Neurophysiological Correlates of Combining Learning Strategies During Second Language Vocabulary Learning

Nicole H. Skieresz [1,2,3], Sandy C. Marca [1,4], Simon Gorin [1], Micah M. Murray [2,3,5,6], Thomas P. Reber [1,7], Nicolas Rothen [1]

1 Faculty of Psychology, UniDistance Suisse, Brig, Switzerland;
2 The LINE (Laboratory for Investigative Neurophysiology), Department of Diagnostic and Interventional Radiology, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland;
3 The Sense Innovation and Research Center, Lausanne and Sion, Switzerland;
4 Faculty of Psychology, University of Geneva, Geneva, Switzerland;
5 CIBM Center for Biomedical Imaging, Lausanne, Switzerland;
6 Department of Hearing and Speech Sciences, Vanderbilt University, Nashville, TN, USA;
7 Department of Epileptology, University of Bonn Medical Center, Bonn 53127, Germany;

nicole.skieresz@fernuni.ch
@n_skieresz

Background

- Various learning strategies, e.g., retrieval practice, corrective feedback, and multisensory learning have proven to be effective in knowledge acquisition.
- Three theoretical viewpoints have been summarized on behavioral performance in a cued recall task when combining a learning strategy with retrieval practice:
  1. *Complementary view*: there are main effects of both strategies and an additive effect when combining them (Morris et al., 2005)
  2. *Redundancy view*: there are main effects of both strategies, but no additive effect as multiple cognitive mechanisms have overlapping effects (Fritz et al., 2007)
  3. *Catalytic view*: there is no testing effect, adding another strategy catalyzes subsequent retrieval (Miyatsu & McDaniel, 2019)
- The N400 can reflect both automatic and controlled lexical-semantic processes, therefore, it is a potential neurophysiological marker of vocabulary learning.
- Research on the interactions between learning strategies, and their neurophysiological correlates has been scarce (Belardi et al., 2021).
- We investigated interactions between learning principles on L2 vocabulary learning and their neurophysiological correlates.

