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Morphological Strata of Tone

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Project Description

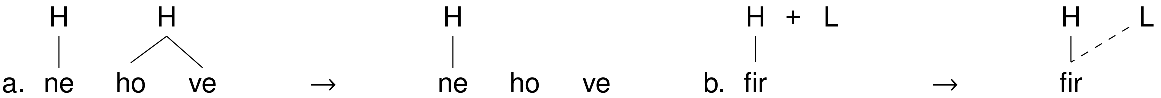
The goal of this project is to develop a new take on tonal morphophonology combining stratal phonology (Kiparsky 2015, Bermúdez-Otero 2018, Trommer 2011) in a Harmonic Grammar version (Nazarov & Pater 2017, Kushnir 2018) with the recently developed theory of Gradient Symbolic Representations (Smolensky & Goldrick 2016, Zimmermann 2019). Our novel hypothesis is that the combination of gradient representations, Harmonic Grammar and cyclicity allows for principled solutions to four persistent empirical problems tone poses for morphological and phonological theories: **E1** global rules and strata straddling (Hyman 1993), **E2** inter-stratal conspiracies (Myers 1991, 1997), **E3** competition of overwriting patterns (Hyman 2013), and **E4** tonal attraction phenomena (Trommer 2019a).

1 State of the art

1.1 Tonal Phonology

Tone, i.e. the use of pitch to mark lexical contrasts (e.g. Chinese *má* 'mother' vs. *mâ* 'hemp', where 'V́' marks high, and 'V̂' falling tone, Yip 2002) or grammatical distinctions (e.g. Gaahmg *fír* '(s)he smells' vs. *fîr* 'they smell', Stirtz 2011) is often considered somewhat outside of 'normal' segmental phonology since it shows a dramatic independence from single segments. Thus in Shona High tone (= H-tone) dissimilation ('Meeussen's Rule'), the second of two adjacent H-tones is deleted (e.g. *né* + *mbwá* → *né mbwa* 'with a dog', where a vowel without a diacritic indicates a toneless syllable), but crucially this effect also extends to a H-tone which covers multiple vowels (or syllables) in a word, as in e.g. *né* + *hóvé* → *né hove* 'with a fish'. In standard autosegmental theory, where tone is represented on an independent level ('tier'), this is a simple case of deletion under adjacency (1-a). Similarly, in autosegmental theory, tonal morphology can be represented as affixation of tones without segments such as a Low-tone (= L-tone) suffix in Gaahmg 3rd plural inflection, which extends an underlying H-tone verb to a falling (High-Low) melody (1-b) by a general phonological process of floating tone association:

(1)



Recent research on tone has highlighted the fact that it provides a more comprehensive picture of possible phonological systems and their interaction with morphosyntax than any other single phonological dimension (Jardine 2016, Rolle 2018, McPherson 2019, Sande 2017), culminating in Hyman's (2011) dictum that "tone can do everything segments and non-tonal prosodies can do, and more so" (p.214). As segments, tones exhibit not only dissimilation, but also a rich variety of (complete and partial) assimilation or 'spreading' processes (e.g. Shona High-tone spreading as in *né* 'with '+ *sadza* 'porridge' → *né sádza* 'with porridge') and fusion and splitting, often cooccurring and interacting in complex ways in the same language, covering word-level as well as phrase-level phonology. Thus, tone is an ideal microcosmos for studying possible phonological systems in a restricted empirical domain.

1.2 Cyclicity of Tone

Research on tonal alternations, especially the work of Pulleyblank (1983, 1986) has provided some of the earliest and most persuasive evidence for the classical model of Lexical Phonology (Kiparsky 1982), where word-level phonological processes have the potential for stratum-internal cyclicity, but phrasal phonology is non-cyclic. While subsequent research has confirmed the central role of cyclicity in virtually all language families that exhibit tone (see e.g. Chen 2004 on Chinese, Zec 1992 on Serbo-Croatian, Morén & Zsiga 2006 on Thai, Trommer 2011 and Trommer & Gleim 2017 on Nilotic), there is also a bulk of evidence which is problematic for the standard model of stratal morphophonology. Tone seems, for example, to provide the most serious challenges for the claim that postlexical processes are non-cyclic (Kaisse 1985, McHugh 1990, Clark 1990, Jones 2014). In addition, extensive work on Bantu claims that tonal phonology here follows not the standard lexical domains stem and word, but instantiates different domains, especially macrostems and prosodic roots (Myers 1987, 1997, Inkelas 1990, Downing 1999).

Apart from the heterogeneity of assumed strata, probably the main problem tonal phonology poses for cyclic approaches is the straddling of strata (**E1** in section 3.2), where representations made opaque by processes of earlier cycles or predicted to be inaccessible by Bracket Erasure still play a role at later strata. A well-known example is Kuria inceptive formation (Marlo et al. 2015, Sande & Jenks 2018, Trommer 2020b) which involves inserting a H-tone on the fourth vocalic mora of the stem ((2-a), "[...]" marks the stem excluding tense and agreement prefixes), and concomitant rightwards spreading. Since the process crucially requires visibility of word-internal stems, it should be a lexical (word-level) process, but under certain circumstances if the stem is too short, the four-mora domain is extended to a following object noun, hence is assigned phrasally across word boundaries (2-b). Other well-known examples of stratal straddling have been identified in Luganda (Hyman & Katamba 1993), Bamileke (Hyman 1985) or Tura (Inkelas 2014).

(2) a. to-ra-[hootoó̲tér-a] ‘we are about to reassure’
1PL-TNS-[reassure-FV]
b. to-ra-[rom-a] eγé̲tɔ́ ‘we are about to bite a banana’
1PL-TNS-[bite-FV] banana

1.3 Optimization in Tonal Alternations

Even pre-OT work on tonal phonology has identified central areas where heterogeneous repair mechanisms are employed to satisfy specific wellformedness conditions in different languages or different phonological contexts. Thus already Pulleyblank (1986) observes that the 1:1 mapping of tone to tone-bearing units characteristic for most tone languages is achieved either by spreading, tone deletion or insertion of default tones, an insight later incorporated directly in OT-analyses (Yip 2002, Trommer 2005). In one of the seminal papers of OT, Myers (1997) shows that the same holds for the Obligatory Contour Principle (OCP), the ubiquitous ban against adjacent identical tones which variably triggers deletion or fusion or alternatively blocks otherwise expected independent processes such as tone spreading – a double role that cannot be captured in a purely rule-based account. Finally, work in optimization approaches has led to crucial new insights on possible tonal reassociation processes (Jones 2014, Breteler 2018) and to the development of new representational approaches such as Optimal Domains Theory (Cassimjee & Kisseberth 1998).

