The Nature of Speech Motor Representations: Evidence from the Transfer of Learning

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Introduction

- **What is the nature of speech motor representations?**
  - When learning novel speech motor patterns, what is being learned?
  - To what extent does the learning **transfer** to other similar but untrained patterns?
- Non-native onset consonant clusters (e.g., GDEEMOO, KTEEMOO)
  - GDEEMOO $\xrightarrow{\text{generalizes}}$ GDAHBEE
  - **Learning is generally at the level of cluster** (Buchwald et al., 2019; Segawa et al., 2019).
- At the level of cluster, what exactly is being learned?
  - General coordination pattern (e.g., stop-stop cluster)?
  - Specific coordination pattern (e.g., GD vs KT)?

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How specific are speech motor representations?

- Manner of articulation is encoded in speech motor representations.
  - Learning of stops $\not\Rightarrow$ fricatives (Ballard et al., 2007)
- Does training on [voiced, voiceless] clusters transfer to untrained clusters with different voicing?

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   - Same representation (stop-stop clusters)
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Does complexity affect transfer?

- Voiced clusters are produced with lower accuracy rate (Davidson, 2006) and hypothesized to be more complex:
  - Phonologically
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  - Phonetically:
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- Practice-based nonword production with orthographic and auditory models.
- Random & variable practice (Maas et al., 2008) without feedback:
  - Voiced condition (/db/, /gb/, /gd/; n = 10)
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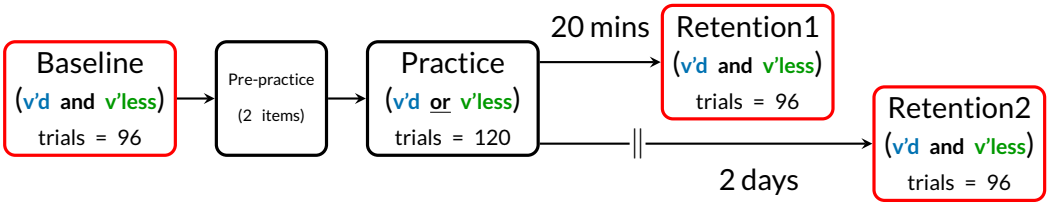
- Probed on all voiced and voiceless clusters at the baseline, retention 1, retention 2
- Pre-practice: Information about how to produce non-native clusters



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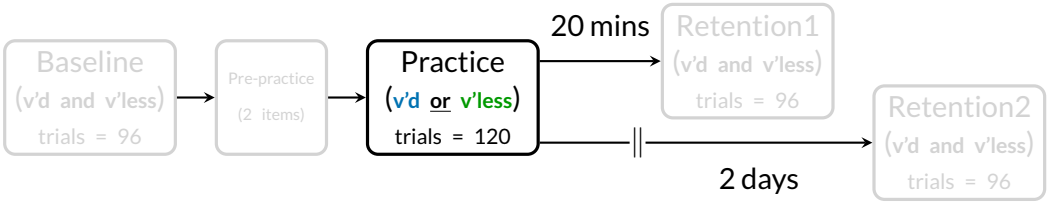

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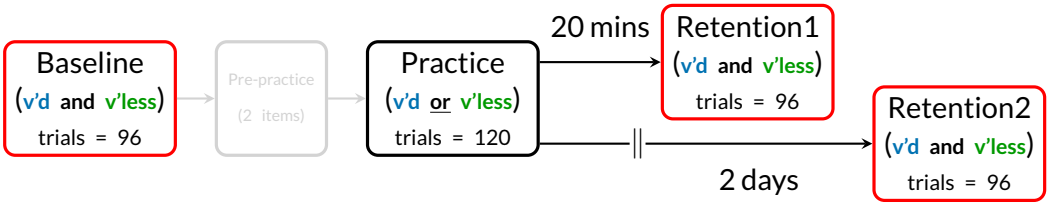

