

Individual Differences in Intergenerational Sustainability are explained by Cortical Thickness of DMPFC and DLPFC

Emmanuel Guizar Rosales*^{1,2}, Thomas Baumgartner*^{1,2}, & Daria Knoch^{1,2}

¹ Department of Social Neuroscience and Social Psychology, Institute of Psychology, University of Bern, Switzerland

² Translational Imaging Center (TIC), Swiss Institute for Translational and Entrepreneurial Medicine, Bern, Switzerland

* The first two authors contributed equally to this work

Background

- Meeting challenges like climate change and public debt requires intergenerational sustainability: Individuals need to overcome the *social* and *temporal* discounting of outcomes benefitting *others* (vs. *oneself*) in the *future* (vs. *now*)^{1,2}.
- Individuals vary greatly in intergenerational sustainability, but the sources of this behavioral heterogeneity have not been thoroughly investigated using objective methods free from response biases.
- Cortical thickness is a stable³ and individually specific⁴ objective trait-like marker capable of explaining individual differences in behavior^{5,6} by allowing inferences about the cognitive processes underlying behavioral heterogeneity⁷.

Research Question & Hypotheses

Can individual differences in cortical thickness as objective neural markers explain differences in intergenerational sustainability?

- Taking the perspective of others reduces social discounting in intergroup situations⁸, and deploying self-control plays a critical role in overcoming social and intertemporal discounting in social dilemmas⁹ and intertemporal choice tasks¹⁰.
- On the neural level, perspective-taking is mainly supported by the DMPFC and TPJ¹¹, while self-control is mainly supported by the lateral PFC^{7,12}.

We hypothesized that sustainable (vs. unsustainable) participants are marked by greater cortical thickness of the DMPFC, TPJ, and/or lateral PFC.

Methods

Participants

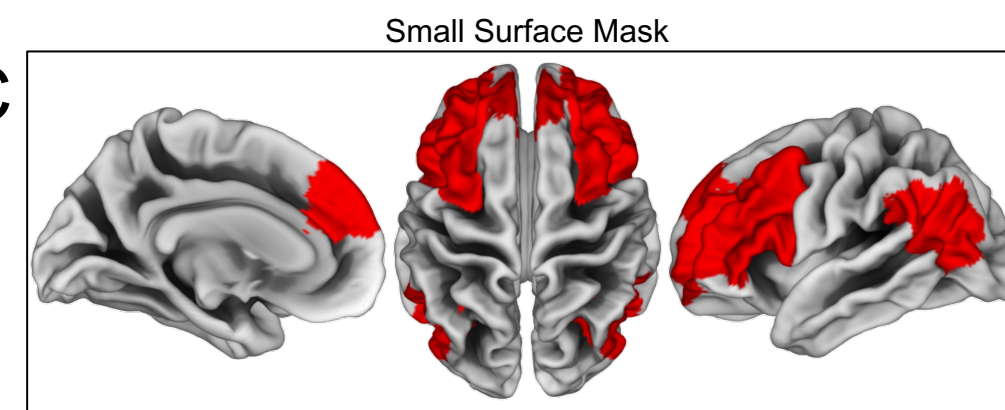
- 63 healthy participants (33 females, mean age \pm SD = 21.79 \pm 2.82 years).