An outstanding problem in optimization-based approaches to tone is the construction- and morpheme-specific nature of many tonal alternations which seem to violate basic principles of modularity such as morphologically distinctive H-tone positioning and spreading in Bantu (Marlo et al. 2015, Odden 2018) or Zapotec (Broadwell et al. 2011), the different overwriting patterns **E3**) triggered by specific modification constructions in Dogon (McPherson & Heath 2016) and many other languages (Trommer 2020a, or the differential behavior of tonal allomorphs of the same morpheme (Trommer & Gleim 2017). In fact, OCP violations in Shona according to Myers (1997) show construction specificity in triggering exhibit different repair strategies in different word-internal strata, a pattern we call here ’inter-stratal conspiracies‘‘ (**E2**).

1.4 Gradient Symbolic Representations

(Smolensky & Goldrick 2016, Rosen 2016) is a version of Harmonic Grammar where not only constraints, but also phonological representations such as segments and features are gradient and hence have ‘strength’ expressible in terms of real numbers. These strength differences can immediately affect the phonological behavior of elements given that constraint violations depend on the activity of phonological elements. A H-tone with the default activity of $\boxed{1.0}$ might hence be protected from deletion if it precedes another H-tone if MAX-H has a higher weight than the OCP. Another H-tone that only has an underlying activity of $\boxed{0.5}$, on the other hand, might be deleted in the same context if 0.5 violations of MAX-H result in a better harmony score than a 0.75 (= the mean activity of an OCP-violating H_1 and $H_{0.5}$) violation of the OCP.

Pioneering applications of Gradient Symbolic Representations have been French liaison (Smolensky & Goldrick 2016), cumulative effects in Japanese Rendaku (Rosen 2016), ghost segments (Zimmermann 2019), and gradient accentual prominence (Zimmermann 2018b, Kushnir 2018). Trommer & Zimmermann (2018) argue that GSR also allows a substantially new take on tonal contrast showing that the difference between high and falling tones in Jumjum can be encoded more directly by H-tones of different strength (cf. Nformi 2018, for a similar reanalysis of tone in Oku). Zimmermann (2018a) demonstrates the usefulness of gradience for lexical exceptionality in Mixtec tone.

Although differential ‘strength’ of linguistic elements is a notion often invoked in theoretical linguistics, most previous work doing so assumes only binary distinctions into ‘strong’ and ‘weak’ (Inkelas 2015, Vaxman 2016a,b, Sande 2017). In addition, the grammar’s sensitivity to strength is often assumed to be the effect of constraints explicitly referring to different diacritically marked classes of segments where ‘strong’ or ‘weak’ thus rather provides a new label for lexically indexed constraints (Inkelas 2015, Sande 2017) (Ito & Mester 1990, Golston & Wiese 1996, Fukazawa 1999, Pater 2000, Pater & Coetzee 2005, Pater 2006, 2009, Flack 2007). In contrast, Gradient Symbolic Representations in the strict sense as assumed here are fully gradient (activity may assume any value given by the infinite set of real numbers) and interact inherently with optimization since gradient activity directly modulates the violation profile of specific constraints.

2 Objectives

The project builds on the observation that combining gradient representations with strata gives rise to a new approach to cyclic effects, explored tentatively for stress-deletion interactions in Trommer (2019b). Applying this approach to lexical tone means that tones can get incrementally stronger or weaker by every cyclic optimization if constraints demanding strong or weak (types of) tones are not out-weighed by faithfulness constraints preserving the underlying strength within a language. This leads to the effect that the ‘same’ tone reacts differently to identical tonotactic problems in larger domains since it has a different activation at this level and constraints are hence violated (gradiently) differently. We expect that this effectively obliterates the need to assume different constraint rankings or weightings for different strata resulting in a model which Trommer (2019b) calls *Harmonic Layer Theory (in the following: HLT)*. If, for example, tone activity decays across strata and thus gets predictably weakened in every stratum, underlying tones will be weaker in the phrasal phonology than they were in the word-level phonology. Thus even if word and phrasal phonology are identical (i.e., have the same constraint weightings), different repairs are predicted for the same marked structure in word and phrasal phonology.

An OCP-violation might, for example, be avoided by fusion inside of words but by deletion of the second tone (‘Meeussen’s Rule’) in phrases, as in the classical analysis of Shona by Myers (1997). Tableaux (3) and (4) illustrate schematically how the same result may be derived in HLT by a single phonological grammar. Tableau (3) shows how constraints may capture the iterative decrease in activation due to the markedness constraint $*\Sigma_{\mathrm{H}}$ against H-Tones which additively penalizes the activation of all H-tones in an output candidate (subscript numbers indicate activation). This is held in check by higher-weighted $|\Delta\mathcal{S}| \leq 0.25$ which blocks changing the activation of a single high-tone beyond the amount of 0.25, as in the b-candidates, and by MAX H which penalizes complete deletion of the H (in the c-candidates). But $*\Sigma_{\mathrm{H}}$ has a higher weight than $|\Delta\mathcal{S}| \leq 0$ which means that the activation of the H-tone changes from $\boxed{1.0}$ to $\boxed{0.75}$ in the first layer, and by the same amount from $\boxed{0.75}$ to $\boxed{0.5}$ in the second layer:

(3) *Sucessive decrease of H-tone activation across levels*

a. **Word Level:** $H_{1.0} \rightarrow H_{0.75}$

Input: = d.	$\lvert\Delta\mathcal{S}\rvert \leq 0.25$ w=∞	MAX H w=11	$*\Sigma_{\mathrm{H}}$ w=10	$\lvert\Delta\mathcal{S}\rvert \leq 0$ w=1	$\mathcal{H}$
☞ a. $H_{0.75}$			-0.75	-0.25	-7.75
b. $H_{0.5}$	-0.25		-0.5	-0.5	∞
c. Ø		-1.0			-11
d. $H_{1.0}$			-1.0		-10

b. **Phrase Level** $H_{0.75} \rightarrow H_{0.5}$

Input: = d.	$\lvert\Delta\mathcal{S}\rvert \leq 0.25$ w=∞	MAX H w=11	$*\Sigma_{\mathrm{H}}$ w=10	$\lvert\Delta\mathcal{S}\rvert \leq 0$ w=1	$\mathcal{H}$
☞ a. $H_{0.5}$			-0.5	-0.25	-5.75
b. $H_{0.25}$	-0.25		-0.25	-0.5	∞
c. Ø		-0.75			-8.25
d. $H_{0.75}$			-0.75		-7.5

Note that the cyclic change in activation here depends crucially on constraint weighting: Higher weighting of $|\Delta\mathcal{S}| \leq 0$ would result in a grammar where activation levels are not changed at all. Plausibly there are also constraints which lead to strengthening of activation (e.g. of tone in stressed syllables). See Trommer (2019b) of an analysis of stress and vowel deletion in Arabic which employs both strengthening and weakening in different phonological contexts.