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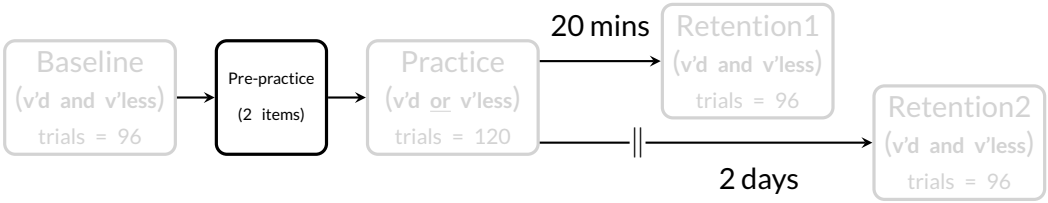
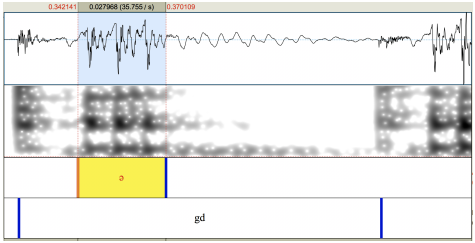


Measurements

- **Accuracy:**
  - Cluster accuracy (agreement: 91%)
  - Acoustically-informed transcription (Wilson et al., 2014)
  - Epenthetic vowel $\equiv$
    1. $\geq$ Two repetitive vocoid cycles.
    2. Higher formant structures (e.g., F2, F3)
  - Coders blinded to condition and session
- **Motor acuity:**
  - Burst-to-burst duration (agreement: 96%):
  - $\downarrow$ duration = better coordination of the cluster



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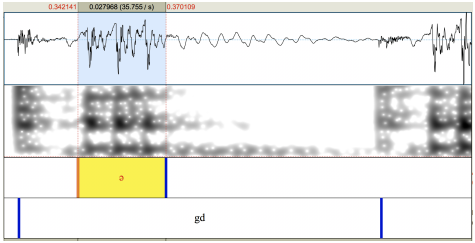

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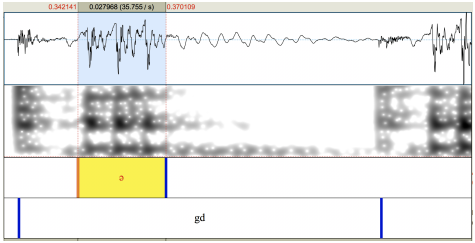

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Statistical approach to detect transfer

- Mixed-effects logistic models for cluster accuracy
  - accuracy $\sim$ **Session*****Type** + Cluster + (1 | Participant) + (1 | Item)
    - Accuracy: correct versus incorrect
    - Session: baseline, retention1, retention2
    - Type: trained versus untrained (transfer)
    - The best fitting model was selected by AIC and **BIC** scores (Harel and McAllister, 2019).
- Transfer (✓) $\equiv$ main effect of Session and no Session by Type interaction

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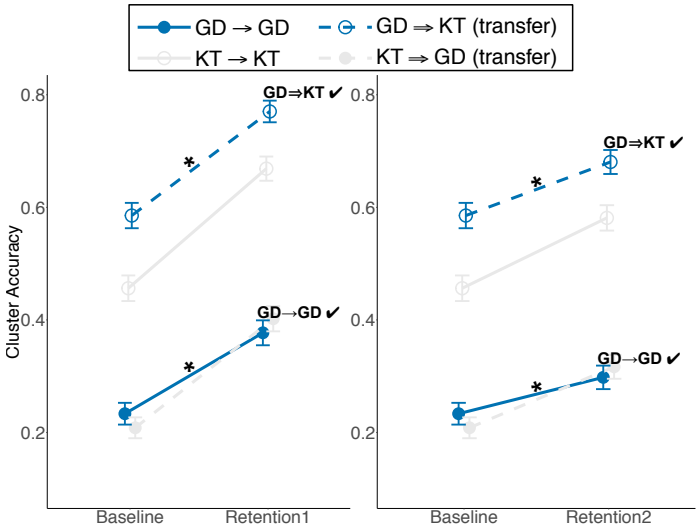

Accuracy ∼ Session*Type + Cluster + (1 | Participant) + (1 | Item)