Behavioral Economic Paradigm

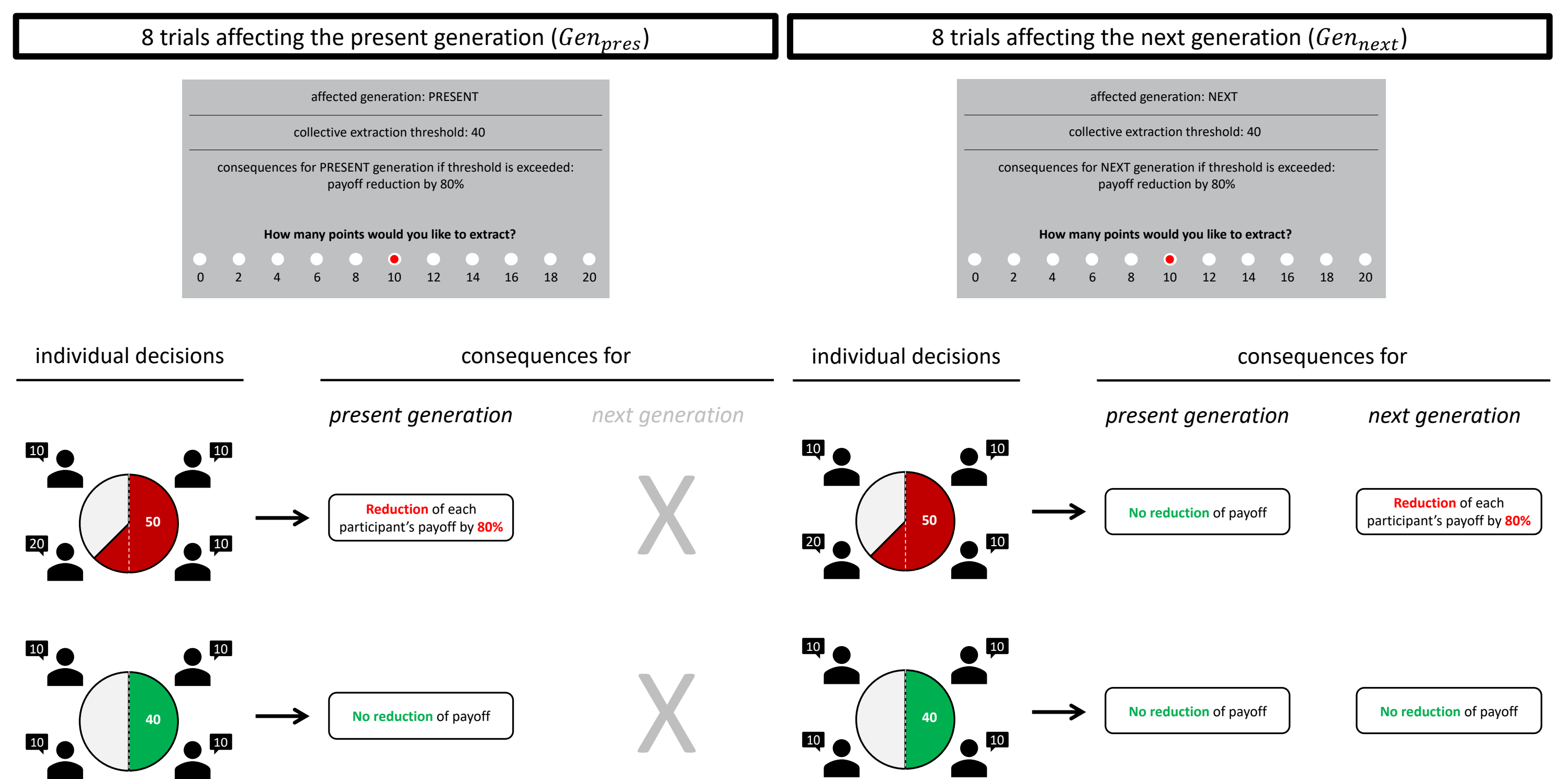
- Intergenerational Sustainability Dilemma Game (see figure to the right)
- Categorization of Behavioral Types according to median extraction in trials affecting the next generation (Gen_{next}): > 10 points: *unsustainable*; \leq 10 points: *sustainable*
- Ratings of in-game engagement in perspective-taking and efforts to resist temptations on a scale from 1 ("do not agree at all") to 11 ("completely agree"):
 - "Putting myself in the shoes of others of the [present/next] generation affected my decision in trials affecting the next generation."
 - "I tried to resist the temptation to extract more than 10 points in trials affecting the [present/next] generation."

Brain Anatomy

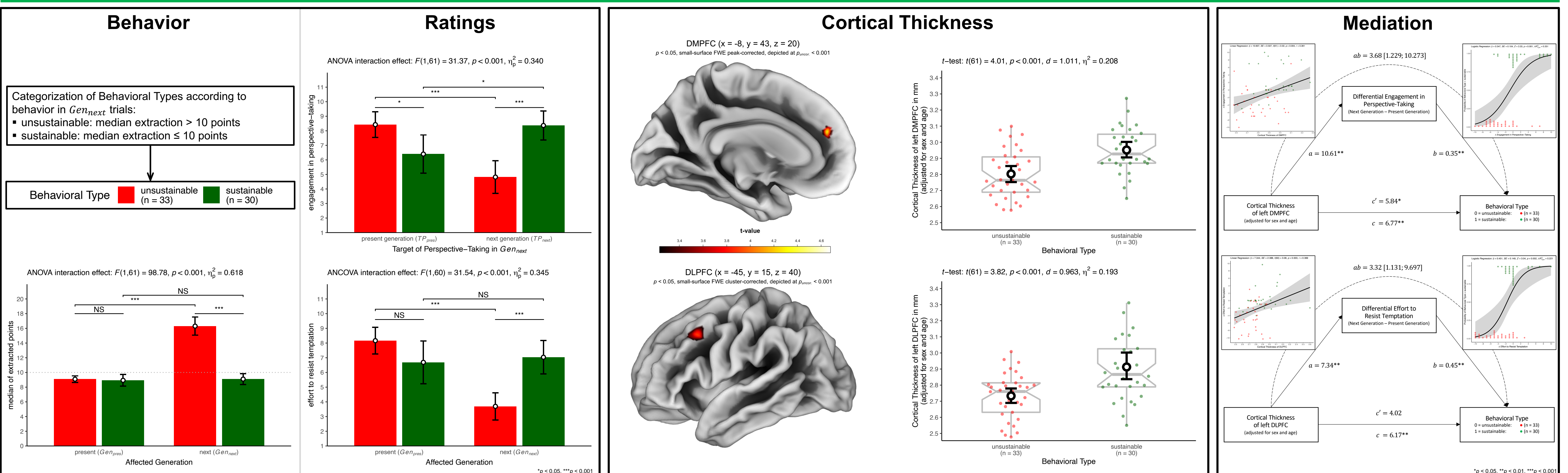
- MRI: T1-weighted MDEFT sequence (resolution: 1 mm³)
- Surface based morphometric analyses of cortical thickness values with correction for sex and age.
- Small surface correction for DMPFC, TPJ, and lateral PFC
- Control for multiple testing
 - $p < 0.05$ FWE-correction on peak- or cluster-level
 - cluster-defining threshold: $p_{uncor.} < 0.001$



- 4 participants partaking on the same day (vs. 7 days later) form the present (vs. next) generation.
- Each generation extracts points from a common pool of 80 points
- Exceeding the collective threshold of 40 points either reduces the present or the next generation's payoff.



