tasks: Working memory (N-back) and Stroop interference
- Same comparison in three ways:



[1]The resulting contrast (and the sample used to compute it) were not used in any ALE analysis.

- Same was done for Stroop (incongruent > congruent), however without single-sample comparison.
- Effect of control condition: Comparing CMeta across experiments with high level control condition (CMeta-HLC) with CMeta across experiments with passive baseline condition (CMeta-Base)

Quantification of similarity as ROI[2]-wise measure of Jaccard similarity coefficient [4], sensitivity, specificity

$$Jaccard = \frac{ROIs\ A \cap ROIs\ B}{ROIs\ A \cup ROIs\ B} \quad Sensitivity = \frac{ROIs\ A \cap ROIs\ B}{ROIs\ B} \quad Specificity = \frac{NOT(ROIs\ A \cup ROIs\ B)}{NOT(ROIs\ B)}$$

[2]defined by Brainnetome Atlas 274 [5] parcellation (246 parcels; Diedrichsen [6] 28 cerebellar regions)

Results

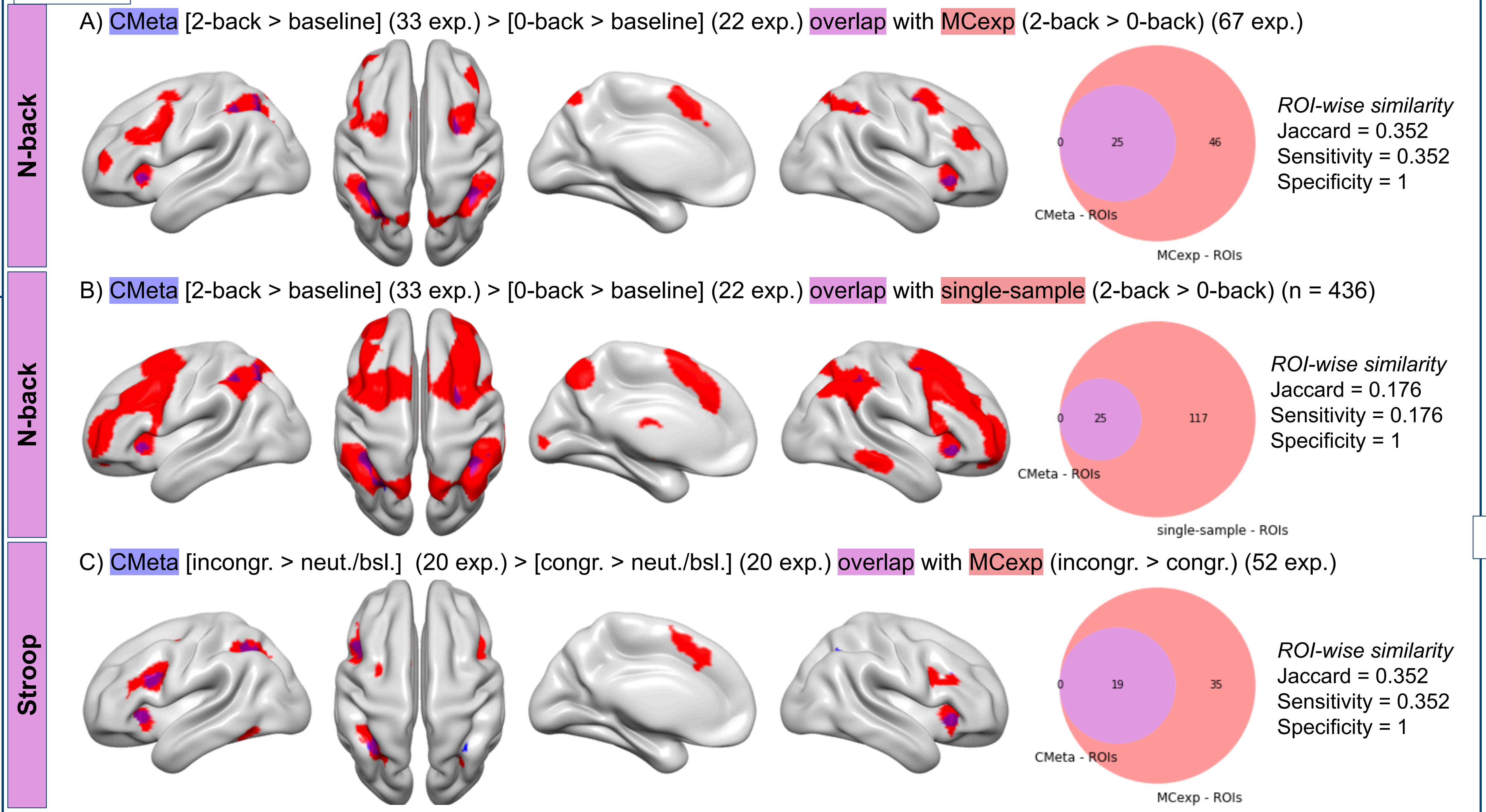


Figure 1. Meta-analytic contrast comparison

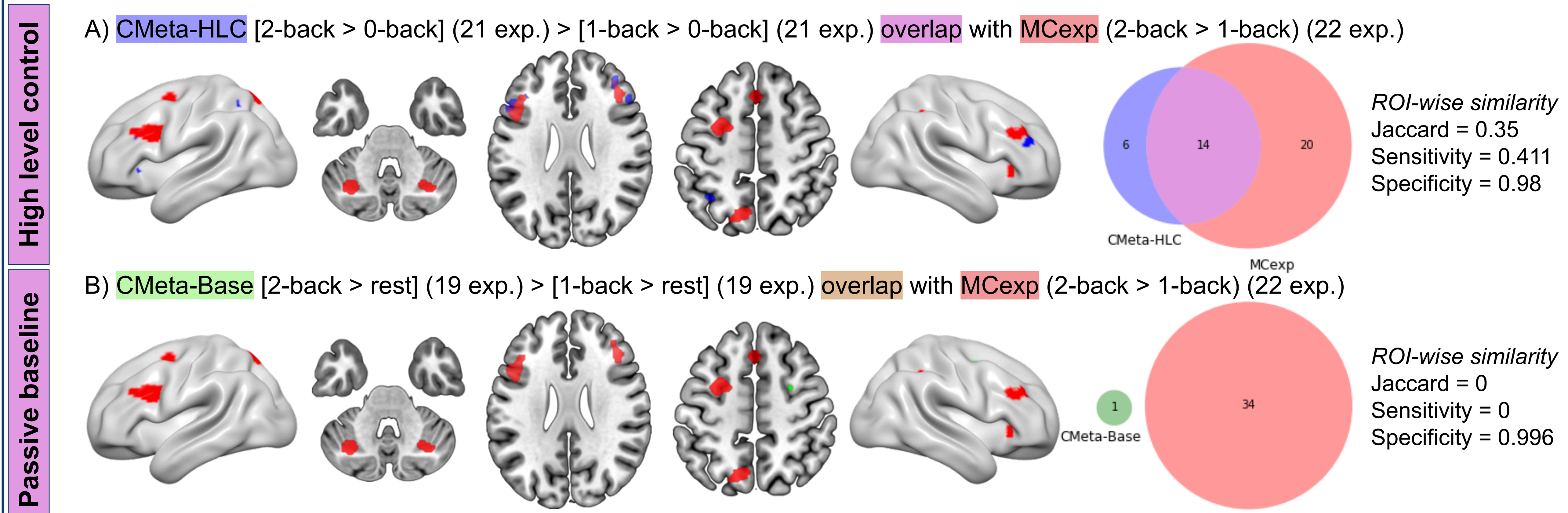


Figure 2. Evaluation of baseline/ contrasting condition

Summary

- Regions showing significantly stronger convergence in the CMeta networks lie perfectly within the network of significant convergence seen in the MCexp for N-back (Fig. 1A) and Stroop (Fig. 1C) (specificity = 1)
- However only 1/3 of regions (sign. in MCexp) seem to be found (in CMeta)
- Comparison of CMeta with single-sample contrast (Fig. 1B) shows similar but overall lower degree of similarity (Jaccard = 0.176, sensitivity = 0.176)