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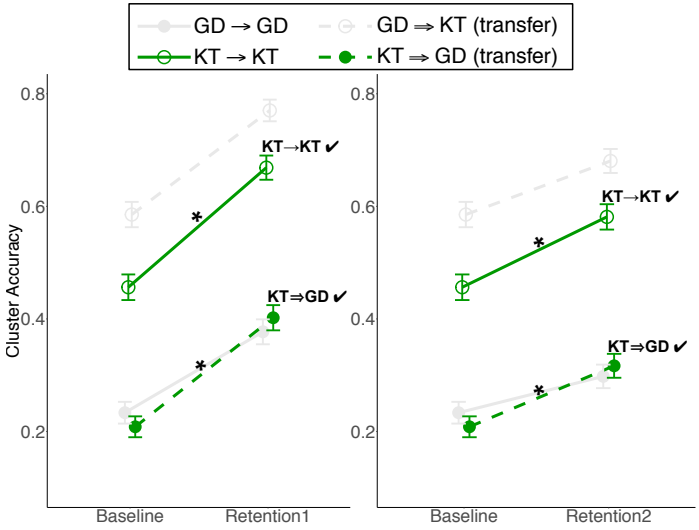

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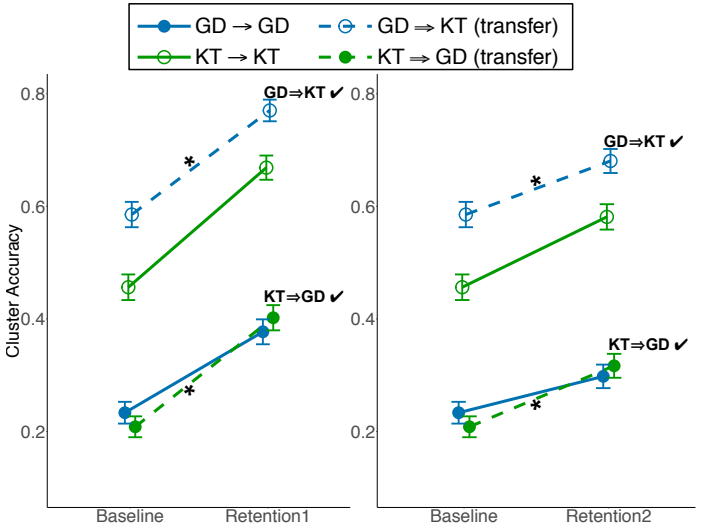

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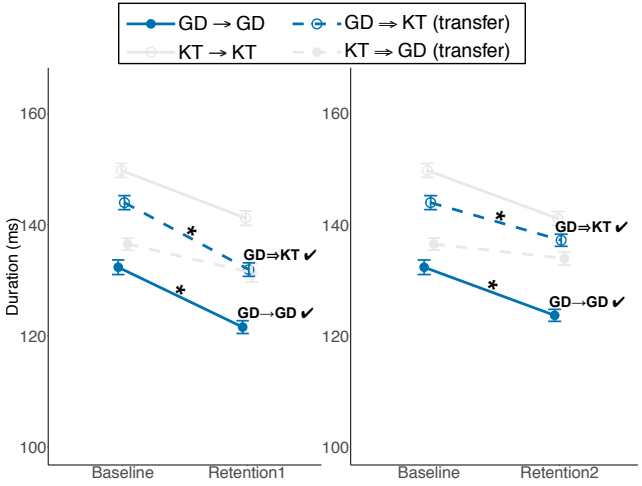

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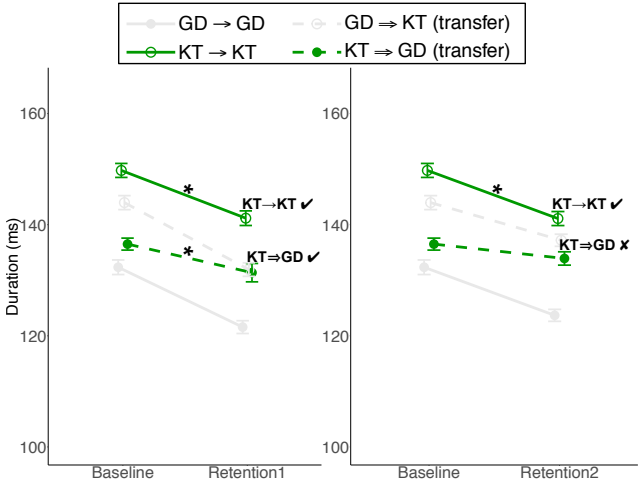