(4) shows the actual OCP effects, adding the constraints which are only relevant for multiple adjacent H-tones. While all of the constraints so far are violated gradiently (e.g. deleting a tone of strength $\boxed{0.75}$

induces only a Max violation of 0.75, but deleting a fully activated H-tone leads to a full 1.0 violation), the OCP penalizes every pair of adjacent High-tones by -1.0, and Uniformity (=Unif) counts a -1.0 violation) for every pair of fused H-tones independently of their underlying activation. Thus at the Word Level, the Max violations outweigh the ones for Uniformity leading to fusion (4-a) (indicated by parentheses), whereas Max becomes concomitantly weaker than Uniformity with the weakening of the tones at the Phrase Level, giving rise to deletion instead (4-b):

(4) *Different OCP-resolutions in different strata*

a. **Word Level:** Tone fusion

Input: = $H_{1.0}$ $H_{1.0}$	$\|\Delta\mathcal{S}\| \leq 0.25$ w=∞	OCP w=100	Max w=11	$*\Sigma_H$ w=10	Unif w=10	$\mathcal{H}$
a. $H_{0.75}$			-1.0	-0.75		-18.5
☞ b. ($H_{0.75}$ $H_{0.75}$)				-0.75	-1.0	-17.5
c. $H_{0.75}$ $H_{0.75}$		-1.0		-1.5		-115.0
d. $H_{1.0}$ $H_{1.0}$		-1.0		-2.0		-120.0

b. **Phrase Level:** Tone deletion

Input: = $H_{0.75}$ $H_{0.75}$	$\|\Delta\mathcal{S}\| \leq 0.25$ w=∞	OCP w=100	Max w=11	*H w=10	Unif w=10	$\mathcal{H}$
☞ a. $H_{0.5}$			-0.75	-0.5		-13.25
b. ($H_{0.5}$ $H_{0.5}$)				-0.5	-1.0	-15.0
c. $H_{0.5}$ $H_{0.5}$		-1.0		-1.0		-110.0
d. $H_{0.75}$ $H_{0.75}$		-1.0		-1.5		-115.0

The project pursues three specific objectives: Ⓐ Reconstruction of representative stratal analyses in HLT, Ⓑ investigating HLT's empirical predictions, and Ⓒ address open questions on the formal nature of GSR and CO based on tonal data.

2.1 Reconstruction of Stratal Analyses

A first central goal of the project is thus to test the hypothesis that all cases of constraint reranking(/reweighting) or construction-specific ranking can be reconstructed in HLT with a uniform constraint weighting. In particular, we will develop detailed reanalyses for the analyses of Igbo in Clark (1990), of Kinande in Jones (2014), of Shona in Myers (1997), and of Hausa in Inkelas (1998) where different rankings are assumed. The null hypothesis in this part of the project is that the complete phonology of any given tone system has a consistent weighting. A natural weaker version of the hypothesis is that re-weighting is possible between lexical and phrasal phonology, whereas these subsystems show an internally consistent weighting, an assumption still substantially more restrictive than the recent claim in Jones (2014) that there are several distinct strata in both phrasal and lexical phonology, but in line with the classical cyclic tone analyses of Pulleyblank (1986).

2.2 Predictions

The second central objective of the project is to test three specific empirical predictions resulting from the HLT formalism:

P1 *Monotonicity* of phonological changes across strata/cycles

P2 *Consistency* of strength in a given stratum

P3 Pervasiveness (and cyclicity) of *Cooperation*

P1 *Monotonicity:* By Monotonicity we understand the fact that representations in HLT monotonically become stronger ('grow') or weaker ('decay') in a grammar in the transition from stratum S_n to stratum

S_{n+1}. Since the constraints and their weighting remain constant across strata, this results in Monotonicity of phonological behavior. We illustrate this again with an OCP-effect, already discussed above, Meeussen's rule where a H-tone is deleted after another H-tone. Assume that a given H-tone H (with lexically determined initial activity A), in a language L undergoes Meeussen's rule at the Stem Level, but not at the Word Level under otherwise identical phonological conditions. This implies that the constraint ranking of L leads to an increase of activity for underlying H-tones across levels such that the violations of MaxH at the Word Level outweigh the ones for the OCP. Under the premises of HLT, it follows that the OCP also doesn't apply (ceteris paribus) at the Phrase Level since the constraint weighting W is consistent for a given language, and since we already know that W increases activity of H-tones in the unmarked case (as shown by the Stem-Level/Word-Level contrast), the same increase is expected for the transition to the Phrase Level, adding further resistance to H-tone deletion.

More generally, Monotonicity predicts the monotonic change of grammatical thresholds: Thus, if a tone with activity ⓧ results in a certain phonological behavior 1, and a tone with lower activity $\boxed{\text{x-y}}$ in phonological behavior 2, a tone with an even lower activity $\boxed{\text{x-y-z}}$ can only show a new phonological behavior 3 if it crosses yet another threshold set by constraint weightings but it can never revert back to show phonological behavior 1 again. HLT hence predicts thresholds for phonological behavior that are either monotonically increasing or decreasing, as briefly illustrated in (5).