Results



Behavior & Ratings

Sustainable (vs. unsustainable) participants extracted considerably less points in Gen_{next} trials (no difference in Gen_{pres}). Sustainable participants took the perspective of others of the present and next generation to an equal extent and equally tried to resist temptations in Gen_{pres} and Gen_{next} trials. Unsustainable participants were biased in more strongly taking the perspective of others of the present (vs. next) generation and in more strongly trying to resist temptations in in Gen_{pres} (vs. Gen_{next}) trials.

Cortical Thickness

Sustainable (vs. unsustainable) participants were marked by greater cortical thickness of DMPFC and left DLPFC. We extracted cortical thickness values (at $p_{uncor.} < 0.001$, as displayed) for visualization in boxplots and for estimating effect sizes. Being of the sustainable or unsustainable Behavioral Type explained 20.8% of variance in cortical thickness of DMPFC and 19.3% of the left DLPFC.

Mediation

Increased cortical thickness of the DMPFC and DLPFC predicted less biased engagement in perspective-taking and less biased efforts to resist temptations, which in turn was associated with a greater probability of being of the sustainable Behavioral Type. Note: Higher values in differential engagement in perspective-taking and self-control mostly indicated more balanced engagement, whereas lower values were mostly due to more biased, present generation oriented engagement.

Discussion

Increased cortical thickness of the DMPFC has previously been associated with less biased engagement in taking the perspective of in- and outgroup members¹⁵. We speculate that greater cortical thickness of the DMPFC reflects a greater capacity to impartially take the perspective of others, irrespective of their relative social and temporal distance to the self, which in turn motivates intergenerational sustainability. Greater cortical thickness of the left DLPFC has previously been associated with a greater capacity to engage in self-control^{16,16}. We reason

that an individual requires self-control to overcome the social discounting of others' (vs. own) outcomes and the temporal discounting of future (vs. immediate) benefits to behave intergenerationally sustainably. The present study might inspire training interventions for promoting sustainability. Long-lasting, effective interventions should be reflected in brain structural changes¹⁷. Promisingly, mindfulness-based trainings have been shown to promote sustainability¹⁸ and to increase cortical thickness in medial PFC¹⁹ and structural interconnectivity with the left DLPFC²⁰.

Conclusion

- Individual differences in cortical thickness are objective neural markers capable of explaining differences in intergenerational sustainability.
- Sustainable (vs. unsustainable) participants showed greater cortical thickness of DMPFC and left DMPFC.
- Mediation analyses suggest that greater cortical thickness of DMPFC and DLPFC represent a greater capacity to impartially engage in perspective-taking and self-control, which in turn promotes intergenerational sustainability.

References

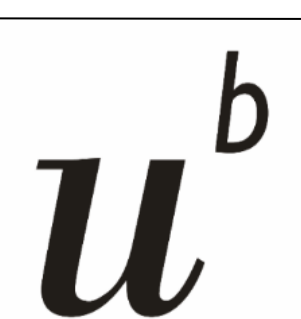
- Shahen et al. (2021). Scientific Reports
- Wade-Benzoni & Tost (2009). Personality and Social Psychology Review
- Gregory et al. (2020). Journal of Magnetic Resonance Imaging
- Valizadeh et al. (2018). Scientific Reports
- Morishima et al. (2012). Neuron
- Yamagishi et al. (2016). PNAS
- Nash et al. (2015). Frontiers in Behavioral Neuroscience
- Todd & Galinsky (2014). Social and Personality Psychology Compass
- Kocher et al. (2017). Experimental Economics
- Keidel et al. (2021). Frontiers in Psychology
- van Overwalle (2009). Human Brain Mapping
- Peters & Büchel (2011). Trends in Cognitive Sciences
- Arioli et al. (2021). Human Brain Mapping
- Fehlbaum et al. (2021). Social Cognitive and Affective Neuroscience
- Baumgartner et al. (2013). Neuroimage
- Steinbeis et al. (2012). Neuron
- von Bastian et al. (2022). Nature Reviews Psychology
- Thiermann & Sheate (2021). Journal of Cognitive Enhancement
- Valk et al. (2017). Science Advances
- Patsenko et al. (2019). Scientific Reports

Contact



SCAN ME

emmanuel.guizarrosales@unibe.ch
thomas.baumgartner@unibe.ch
daria.knoch@unibe.ch



UNIVERSITÄT
BERN