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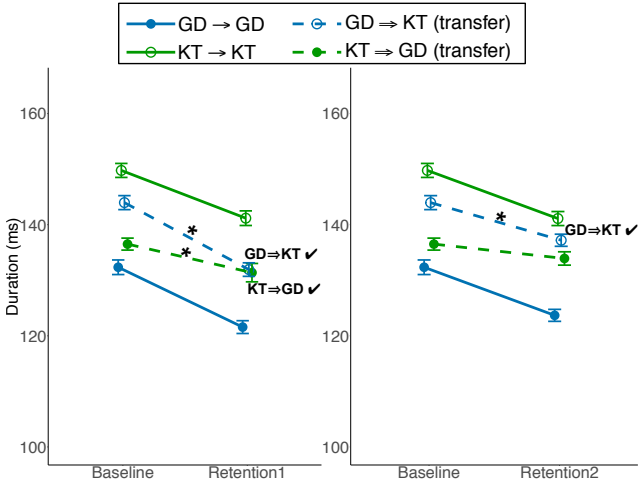

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- Measureable learning gains on trained clusters
- Bi-directional transfer across voicing categories
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Acknowledgement

- We would like to thank
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  - **Members of Speech Reading Group**
  - **Members of PLAN lab**
  - **Alexandra Gordon, Izabela Grzebyk, & Kevin Tjokro**

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Questions?

References

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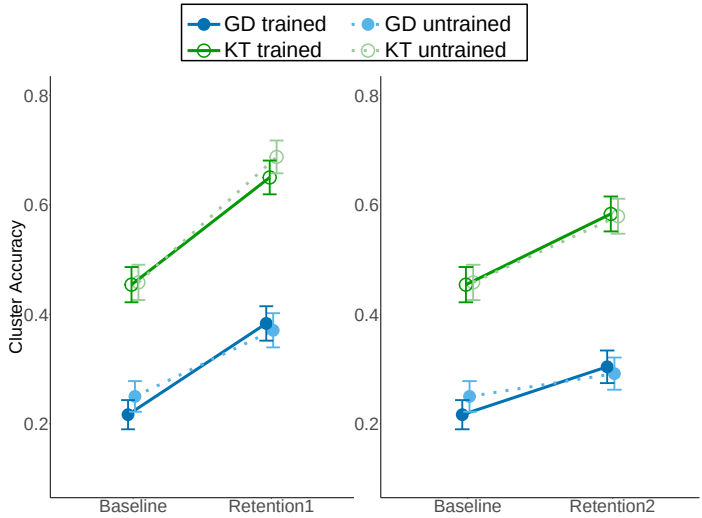
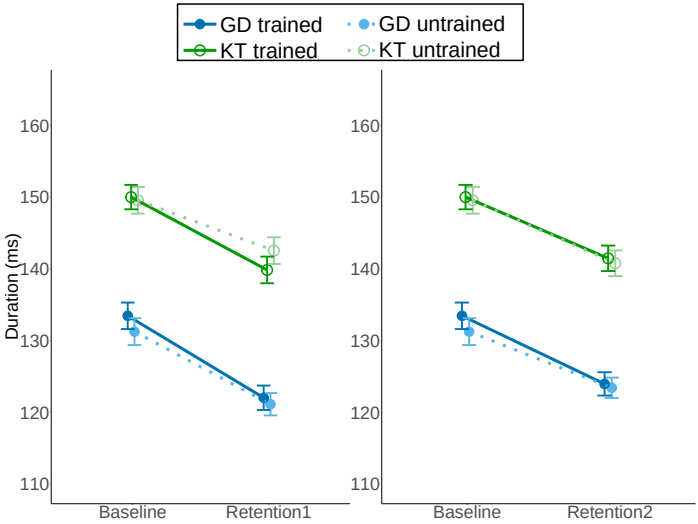
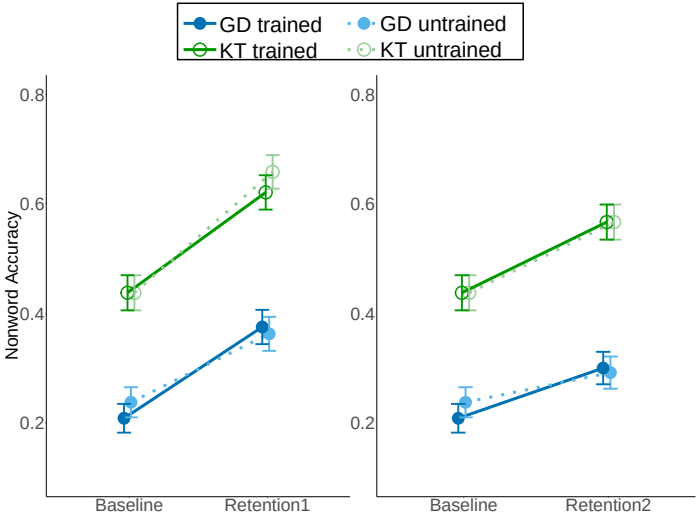
Cluster accuracy: generalization