(5) Monotonicity of thresholds for phonological behavior in HLT

T_x → Phonological behavior 1

______________________________WEAKER: THRESHOLD 1

T_{x-y} → Phonological behavior 2

______________________________WEAKER: THRESHOLD 2

T_{x-y-z} → Phonological behavior 3

The Monotonicity prediction is in sharp contrast to a classical stratal account without GSR. Thus in a Stratal-OT account of our hypothetical Meeussen's rule example, nothing would exclude application of the process at Stem and Phrase Level, but not at the intervening Word Level via the ranking in (6):

(6) Stem Level: OCP $\gg$ MaxH
Word Level: MaxH $\gg$ OCP
Phrase Level: OCP $\gg$ MaxH

P2 *Consistency* is taken to describe the fact that in HLT different repairs for elements must be contingent with their input strength since constraint weighting remains constant. It is based on the application of the GSR formalism to account for apparently morpheme-specific phonological processes (Zimmermann 2017, Trommer & Zimmermann 2018). A simple example for this is Giphende (Hyman 2017b, Rolle 2018), which has several nominal prefixes whose phonological substance is a H-tone, i.a. marking Focus, Genitive, and Predicative. All these H-tone prefixes show up consistently with L-tone roots (note that nouns of all tonal shapes also consistently have a segmental L-tone prefix). However, the phonological behavior of the three H-tone morphemes differs for roots also containing a H-tone. Whereas the Focus-High is realized only on roots without H-tones (7-a), the Predicative surfaces independently from the tonal shape of the Base (7-a,b,c,d). The behavior of the Genitive-H is in-between: It is realized if and only if it is not-adjacent to a root-H (7-a,b):

(7) Giphende nominal morphology

Citation Form:	a. L-LL	b. L-LH	c. L-HL	d. L-HH
Focus:	**H-H**L	L-LH	L-HL	L-HH
Genitive:	**H-H**L	**H**-LH	L-HL	L-HH
Predicative:	**H-H**L	**H**-LH	**H**-HL	**H**-HH

GSR allows for a maximally simple formalization for this kind of pattern, based on well-motivated phonological constraints. Attributing the Giphende effects to the OCP (against adjacent H-tones) in tandem with a more general CULMINATIVITY constraint (Hyman 2009), which penalizes distinct H-tones in a PWord even when they are not adjacent, we can simply assume that the affix H-tones have different activities and due to MAXH more active tones enjoy more extensive protection by faithfulness (*Activity*(Predicative-H) > *Activity*(Genitive-H) > *Activity*(Focus-H)).

The Giphende pattern obeys Consistency since the tonal morphemes which are stronger with respect to the OCP effect are also stronger with respect to CULMINATIVITY. Thus it can be captured by morpheme-specific grammars in a construction-based approach (Inkelas 2016, 2018) but also by a GSR account where all these morphemes apply at the same stratum. However, it is easy to construct similar hypothetical systems which violate Consistency but can be captured in construction phonology accounts, where different markedness constraints M_1 and M_2 may be ranked divergently differently with respect to a given faithful constraint F:, given in (8). Thus if M_1 = *H#, M_2 = *HH (the OCP), and F = MAX H in Construction C_1 a H-tone of the affix introduced by C_1 might be deleted at the end of prosodic words, but not under adjacency of other H-tones, whereas the situation would be reverted for an affix tone in C_2. This is illustrated in (8) where the behavior for two H-tones in the two contexts is given.

(8) Construction-specific rankings

		H]$_{\text{PrWd}}$	**H**H
Construction 1	$M_1 \gg F \gg M_2$	Deletion	No deletion
Construction 2	$M_2 \gg F \gg M_1$	No Deletion	Deletion

This state of affairs is predicted to be impossible in HLT since constraint weighting is constant, and different repairs are contingent with the input strength of the involved tones. Thus if a tone at a given stratum is weak it should behave consistently weakly with respect to all markedness constraints.

Consistency effects also extend to tonal spreading ('assimilation'), as in Babanki (Hyman 1979:164) where nouns which have a H-tone on their monosyllabic root in isolation show three different kinds of behavior in spreading processes, triggered by preceding associative markers (9). Weak-H nouns are always affected by two spreading processes: In Low-spreading the L-tone of the associative marker ə̀ spreads all the way to the root, across the L-toned class prefix kə̀. H-spreading from associative *kə́*, on the other hand, targets only the nominal prefix but the L-tone of the latter reassociates to the noun root, hence also resulting in lowering for the stem. With medium-strength H-tone roots, lowering is only observed in L-tone spreading contexts but not in contexts with H-tone spreading. And strong lexical H-tones resist lowering in both contexts.

(9) Babanki nouns and tone spreading

	Weak H	Medium H	Strong H
Isolation Form	kə̀-fɔ́	kə̀-kə́m	kə̀-fó
H-Spreading (weak)	kə́ kə́-fɔ̀^{H}	kə́ kə́-^{L}kə́m	kə́ kə́-^{L}fó
L-Spreading (strong)	ə̀ kə̀-fɔ̀^{H}	ə̀ kə̀-kə̀m^{H}	ə̀ kə̀-fó
	'thing'	'crab'	'medicine'

Thus, the three types of lexical Highs form a strict hierarchy of strength, as predicted under a GSR account, under the natural assumption that Lowering in L-tone spreading is triggered by constraints with higher weight than the triggers for lowering in H-tone spreading. On the other hand, in a construction-based or indexed-constraint approach, there might be an additional class of nouns which resists lowering under Low-spreading, but not under High-spreading (the complementary case to the medium-strength H-tone actually observed).

P3 *Pervasiveness of Cooperation:* Especially in classical versions of Construction Phonology (Orgun 1996b, Inkelas 1998), it is predicted that morpheme-specific phonological effects are triggered unilaterally by morphological constructions (≈ in most cases, single affixes/morphemes). On the other hand, the very raison d'étre for developing the GSR approach has been that it allows for a simple model of multilateral conditioning of morphophonological processes since representational strength is inherently non-directional, and does not impose a fixed scope thus that fused phonological material of different strength may contribute cumulatively to phonological behavior (Smolensky & Goldrick 2016, Rosen 2016). Cooperative tonal effects thus provide strong empirical support to the general framework. A fascinating example for a cooperative tonal effect is described by Gjersœ et al. (2016) and Gjersœ et al. (2019) who argue that phrase-final low boundary tones in Limbum further lower final syllables which are already Low and extend High- and Mid-tone syllables to falling (High-Low and Mid-Low) tones. This lowering shows a crucial component of lexical conditioning since many High- and Mid-tone morphemes resist this process. A natural interpretation of this pattern in GSR is to assume that the boundary tone is a L-tone with partial activity, and that the High/Mid morphemes which undergo contour formation also carry a (low-activity) Low-tone which is not realized in isolation. Only if the partially active Lows cooccur, they fuse, and result in a full L-tone (or the boundary tone adds further strength to a lexical Low) in parallel to the coalescence-based analyses of cooperative effects in French liaison by Smolensky & Goldrick (2016) and for Japanese Rendaku by Rosen (2016). Evidence for the truly (morpho-)phonological character of cooperation processes of this type is provided by a detailed analysis of Zimmermann (2018a) for San Miguel el Grande Mixtec tone ‘perturbation’ where specific nouns idiosyncratically trigger a H-tone on a following morpheme, a process which is in turn blocked for a second idiosyncratic class of morphemes, but only if the first – trigger – morpheme ends in a H-tone syllable, hence exactly if an additional H-tone would result in an OCP violation. Thus the cooperation mechanism has to take into account different morphological triggers and phonological constraints simultaneously. See Trommer (2019c) for additional examples of morphophonological cooperation involving tone, and Rosen (2017) for a further potential case (under a tonal analysis of accent) in Japanese compounds.

