

# Learning to unlearn: The role of negative evidence in morphophonological learning

Erdin Mujezinović & Ruben van de Vijver

Department of General Linguistics, Institute for Language and Information, Heinrich-Heine University Düsseldorf

Erdin.Mujezinovic@hhu.de; Ruben.Vijver@hhu.de

## Learning theories

### Statistical learning

- Associative: Co-occurrence of cues and outcomes (Aslin, Saffran, & Newport, 1998; Maye, Werker, & Gerken, 2002)
- Faithful tracking of the input statistics: If input is frequent enough, the association is learned
- Only positive evidence is considered; learning order does not matter

### Error-driven learning

- Discriminative: Cues predict outcomes (Nixon, 2020; Ramscar, Dye, & McCauley, 2013; Ramscar et al., 2010)
- Learning occurs on the basis of prediction error; if cues are discriminative, the association is learned
- Both positive and negative evidence is considered; learning order matters

## Learning experiment – Design

120 adult German native speakers (across four groups) were taught morphological functions

Table 1: Stimuli design

Abbr.	Category	Cue	Example
SG	singular	[a]	[be.fan]
PL	plural	[i]	[bef.ni]
DM	diminutive	[iʃ]	[bef.niʃ]
DMPL	diminutive-plural	[iʃi]	[bef.ni.ʃi]

Table 2: Learning groups

Abbr.	Group	Learning I	Learning II	Test cues
g <sup>1</sup>	DM: No_Unlearning	[i] → PL	[iʃi] → DMPL	[iʃi] → DM; [i] → PL
g <sup>2</sup>	DM: Unlearning	[iʃi] → DMPL	[i] → PL	[iʃi] → DM; [i] → PL
π <sup>1</sup>	PL: No_Unlearning	[iʃi] → DM	[iʃi] → DMPL	[iʃi] → DM; [i] → PL
π <sup>2</sup>	PL: Unlearning	[iʃi] → DMPL	[iʃi] → DM	[iʃi] → DM; [i] → PL

- One morphological category was only learnable through diminutive-plural exposure
- Two conditions: DM\_absent (diminutives did not occur) & PL\_absent (plurals did not occur)
- Two groups each: No\_Unlearning & Unlearning

## Learning experiment – Procedure

- Phonological cues → Morphological outcomes
- learning: auditory stimulus presented first, visual outcome second (128 learning trials)
- test: auditory stimulus and two-forced choice alternatives simultaneously (64 test trials)
- Only diminutive and plural word forms tested

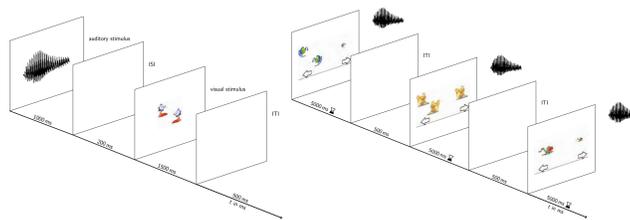


Figure 1: Example for a trial in the learning phase (left) and 3 forced choice trials in the test phase (right)

## Learning order structure

- (1) No\_Unlearning: (1) A → X (2) AB → XY (3) A → Y, B → Y  
 Unlearning: (1) AB → XY (2) A → X (3) A → Y, B → Y

## Research Question

Does unlearning incorrect cue-outcome associations help morphophonological learning?

## Predictions

Learning simulations for the absent morphological category using the Rescorla-Wagner equations (Rescorla & Wagner, 1972) as implemented in the edl-package (van Rij & Hoppe, 2021)

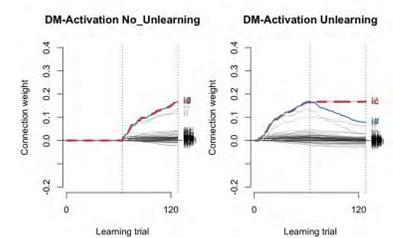


Figure 2: Diminutive-Activation for DM\_absent (left: No\_Unlearning, right: Unlearning)