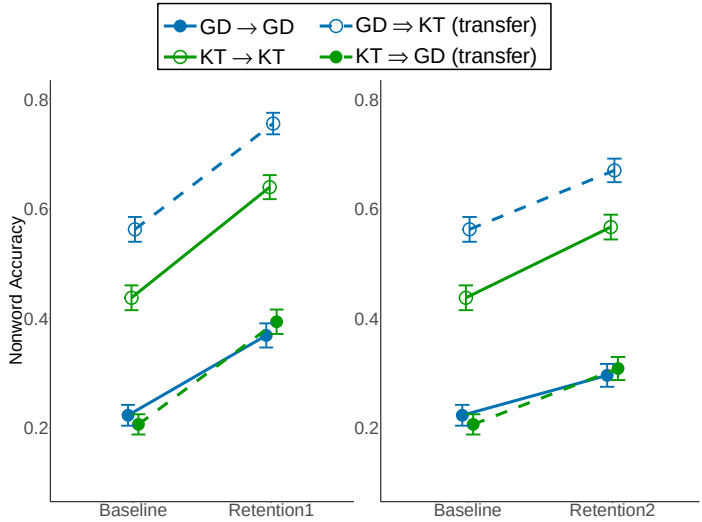
Burst to burst duration: generalization



Nonword accuracy: generalization

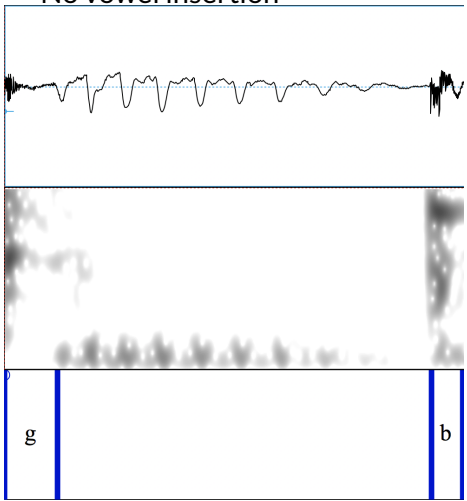


Nonword accuracy: transfer of learning



Vowel epenthesis example

- No vowel insertion