2.3 Open Questions

A third, more general goal of the project is to make the potential richness of tonal morphophonology accessible for the theoretical approaches employed in the project and the Research Unit. Thus tone has so far hardly played any role for the development of Stratal OT, and the few counterexamples have assumed models tailor-made for specific languages or language families (Trommer 2011, Jones 2014). Here the scope of the project on three different groups of languages (Bantu, West-African and Nilo-Saharan) promises a more general picture of possible stratal effects. A similar point also holds for GSR: Whereas the Emmy-Noether project by EZ addresses pitch accent systems (see also Kushnir 2018 on Lithuanian and Rosen 2017 on Japanese) and tonal morphology, there is so far virtually no published work on general phonological processes in tone languages in GSR (apart from Nformi 2018). Especially for the relatively young GSR approach, we hope that tonal data will also help to answer basic formal questions:

1. Is the evaluation of all constraints gradiently sensitive to activation (as the Max constraint in (2)/(3)), or is this parametrized so that specific constraints may categorically penalize structures with different activation levels by the same amount of violations? Our working assumption is that the latter option is correct and crucial to derive differences between strata (as with the interpretation of the Uniformity constraint in (2)/(3)), and crosslinguistic variation.
2. Can constraints explicitly refer to specific threshold levels of activation (Trommer 2019b) as $|\Delta\mathcal{S}| \leq 0.25$ in (2), or are threshold effects emergent from the interaction of constraints which are individually ‘blind’ to activation levels (Smolensky & Goldrick 2016)?
3. Can output representations also be gradient, as proposed by Zimmermann (2018b) in contrast to the original proposal by Smolensky & Goldrick (2016), where all output activations are either ⓪ or ①? As a consequence, can markedness constraints refer to strength differences in the output as the ocp in (3) and (4)? If this option is adopted, how do markedness constraints refer to strength? Are they violated by the "mean activity" of the single tokens violating the constraint, or is there a single scopal element whose activity determines the overall violation profile?
4. Is different output strength visible to phonetic interpretation, as in the proposals of Trommer & Zimmermann (2018) and Nformi (2018) for (phonetically) different Mid tones which differ, not in their featural components, but the respective activation of the latter?

Gradient activity in output representations seems to be especially natural in a stratal/cyclic framework since here the output of one cycle provides the input for subsequent cycles. Thus the original analysis of French liaison by Smolensky & Goldrick (2016), where lexically different activations become relevant in the phrase-level phonology, would only be possible in a stratal account if the output of the word-level (providing the input of then Phrase Level) has preserved these activation levels, hence has gradient outputs. Combining options from questions 2.+3., another hypothesis we pursue is that there are special constraints requiring categorial ('1' or '0') outputs, making gradiency in the output of strata dependent on the constraint weighting.

In addition, the project will also address central questions which are relevant for stratal architectures more in general in cooperation with the Sem🚲Phon project:

1. Are there more than two word-internal strata (Stem Level and Word Level) as argued explicitly for tonal morphophonology by Clark (1990) and Jones (2014). In line with Sem🚲Phon, we adopt the hypothesis that additional strata are unwarranted.
2. Are there qualitative differences between strata motivated by different types of lexical listing thus that the Stem Level may exhibit stratum-internal 'fake cycles' whereas the Word-Level phonology doesn't involve any stratum-internal cycles, as proposed by Bermúdez-Otero (2013)? Pseudo-cycles at the Stem Level might provide a natural account for the dense cyclicity of tonal processes claimed by Pulleyblank (1985, 1986) for languages like Tiv.
3. Do tonal affixes obey the Affix Ordering Generalization, i.e. are all affixes exhibiting the phonological alternations of a given stratum concatenated as a block with respect to affixes of another stratum? Compared to the classical stratal system assumed in Sem🚲Phon, this assumption seems to be even more cogent in our approach, where strata are not distinguished by different rankings/weightings, but only by their cyclic 'history'. Still, potential violations of the Affix Ordering Generalization, could be due to some kind of interfixation (Hyman 2002, Kiparsky 2017, Kushnir 2018) or affix movement as explored in project Mor🚲Mor.

3 Work program

3.1 Data

Data for the project will be drawn from African languages which exhibit both complex word-internal morphologies, and intricate systems of tonal phonology crucial to the project. Our focus is on three groups of African languages which show a particular richness in the phenomena we identify below in section 3.2 as especially relevant for optimizing and stratal accounts: **E1** global rules and strata straddling, **E2** inter-stratal conspiracies, **E3** competition of overwriting patterns, and **E4** tonal attraction phenomena. For **Bantu**, the last decades have accumulated a wealth of detailed high-quality language documentation on tonal morphophonology (see Hyman 2017a and Odden & Marlo 2019 for recent overviews) which has only received tentative theoretical evaluation. **West African** languages of different genetic language families (Niger-Congo, Chadic, and isolates) pose especially hard challenges for a classical stratal architecture since the boundary between lexical and phrasal tonology is often blurred and cyclicity seems to 'leak' into the phrasal domain (McPherson & Heath 2016, McPherson 2019, Sande 2017, Rolle 2018). And the complex stratal tone systems in **Nilo-Saharan** languages have only recently become prominent in theoretical phonology (Trommer 2011, Gjersøe 2019, Remijsen et al. 2015, Trommer & Gleim 2017). The latter empirical focus will also build on recent Leipzig PhD theses (Gjersøe 2019 on Nuer) and ongoing undergraduate theses involving fieldwork on Kanuri, and Warkimbee.