Design

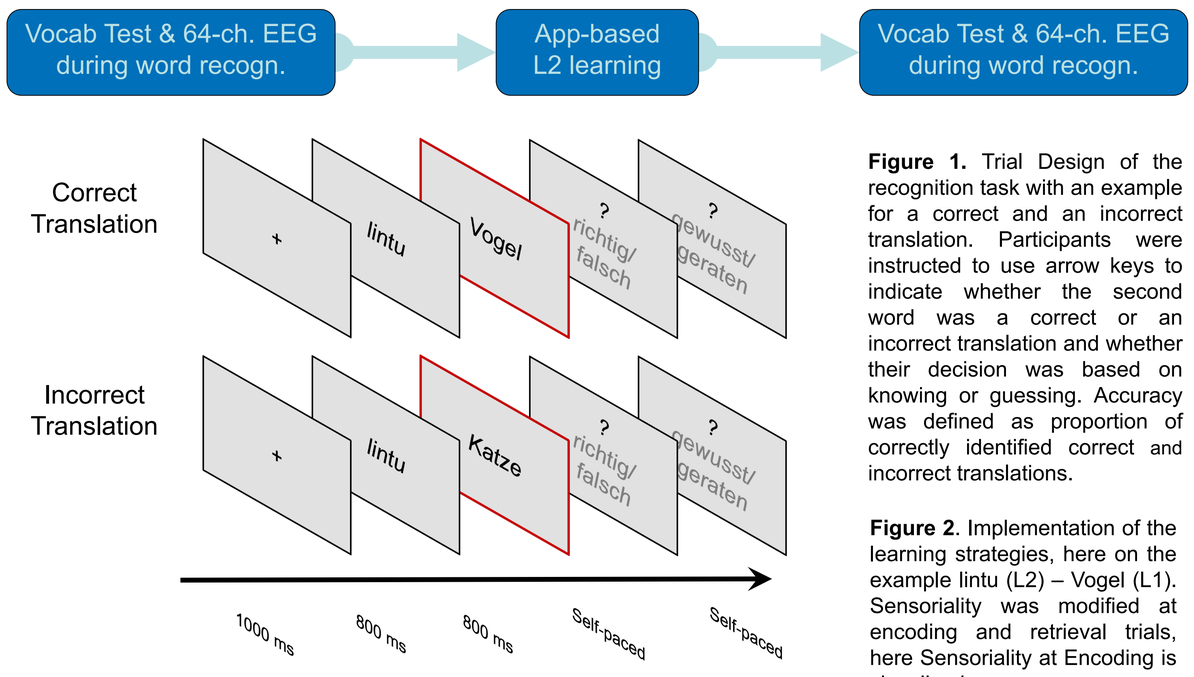
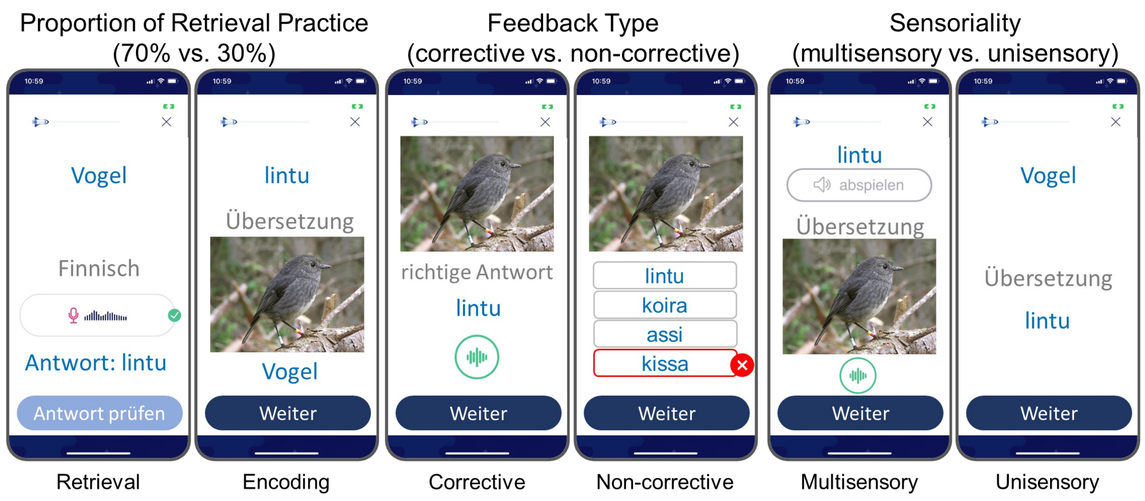


Figure 1. Trial Design of the recognition task with an example for a correct and an incorrect translation. Participants were instructed to use arrow keys to indicate whether the second word was a correct or an incorrect translation and whether their decision was based on knowing or guessing. Accuracy was defined as proportion of correctly identified correct and incorrect translations.

Figure 2. Implementation of the learning strategies, here on the example lintu (L2) – Vogel (L1). Sensoriality was modified at encoding and retrieval trials, here Sensoriality at Encoding is visualized.



Methods & Processing Pipeline

- N=36 healthy, adult participants (M_{age} = 28.83 years; range = 18-40 years; 21 female)
- Stimuli: 48 Finnish (L2) – German/French (L1) translations
- Within-subject factorial design: 2 Proportion of Retrieval Practice × 2 Feedback Type × 2 Sensoriality at Encoding × 2 Sensoriality at Retrieval
- EEG data were downsampled (1000 to 250Hz), filtered, re-referenced to average, epoched -200 to 1500ms around translation onset, pre-stimulus baseline corrected-
- Cluster-based permutation test (CBPT) (Maris & Oostenveld, 2007): dependent-samples T-statistic (channels x time points), cluster-alpha = 0.001, cluster-statistic = maxsum criterion, number of permutations = 1000, alpha = 0.025 (two-sided permutation test)

Conclusions

- The N400 is a neurophysiological correlate for successful L2 vocabulary learning.
- No evidence was gathered for either the complementary, redundancy or catalytic view.
- The N400 showed a dosage dependency of Sensoriality at Encoding. Multisensory encoding was beneficial at low doses, with no reliable differential effect over Unisensory encoding at a higher dose.