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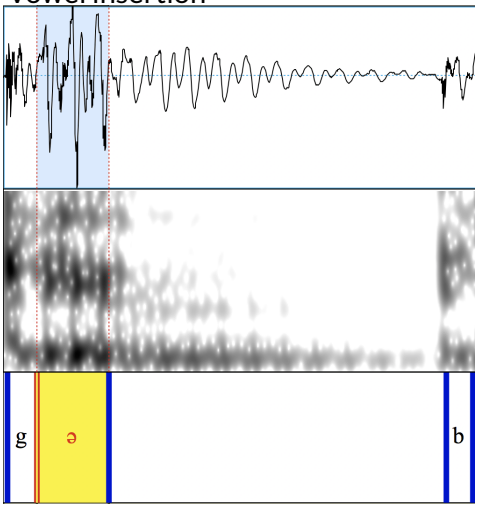
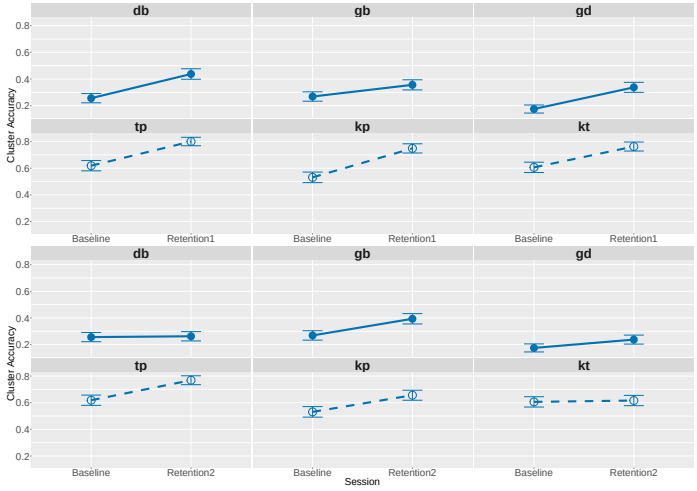
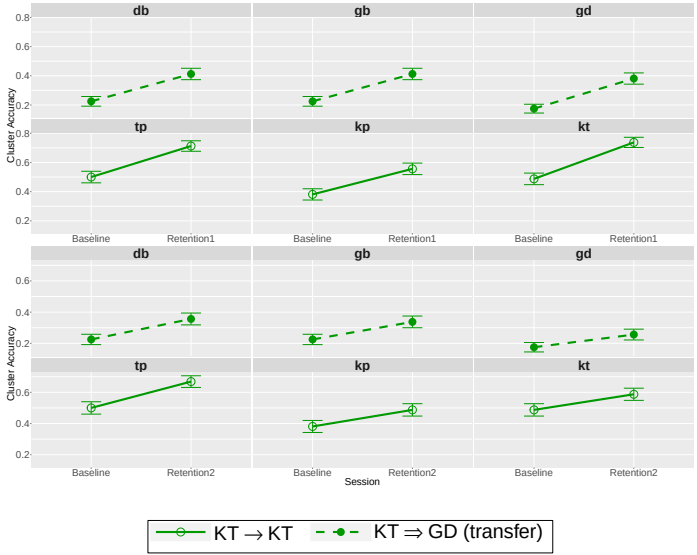


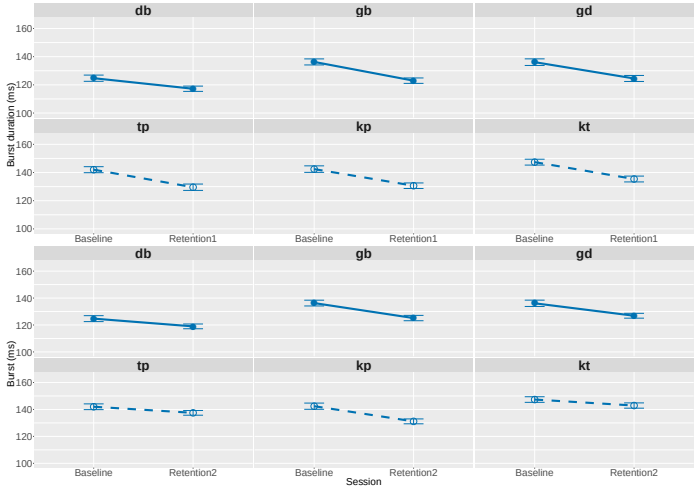
Voiced condition: cluster accuracy by types