Reconstruction of Classical Stratal/Cyclic Analyses: The first phase of the project involves reconstructing detailed stratal accounts of comprehensive language-specific tonal phonologies that already have a cyclic analysis within HLT. Given the mostly peripheral status of Nilo-Saharan languages in the morphophlogical and phonological literature, the sources for this part of the project will be necessarily restricted to Bantu and West African languages, especially the detailed analysis of Tiv by Pulleyblank (1985, 1986) Clark's 1990 comprehensive treatment of Igbo, Jones (2014) on Kinande, Myers (1987,

1997) for Shona, and Odden (1996) for Kimatuumbi, and McPherson & Heath (2016) for Dogon. These sources not only provide especially detailed data coverage and explicit analyses, but also exhibit a representative set of challenges to our working program. While we are assuming following Bermúdez-Otero (2018) a minimal stratal architecture with only two lexical levels (stem and word), a single phrasal level, and no stratum-internal cyclicity, Clark and Jones argue for a rich lexical and postlexical stratification. And a main claim of Pulleyblank is that cyclicity is triggered by every affixation step while McPherson captures the hierarchical overwriting in Dogon by multiple phrasal cycles. Finally, according to Odden, tone in Kimatuumbi requires major departures from standard stratal architectures and especially the visibility of lower-level material at later strata.

An advantage of these reference works is that for most of these languages, there is a also a substantial body of work on segmental phonology (e.g. Pulleyblank 1985, 1986 on Tiv, Archangeli & Pulleyblank (1994, 2002) on Kinande, Mudzingwa 2010 for Shona, and the books by Clark and Odden for Kimatuumbi and Igbo) which allows to test the motivation for stratal organization independently from the tonal data under investigation.

Data from Descriptive Sources and Fieldwork: In the second stage of the project, we will retrieve new data from a larger sample of languages. We estimate that roughly 90% of these data can be retrieved directly from published descriptive material, and will use additional data sources mainly for double-checking and filling gaps in this body of data (i.e., for languages with at least a reasonable level of published documentation on their tonal phonology). For the Bantu and West African languages we will rely on our cooperation with the coapplicants for the DFG network 'Grammatical Tone in Words and Phrases: Theory and Typology' for which we are applying at the DFG in parallel to the Research Unit application. They comprise specialists carrying out continuous original fieldwork for these language groups: Nick Rolle, and Lee Bickmore on Bantu, and Hannah Sande, Laura McPherson, Katharina Hartmann, Nick Rolle on West African, and Bert Remijsen on Nilo-Saharan. Due to their marginal status in language documentation, tonal data on Nilo-Saharan pose specific problems of two kinds: *First*, inconsistencies in single sources, especially in cases where extensive paradigms for word forms are given, which don't fully match the examples in the concomitant prose descriptions (e.g. in the detailed Karimojong grammar by Novelli 1985). *Second,* variable levels of tonal transcription: In many descriptive sources, data are partially transcribed in their actual pronunciation (in phrasal context), and partially in word-level (or even: underlying) forms, abstracting away from a rich set of phrase-level tone alternation, often without making it fully transparent which specific data are transcribed at which level (e.g. Reh 1996 on Anywa, Creider 1982, Creider & Creider 1989 on Kalenjin, and Tucker 1994 on Dholuo). In the extreme case, especially in otherwise high-quality pedagogical sources, tone remains unmarked for many examples (e.g. Tucker & Mpaayei 1955 on Maasai). For these cases we will use the unique opportunity that Maria Kouneli already carries out fieldwork for many of the relevant Nilo-Saharan languages as part of the Research Unit, to check the existing data from grammars with the informants independently recruited for the Syn🚲Mor project, and to fill remaining gaps.

3.2 Empirical phenomena

To test the hypotheses identified in **??**, the project focuses on four empirical areas of tonal phonology which either have proven to be notoriously problematic for standard cyclic and optimizing accounts, and/or which are inherently closely linked to intuitive notions of strength and morphosyntactic cyclicity:

E1 *Global Rules and Stratal Straddling:* Numerical strength distinctions allow for a principled way to capture effects where processes at earlier strata are still partially recoverable at later strata. Thus in Luganda an earlier word-level process neutralizes specific H-tones and underlying L-tones, but later (phrasal) spreading processes treat underlying and derived L-tones differently (Hyman 1993, Hyman & Katamba 1993). This pattern can be straightforwardly captured if the neutralization process is incomplete and thus gradient at the Word Level and only achieves categorial status at the Phrase lLevel so that phrasal faithfulness constraints might still react differently to the two types of L-tones although the difference is obliterated in the output.

Other cases of stratal straddling we want to adress are: construction-specific H-boundary tones in Gã (Paster 2003, Trommer 2019c), the lexical influence on the realization of phrasal boundary tones in Limbum (Gjersœ et al. 2019) and Bimoba Snider 1998:82), Kimatumbi initial tone insertion (Odden 1990, 1996) Marlo, 'realignment' of nominal prefixes in Bamileke Dschang (Hyman 1985) or Tura (Inkelas 2014), anticyclic polarity in Asante Twi (Trommer 2015), Ekegusii and Lumarachi (Marlo 2008), directionality of H-tone association in Makaa (Cahill 2000).

A central prediction of the HLT approach for Stratal Straddling is that it should obey *Monotonicity*. Moreover several of the above cited cases (Gã, Limbum, and Bimoba) also seem to instantiate *Cooperation* (e.g., only coocurrence of a lexical tone component and a phrasal tone component results in a phonetically overt tone).

E2 *Inter-Stratal Conspiracies:* A central insight of stratal phonology is that the same process tends to happen in a language at different strata, but under slightly different conditions (see.g. Myers 1991 on the Strong' Domain Hypothesis'). Since attempts to substantially restrict this phenomenon synchronically by general conditions on rule activity or constraint rankings on adjacent ordered strata have proven problematic (see Orgun 1996a, but Bermúdez-Otero 2007 on diachronic conditions), we want to pursue an alternative route, where inter-stratal conspiracies do not follow from related cophonologies, but from successively changing gradient representations (Kushnir 2018, Trommer 2019b). Tonal alternations in languages with lexical and grammatical tone systems seem to be the ideal empirical testing ground since they typically exhibit rich alternations at both the lexical and postlexical level.