- Low-level baseline conditions (i.e., rest, fixation) seem to be less suitable for meta-analytic contrasts (Fig. 2B)
  - Possibly: large clusters formed in such contrasts → not reliably covered by a few coordinates reported
- Substantial similarity between CMeta-HLC (high level control condition, i.e., 0-back) and MCexp map (Fig. 2A) → eventually better suitability for meta-analytic contrasts

Conclusions – How valid are meta-analytic contrasts?

- High specificity → regions identified in CMeta appear to be highly valid – interpretation: similar as results of MCexp/ single experiments
- Low sensitivity → highly conservative → absence of expected regions ⇏ lack of involvement in the mental processes investigated
- Ideally, inclusion only of experiments contrasting against a high-level control condition

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Acknowledgments

We would like to thank all the authors who kindly provided their additional results, without which this analysis would not have been possible. Namely, Cristina Forn Frías, Salvatore Campanella, Marcel Daamen, Yu Fukuda, Ute Habel, Kathrin Koch, Ian Harding, Kyesam Jung, Jakob Kaminski, Tricia Z. King, Axel Krug, Jacob Lahr and Lora Minkova, Xiao-you Zhang and Lin Li, Anna Miró Padilla, Frank Schneider, Florian Schlagenhauf, Marion Smits, Mara Rocca, Harm Jan van der Horn, Yuan Zhou, Alessandro Agostini and Francesca Benuzzi, Sareh Asadi and Nooshin Ghavidel, Andy Schumann and Karl-Jürgen Bär, Elisa H. Kozasa, Jamie Cohen Peven, Christina Schmidt, Sneha Shashidhara, Gerd Wagner, Mikkel Wallentin, Zheng Ye.