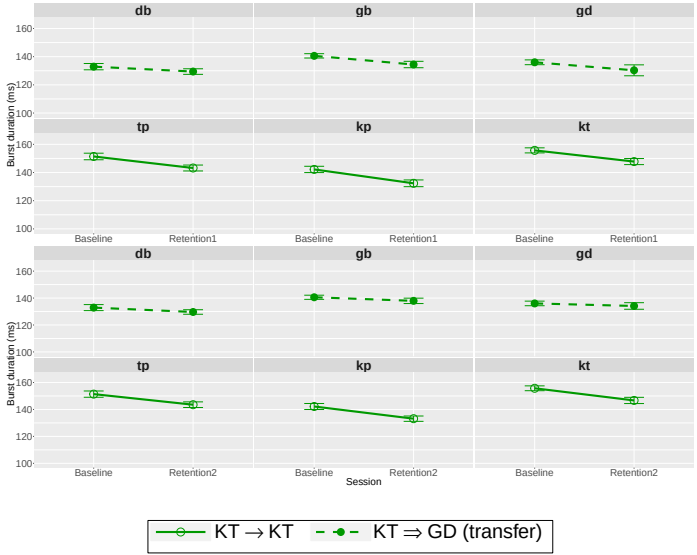
Voiceless condition: cluster accuracy by types



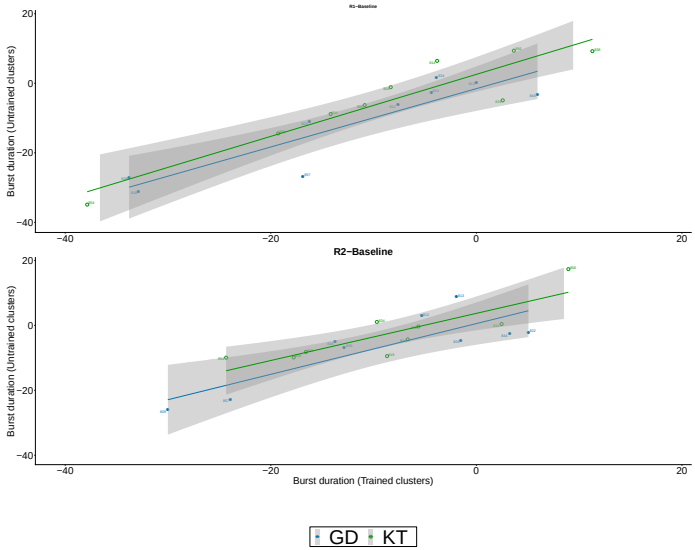
Voiced condition: burst duration by types



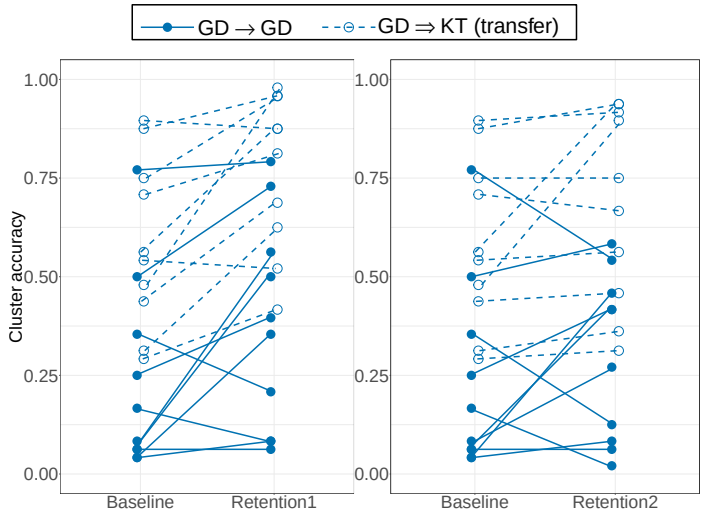
Voiceless condition: burst to burst duration by types