Another domain where conspiracies seem to show up is CULMINATIVITY, resolved e.g. in Japanese in slightly different ways in domains of different sizes (words, intermediate phrases). In Shona, stem-level tone spreading applies unboundedly up to the end of the domain, word-level spreading stops before the last syllable, and phrasal spreading is strictly local, affecting only the right-adjacent syllable (Kenstowicz 1994:331). Finally, in Gaahmg, contour tone simplification (Stirtz 2011) is applied in a 'soft' form (counterfed by other processes) in clitics, but in a strict form (fed by other processes) in affixes. Under an optimization perspective, the notion of conspiracy is not restricted to alternations of the same formal type (such as different types of spreading), but extends to sets opf processes which resolve the same markedness violations. A classical case for this is again found in Shona, where violations of the OCP are resolved by tone deletion, and tone fusion at different strata (Myers 1997). A similar case is found in the different repairs for toneless syllables in Margi, which employs spreading for affixes, but polarity for clitics (Pulleyblank 1986).

Phenomena of Inter-Stratal Conspiracies are the central empirical testing ground for *Monotonicity*, which predicts that we should not find an ABA pattern in markednedss resolution across strata (e.g. H-tone deletion at Stratum 1 and 3, but Fusion at Stratum 2).

E3 *Competition of Overwriting Patterns:* Overwriting patterns where an affix or word triggers tonal patterns on adjacent morphemes have been one of the central arguments for the development of Autosegmental Phonology since they can be captured by unassociated 'floating' structure as part of the lexical specification of trigger morphemes (Leben 1973, Goldsmith 1976, Clark 1990), but the heterogeneous conditions under which overwriting happens have been a long-standing problem. Thus, apparently identical tones may lead to complete or to partial overwriting on a morpheme-specific basis (Inkelas 1998) and overwriting might be blocked for specific lexemes or specific phonological contexts (Rolle 2018). When different overwriting patterns cooccur, complex resolution strategies emerge (Andersen 1995, Otelemate & Hyman 2014, Hyman 2013). Whereas stratal models predict part of these effects (Trommer 2011) they have proven to be only partially successful, and we expect that as in the case of tonal accent systems, gradient strength provides new principled answers here.

A case study in a related phonological domain which illustrates this point is Zimmermann (2018b) where the lexical accent system in Moses Columbian Salish is analyzed as the result of combining morphemes that contain lexical accents (=contrastive foot structure) with different activities. More concretely, competition between five different morpheme types is necessary (no lexical accent or lexical accent with activity $\boxed{0.4}$, $\boxed{0.6}$, $\boxed{0.8}$, $\boxed{0.9}$, or $\boxed{1.0}$) to predict the complex accent pattern. Assuming similar gradient activities for floating tones will allow to explain different overwriting behavior of identical tones within the same language.

In contrast to a construction-morphology account where the morphological structure determines which morpheme takes scope over the whole construction and hence will determine the overwriting property, competition within one stratum is resolved based on underlying representations in HLT. This difference is illustrated with a hypothetical example in (10) (similar to the Giphende data above), where three different morphemes that add H-tones show different realization patterns: Whereas the H of morpheme 1 is added to its base and creates a contour, the H of morpheme 2 overwrites the final base tone, and the H of morpheme 3 spreads to the whole base (10-a). Combining these morphemes is then taken to result in the surface patterns (10-b).

(10) Toy language: Three different morphological H-tones

	Morphology	Surface	
a.	stem + morpheme 1	contour creation:	LL –> L.LH
	stem + morpheme 2	overwriting:	LL –> L.H
	stem + morpheme 3	overwriting + spreading:	LL –> H.H
b.	stem + morpheme 1 + morpheme 2	overwriting:	LL –> L.H
	stem + morpheme 2 + morpheme 3	overwriting + spreading:	LL –> H.H

In a construction morphology account, this pattern relies on the morphological structures (11-a) – the morpheme whose H-tone behavior is realized on the surface takes scope over the whole construction. In HLT, however, the pattern results from competition between H-tones with different activities (11-b) if those are added in the same stratum.

(11) Theoretical accounts

a. Construction Morphology: Morphological structure

[[M1] M2]	M2's phonology superimposed: overwriting
[[M2] M3]	M3's phonology superimposed: overwriting + spreading

b. HLT: Underlying representations

<M1> ↔ /H_x/	H-tone with strength ⓧ
<M2> ↔ /H_{x+y}/	H-tone with strength $\boxed{x+y}$ –> stronger than M1's H-tone
<M3> ↔ /H_{x+y+z}/	H-tone with strength $\boxed{x+y+z}$ –> stronger than M1's and M2's H-tone

A first important difference between both accounts is hence that construction morphology predicts that morphological scope always implies determining the overall overwriting pattern. In HLT, the prediction differs depending on the independently motivated presence of strata between the morphemes: Within a stratum, the competition is resolved based on lexical properties. More concretely, the two morphological structures [[M1] M2] and [[M2] M1] are expected to result in different surface patterns in Construction Morphology (=overwriting in the former; contour creation in the latter) but in the same surface form in HLT (= overwriting in both cases).

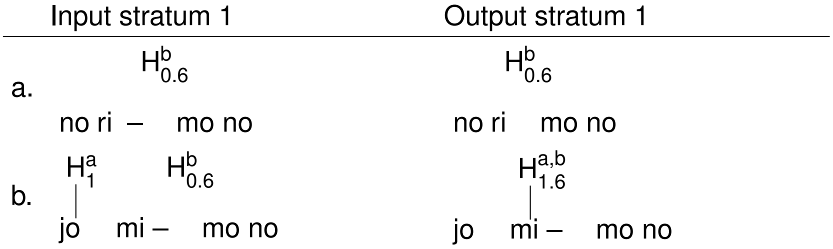
Also *Consistency* within a stratum restricts possible Overwriting patterns. Thus, given the facts above, the morpheme combination M1+M3 will by transitivity always result in M3's pattern and hence overwriting and spreading. This follows given that M3's pattern wins the competition against M2 and M2's pattern wins the competition against M1. For construction morphology, the surface pattern again depends solely on morphological scope.

A third prediction of our model is that under specific constraint weightings (allowing for coalescence of like partially activated affix tones), competition should alternate with mutual reinforcement of overwriting patterns (hence *Cooperation*). Possible examples for this might be found in cases of 'portmanteau' patterns in tonal overwriting in Bantu and Nilotic (see Trommer 2020a for discussion).