Results

- Participants' accuracy on the vocabulary test and recognition task improved significantly after the intervention but was not influenced by learning strategy.
- CBPT revealed an N400 (312-428ms) with a significant cluster of 16 channels at centro-parietal sites after L2 vocabulary learning, not before.
- Mean amplitudes of difference waves (post - pre) of the 16 channels in the significant time window served as dependent variable for a 2x2x2x2x3 ANOVA.
  - There was a main effect of Sensoriality at Encoding ($F(1,1647) = 4.23$, $p<0.05$), but no main effect of Proportion of Retrieval Practice ($F(1,1647) = 0.22$, $p > 0.05$).
  - There was a significant interaction of Sensoriality at Encoding and Proportion of Retrieval Practice ($F(1,1647) = 4.98$, $p < 0.05$).

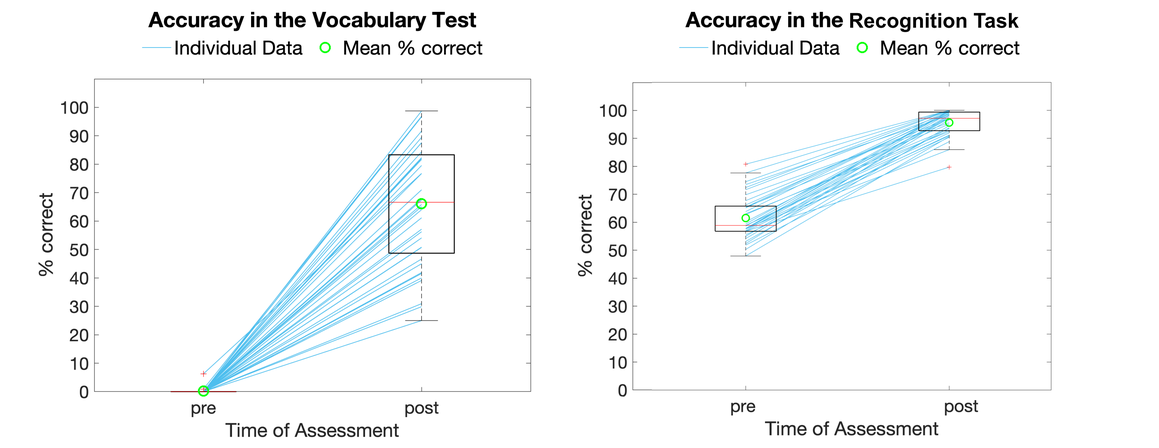


Figure 3. Participants' accuracy in vocabulary test and recognition task before and after app-based L2 learning.

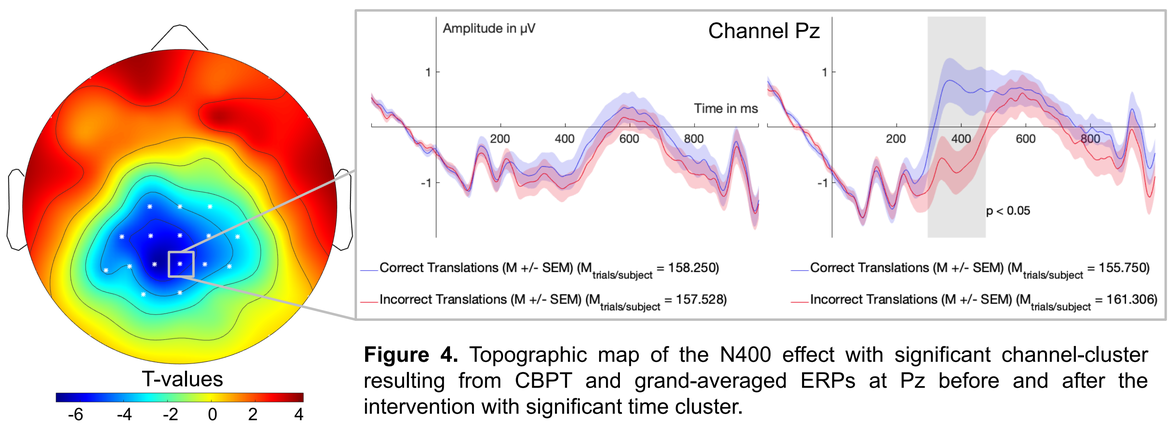


Figure 4. Topographic map of the N400 effect with significant channel-cluster resulting from CBPT and grand-averaged ERPs at Pz before and after the intervention with significant time cluster.