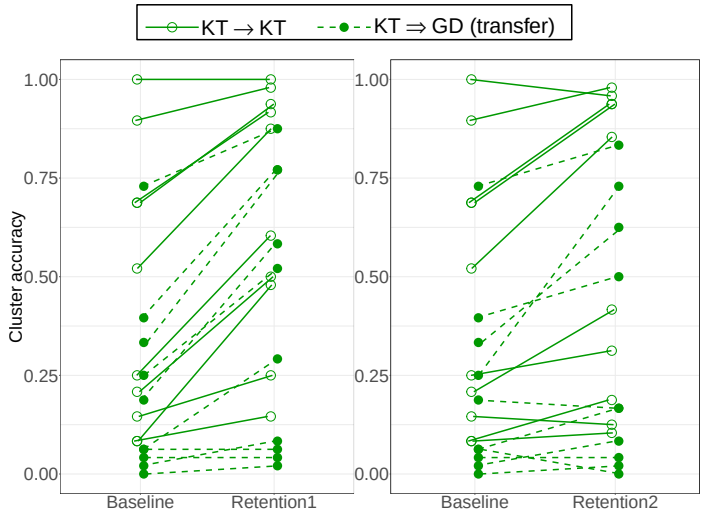
Magnitude of transfer: burst to burst duration



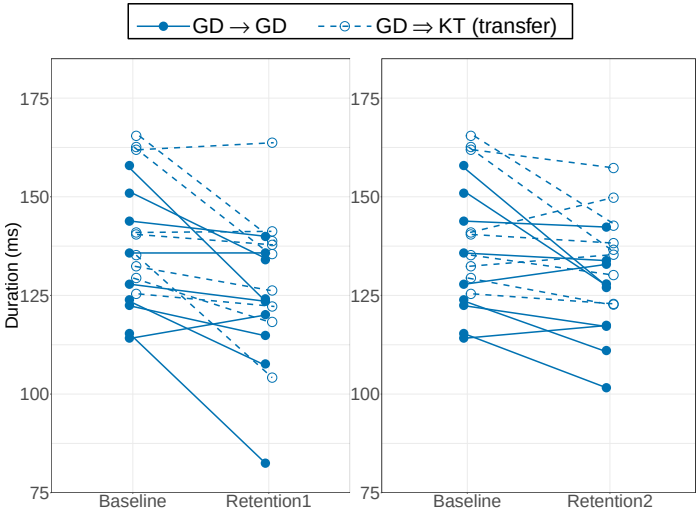
Cluster accuracy: Voiced condition individual data



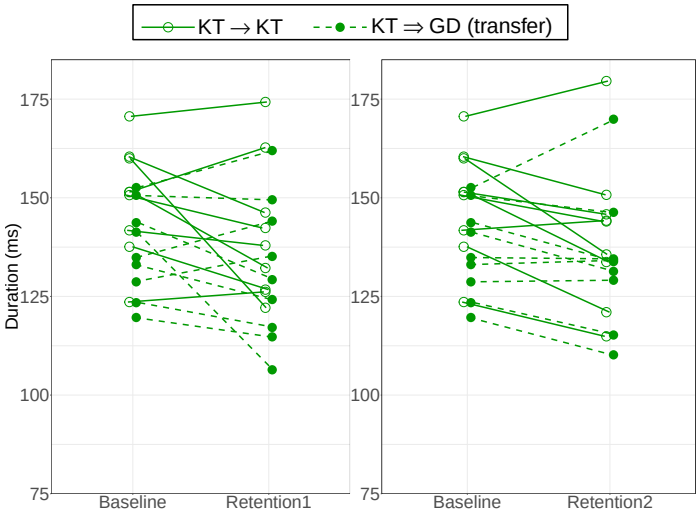
Cluster accuracy: Voiceless condition individual data



Burst to Burst duration: Voiced condition individual data



Burst to Burst duration: Voiceless condition individual data



Numbers of tokens for burst to burst duration

		Correct		Epenthetic vowel	
		Trained	Untrained	Trained	Untrained
Voiced condition	Baseline	94	245	314	165
	Retention1	172	331	226	83
	Retention2	138	293	282	130
Voiceless condition	Baseline	179	80	250	340
	Retention1	271	157	150	259
	Retention2	232	130	196	298