[iʃi] → Diminutive  
 No\_Unlearning < Unlearning

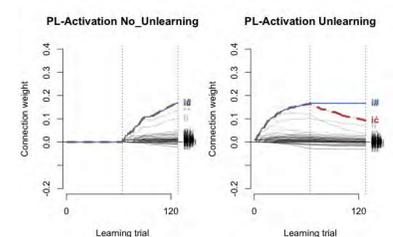


Figure 3: Plural-Activation for PL\_absent (left: No\_Unlearning, right: Unlearning)

[i] → Plural  
 No\_Unlearning < Unlearning

## Results

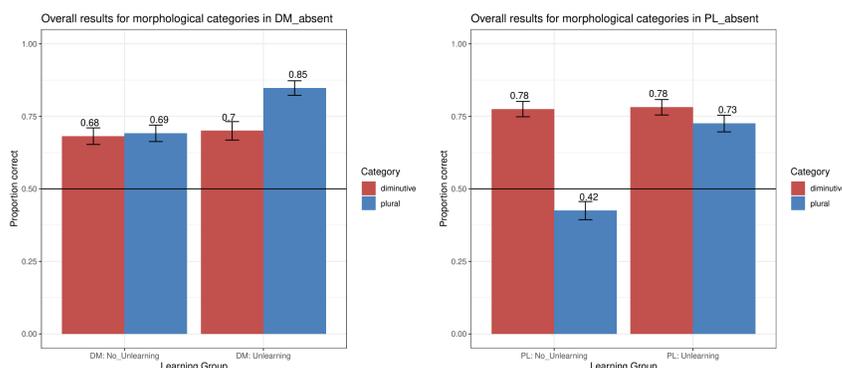


Figure 4: Accuracy for DM\_absent (left) and PL\_absent (right)

Statistical analyses in R (R Core Team, 2021) using *Generalized linear mixed regression models* with random intercepts for *item* and *participant*; test-choice coded as incorrect = 0 or correct = 1; 7424 data points

- DM\_absent (left): Significant interaction between *group* and *category* ( $z = 5.123, p < 0.001$ ) → (present) plural category better in Unlearning-group (0.85 vs. 0.69)
- PL\_absent (right): Significant interaction between *group* and *category* ( $z = 10.765, p < 0.001$ ) → (absent) plural category better in Unlearning-group (0.73 vs. 0.42)

## Discussion

Unlearning of incorrect cue-outcome relationships helped morphophonological learning

- Plural category in the PL\_absent condition was better learnable, if the incorrect [iʃi]-cue occurred with diminutives – after initial diminutive-plural exposure (so that unlearning [iʃi] → PL was possible)
- Plural category in the DM\_absent condition was better learnable in the Unlearning-group
- Unlearning for the absent category is only helpful, if a more salient cue is unlearned
- Results are in line with error-driven learning theory; prediction and prediction error drive learning (Rescorla & Wagner, 1972)
- The role of cue salience needs further testing
- Learning order and both positive and negative evidence matter! (Nixon, 2020; Ramscar et al., 2010)

**Learning morphophonology is discriminative!**

## References

Aslin, R. N., Saffran, J. R., & Newport, E. L. (1998). Computation of conditional probability statistics by 8-month-old infants. *Psychological science*, 9(4), 321–324.  
 Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, 82(3), B101–B111.  
 Nixon, J. S. (2020). Of mice and men: Speech sound acquisition as discriminative learning from prediction error, not just statistical tracking. *Cognition*, 197, 104081.  
 R Core Team. (2021). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.  
 Ramscar, M., Dye, M., & McCauley, S. M. (2013). Error and expectation in language learning: The curious absence of mice in adult speech. *Language*, 760–793.  
 Ramscar, M., Yarlett, D., Dye, M., Denny, K., & Thorpe, K. (2010). The Effects of Feature-Label-Order and Their Implications for Symbolic Learning. *Cognitive Science*, 34(6), 909–957.  
 Rescorla, R. A., & Wagner, A. R. (1972). A theory of pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement (A. H. Black & W. Prokasy, Eds.). *Classical conditioning II: current research and theory*, 64–99.  
 van Rij, J., & Hoppe, D. (2021). *edl: Toolbox for Error-Driven Learning Simulations with Two-Layer Networks* [R package version 1.0].