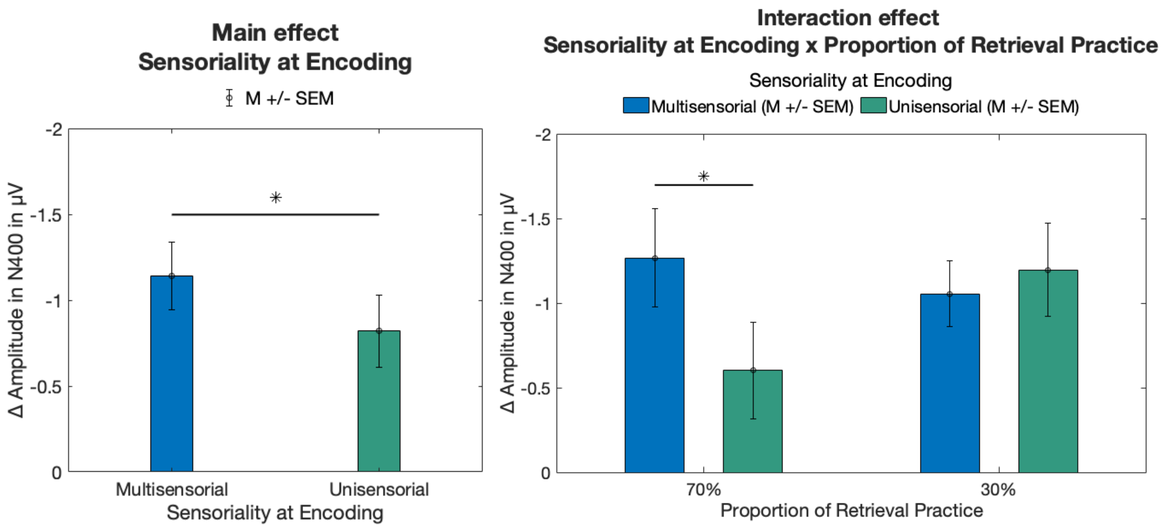


Figure 5. A main effect of Sensoriality at Encoding indicated that words learned multisensorial at encoding elicited a larger N400 after the intervention than words learned unisensorial at encoding. This effect persisted at a high Proportion of Retrieval Practice (corresponding to a low proportion of encoding) but not at a low proportion (high proportion of encoding).

References

•Belardi A, Pedrett S, Rothen N and Reber TP (2021). Spacing, Feedback, and Testing Boost Vocabulary Learning in a Web Application. *Front. Psychol.* 12:757262. https://doi.org/10.3389/fpsyg.2021.757262
•Fritz, C. O., Morris, P. E., Acton, M., Voelkel, A. R., & Etkind, R. (2007). Comparing and combining retrieval practice and the keyword mnemonic for foreign vocabulary learning. Applied Cognitive Psychology, 21(4), 499–526. https://doi.org/10.1002/acp.1287
•Maris, E., & Oostenveld, R. (2007). Nonparametric statistical testing of EEG- and MEG-data. Journal of neuroscience methods, 164(1), 177–190. https://doi.org/10.1016/j.jneumeth.2007.03.024
•Miyatsu, T., & McDaniel, M. A. (2019). Adding the keyword mnemonic to retrieval practice: A potent combination for foreign language vocabulary learning? *Memory & Cognition, 47*(7), 1328-1343. https://doi.org/10.3758/s13421-019-00936-2
•Morris, P. E., Fritz, C. O., Jackson, L., Nichol, E., & Roberts, E. (2005). Strategies for Learning Proper Names: Expanding Retrieval Practice, Meaning and Imagery. Applied Cognitive Psychology, 19(6), 779–798. https://doi.org/10.1002/acp.1115

UNIVERSITÉ DE GENÈVE · CHUV · UNIL | Université de Lausanne · CIBM Center for Biomedical Imaging · the sense innovation and research center · VANDERBILT UNIVERSITY MEDICAL CENTER · FernUni.ch UniDistance.ch

Universitäres Institut akkreditiert nach HFKG
Institut universitaire accrédité selon la LEHE