E4 *Tonal Attraction:* The fourth empirical phenomenon we will investigate is the least understood both empirically and theoretically, a tone sponsored by a morpheme M_1 is 'attracted' to (realized on) a designated position P under influence of a second morpheme M_2. the attraction of underlying tones of a morpheme to a designated position in a specific different morpheme. Thus the Japanese suffix *-mono* 'thing' has no effect on bases without an underlying tone (e.g. *nori* 'to ride' → *nori-mono* 'thing to ride'), but if the base contains an underlying accentual High, this is realized on the mora preceding the suffix (e.g. *jómi* 'to read' → *jomí-mono* 'thing to read'). Significantly, this affix type contrasts with the behavior of 'true' preaccenting suffixes which impose a H-tone on the stem-final mora independently from the availability of a base H-tone (e.g. *-si* 'Mr.' in *ono* → *onó-ke* 'Mr. Ono' and *úra* → *urá-ke* 'Mr. Ura'). A more complex pattern of attraction is found in Kanuri Cyffer 1992:132). The nominalizing suffix *-ram* has an L-tone if the base verb is all-Low (e.g. gàwò 'to enter' → gàò-ràm 'entrance'), but usurps the High of a non-adjacent base syllable (e.g. *cídà* 'to work' → *cìdà-<u>rám</u>* 'working place'). In contrast, an adjacent High resists attrraction is (e.g. *zə̀ptə́* 'to lodge' → *zə̀ptə́-ram* 'guest room'). A similar pattern is found in the un-related language Afar (Bliese 1981). The most challenging aspect about tonal attraction is that it often seems to require identical tones of the same quality, resulting in apparently licentious violations of the OCP. Thus in Idakho, the H-tone of the passive suffix *-u* is only realized under specific morphological conditions where the central trigger is the presence of an independent H-tone contributed by tense and aspect. In Ciyao, a floating morphological suffix-H only targets the verb stem if a concomitant prefix-H results in an adjacent position (i.e. if the stem is short enough, otherwise the suffix H reverts to a noun following the verb or remains unrealized). Tone attraction has so far not enjoyed any systematic attention in the theoretical literature, but seems to be a highly promising testing ground for a GSM account, since it inherently involves *Cooperation*: tone realization depends on the joint presence of multiple morphophonological triggers much in parallel to the original motivation for the framework in French liaison (Smolensky & Goldrick 2016).

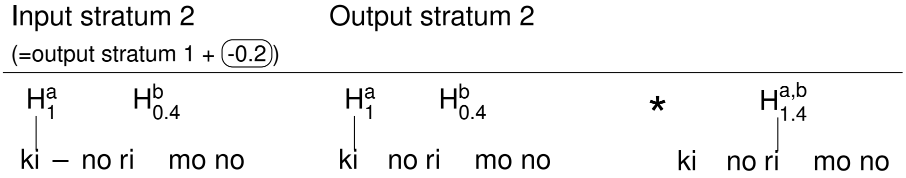
For the Japanese attracting suffixes, for example, one can assume that they contain a floating tone that must be realized on the immediately preceding TBU (the position closest to the morpheme but not the affix itself, avoiding a homomorphemic association) but that this tone is too weak to be realized on its own. In the example in (12-a), the illustrating underlying activity of this affix tone is set to $\boxed{0.6}$ which is taken to cause not enough violations of *FLTT (=demanding that a floating tone is realized) to induce association to a TBU. If now another H-tone is present in the word, the optimal repair is fusion between the two tones: The weak affix tone is strengthened by this fusion operation, receives a combined activity of $\boxed{1.6}$, and can be realized in its preferred position (12-b) (the superscript letters 'a,b' here indicate correspondence between input and output tones, hence $H^{a,b}$ is the result of fusing H^a and H^b).

(12)



Since HLT implies monotonic activity changes across strata, the model predicts that cooperation in general and attraction more specifically that was successful in one stratum might become impossible in a later stratum. If we extend our Japanese example (12) with a hypothetical H-toned prefix that is added in a later stratum, a decay of activity between the strata (assumed to be $\boxed{-0.2}$) might mean that the now even weaker affix tone is not provided with enough additional activity to be realized, even if it undergoes fusion (if, for example, the threshold set by *FLTT is set at $\boxed{1.5}$). Attraction that was possible within H-tones added in the same stratum hence becomes impossible if the candidate for attraction is added too late. This is shown in (13-a) for example (12-a) when entering the following stratum:

(13)



The HLT model hence predicts that tones that are added in a later stratum might not successfully enter an attraction relation that is possible for tones added in an earlier stratum.

3.3 Cooperation within the RU

There is an especially close connection to project Syn🚲Mor with which we share an empirical basis in African languages. Our supplementary empirical fieldwork on Nilotic will be executed in tight cooperation with this project. Conversely, we will provide expertise on tonal morphophonology to this partner project since number morphology in many Eastern Sudanic languages is at least partially expressed by tone (see e.g. Gjersøe 2019 on Nuer). At the theoretical level, we will work together on ways to model 'underexponence' which is instantiated by tone in *Competition of Overwriting Patterns* (our empirical domain **E3**, see section 3.2 above).

With project Sem🚲Phon, we share the basic theoretical assumption of a classsical 3-way stratal architecture, and consequently the question whether the Affix Ordering Hypothesis can be maintained. We will provide this project with expertise and data on tone, and plan to cooperate in particular on the African languages in Sem🚲Phon's samples. The non-tonal phonological and semantic evidence under evaluation in Sem🚲Phon will function as a corrective to the analytic choices we are basing on tonal evidence.

A question we want to adress in an explorative way with project Syn🚲Phon is the status of tonal clitics. Possible candidates for such an analysis are phrase level tonal overwriting patterns (see e.g. McPherson & Heath 2016 on Dogon), morphosyntactically 'mis-aligned' tones (see Trommer 2015 on Asante Twi), or even standard pitch accent and boundary tones. Word-level tonal morphemes show few evidence for dislocation, but there are well-known cases from sentence-level prosody where this might be the case (see e.g. Grice et al. 2000 on 'phrasal tones' in Eastern European languages). We plan to implement this cooperation by an 'internship' of our project employee in the Syn🚲Phon project as part of the RU's rotation program.

A further question we want to approach together with project Mor🚲Mor is how Gradient Symbolic Representations might interact with serial optimization (either inside or without a stratal superstructure). This will also be addressed by pilot studies on phonological and morphological applications in a rotation internship.

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