Selective adaptation between allophones of /r/ in German

Holger Mitterer[1,2] and Eva Reinisch[2]
[1]*University of Malta,* [2]*Hanyang University*, [3]*Austrian Academy of Sciences*

Selective adaption (SA) is an experimental paradigm that is often used to investigate pre-lexical representations of the speech signal (Harnad, 1987). In this paradigm, participants are exposed to a series of adaptor stimuli before categorizing a test stimulus from a continuum between two speech sounds. SA seems to reflect general perceptual principles, with counterparts in visual perception, such as the waterfall illusion (Goldstein, 1958), in which observers watch a waterfall for around 30s and then perceive stationary objects moving upwards. Such a contrastive effect is also observed in speech perception, with listeners perceiving the test stimuli as contrasting with the adaptors. That is, after hearing a serious of /b/-initial words, a stimulus from a [ba]-[da] continuum is more likely to be perceived as /da/, contrasting with the /b/-initial adaptors (Kleinschmidt & Jaeger, 2015).

The paradigm has had a waxing and waning popularity (Kleinschmidt & Jaeger, 2015) and critics pointed out potential post-perceptual influences on SA (Harnad, 1987). More recently, SA has been used to investigate pre-lexical representations in spoken-word recognition with the rationale that SA between adaptors in coda position and test stimuli in onset position would reflect position-invariant phonemic representations at a pre-lexical level. While one study found such an effect (Bowers et al., 2016), others (Mitterer et al., 2018; Samuel, 2020)) did not and pointed out phonetic confounds in (Bowers et al., 2016). One critical finding was that there was no adaptation between word-initial trilled /r/ and a sonorant /r/ in the coda position in Dutch (Samuel, 2020). Here we present three SA experiments, conducted online with about 30 participants each (advertised via *prolific.co*), that aim to replicate and extend this finding in German. Similar to Dutch, German has a large variety of allophones of /r/, including uvular and alveolar trills and a vocalized /r/ in the coda position (e.g., *Fischer*, Engl., 'fisherman', [fiʃɐ]).

The first experiment used an alveolar trill-lateral continuum ([rozə]-[lozə], Engl. 'rose'-'lottery tickets') as target stimuli, and different adaptor series containing either alveolar trills [r] (the maximal overlap with the test stimuli), uvular fricatives [ʁ], or vocalized versions of /r/ ([ɐ]). A control-adaptor condition was generated from words that did not contain any variant of /r/ or /l/. Results replicated (Mitterer et al., 2018) for Dutch, such that the most sonorant adaptor, the vocalized [ɐ], did not trigger any SA for the test stimuli containing an alveolar trill (with a Bayes Factor supporting the null over an alternative hypothesis, see Table 1 for a summary of the results). However, the uvular fricative, though phonetically different from the trill, led to SA. Experiments 2 and 3 focused on the uvular fricative and used an [ʁ]-[h] continuum ([ʁozə]-[hozə], Engl. 'rose'-'trousers', note that in German /h/ is the phoneme closest to [ʁ]) as test stimuli. The adaptor series contained either alveolar trills, uvular trills, or uvular fricatives. In Experiment 2, /r/ in the adaptors was word-initial (e.g., [ra:t], Engl. 'advice'), while in Experiment [3], it was word-medial but still in the syllable onset (e.g., *Barock,* Engl., 'baroque', [barɔk]). In both experiments, the surprising result was that the [r] adaptors caused stronger adaptation effects on the uvular-fricative stimuli from the test continuum than [ʁ] adaptors. In fact, in Experiment 3, the [ʁ] adaptors, with the same allophone

as the test stimuli, even failed to produce any selective adaptation at all, while the trill adaptors did.

Overall, the results show that phonemic overlap is not sufficient to generate SA, which questions the assumption of phonemic representations at a pre-lexical level. However, in some cases SA is observed between different allophones, with the surprising result that alveolar trilled /r/ leads to stronger adaptation for both alveolar-trill and uvular-fricative test stimuli. This indicates that SA, as early critics already suggested (Harnad, 1987), may also arise at later, post-perceptual (rather than prelexical) levels of processing. For [r], this may be due to saliency of the amplitude modulation in trills (Delgutte & Kiang, 1984). With such post-perceptual influences, selective adaptation may not be the ideal paradigm to reveal prelexical representations in spoken-word recognition.

Table 1: Overview of selective-adaptation effects in the current study

	/r/ target stimulus	Adaption effects				
		strongest	→		weakest	
Exp1	[rozə] (alveolar trill)	[#rV…]	>	[#ʁV…]	>	[…Vʊ(C)#] = ∅
Exp2	[ʁozə] (uvular fricative)	[#rV…]	=	[#ʀV…]	>	[#ʁV…] > ∅
Exp3	[ʁozə] (uvular fricative)	[#...rV…]	=	[#...ʀV…]	>	[#...ʁV…] = ∅

Note: "= ∅" means that an adaptor condition is similar to the control condition according to a Bayes Factor. "#" indicates a word boundary.

References

Bowers, J. S., Kazanina, N., & Andermane, N. (2016). Spoken word identification involves accessing position invariant phoneme representations. *Journal of Memory and Language, 87*, 71–83. https://doi.org/10.1016/j.jml.2015.11.002

Delgutte, B., & Kiang, N. Y. S. (1984). Speech coding in the auditory nerve: IV. Sounds with consonant-like dynamic characteristics. *The Journal of the Acoustical Society of America, 75*(3), 897–907. https://doi.org/10.1121/1.390599

Goldstein, A. G. (1958). On the after-effects of the "waterfall" and "spiral" illusions. *The American Journal of Psychology, 71*, 608–609. https://doi.org/10.2307/1420264

Harnad, S. (1987). *Categorical perception: The groundwork of cognition*. Cambrigde University Press.

Kleinschmidt, D. F., & Jaeger, T. F. (2015). Re-examining selective adaptation: Fatiguing feature detectors, or distributional learning? *Psychonomic Bulletin & Review*, *23*(3), 678–691. https://doi.org/10.3758/s13423-015-0943-z

Mitterer, H., Reinisch, E., & McQueen, J. M. (2018). Allophones, not phonemes in spoken-word recognition. *Journal of Memory and Language*, *98*(Supplement C), 77–92. https://doi.org/10.1016/j.jml.2017.09.005

Samuel, A. G. (2020). Psycholinguists should resist the allure of linguistic units as perceptual units. *Journal of Memory and Language, 111*, 104070. https://doi.org/10.1016/j.jml.2019.104070