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Directionality: Constraints on Derivation?

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Abstract

Certain tone sandhi facts of the northern Mandarin dialect of Tianjin suggest that there are constraints that hold not on outputs per se, but on the derivations that lead to the outputs. Inasmuch as these constraints are processual in nature, they do not readily translate into classical, monostratal OT terms (Prince-Smolensky 1993). Technically speaking it is possible to restate the facts in a two-level OT, extending somewhat the "correspondence theory of faithfulness" (McCarthy-Prince 1995), but in doing so one runs into some conceptual problems and obscures certain insights implicit in the derivational account. Constraints on competing derivations are not necessarily incompatible with the spirit, if not the current practice, of OT: if we construe OT as a proposal about evaluating some set of candidates with respect to some set of soft constraints, where candidates could be representations or derivations (attributed to Paul Smolensky by David Pesetsky on OT-net, 9.95). [Note: this manuscript consists of the original Tilburg conference handout, with minimal narrative added for posting on ROA.]

I. A Derivational Account

Tianjin has the familiar 4-tone system (1.1). OCP and OCP' (the latter bans adjacent *partially* identical tones, (1.3)) are enforced by Dissimilation and Tonal Absorption (1.4), as illustrated in (1.2).

(1.1) Tianjin Tones:

11	55	24	53	(1 = low, 5 = high)
L	H	R	F	(symbols used here, for *low*, *high*, *rising*, *falling* tones)

(1.2)

	base form	sandhi form		
a.	LL	RL	*guan xin*	'to be concerned'
b.	RR	HR	*hen hao*	'very good'
c.	FF	LF	*lang fei*	'wasteful'
d.	FL	HL	*kan shu*	'to read a book'

(1.3) OCP bars a sequence of adjacent like tones (except HH)
OCP' (partial OCP) bars the sequence FL (= H<u>L.L</u>)

(1.4) Dissimilation
a. LL → RL
b. RR → HR
c. FF → LF

Tonal Absorption
FL → HL (= HL.L → H.L)

cf. σ σ σ σ (Bamileke, Mende, Kikuyu, Hausa, Ngizim;
/ \ | → | | cf. Hyman-Schuh 1974)
HL L H L
LH H L H

Longer tonal strings pose a problem regarding the mode of rule implementation. Of the 64 (4^3) logically possible 3-tone combinations, 7 patterns (P1-7 of Table 1) constiute the focus of our interest, since they are potentially subject to more than one instance of rule application. Specifically, rules apply left to right in P1-2, but in the opposite direction in P3-7 (see Tableau 1). Observational generalization: (1.5). Deconstructing (1.5) yields (1.6). P7 requires the preemptive clause (1.7), and ranking (1.8). But left to right or right to left modes of rule application do not exhaust the logical possibilities. A third possibility: rules apply consistently left to right, with backtracking where necessary to produce a wellformed string -- as illustrated in Tableau 2. To exclude candidates (c) of P3 and P4, one needs to explicitly posit a ban on backtracking (1.9). (1.10) encapsulates the derivational account.

Table 1

	Input	**Output**	**[x x] x**	**x [x x]**	**[x x x]**
P1.	FFL	LHL	[*si-ji*] *qing* evergreen	*zuo* [*dian-che*] take a tram	
P2.	RRR	HHR	[*li-fa*] *suo* barber shop	*mu* [*lao-hu*] tigress	[*ma-zu-ka*] mazurka
P3.	FFF	HLF	[*su-liao*] *bu* plastic cloth	*ya* [*re-dai*] sub-tropical	[*yi-da-li*] Italy
P4.	LLL	LRL	[*tuo-la*] *ji* tractor	*kai* [*fei ji*] pilot a plane	
P5.	RLL	HRL	[*bao-wen*] *bei* thermo cup	*da* [*guan-qiang*] speak in a bureaucratic tone	
P6.	LFF	RLF	[*wen-du*] *ji* themometer	*tong* [*dian-hua*] make a phone call	
P7.	FLL	FRL	[*lu-yin*] *ji* cassette recorder	*shang* [*fei-ji*] board an airplane	

(primary source: Li-Liu 1985;
cf. Chen 1986,1987, Hung 1987, Tan 1987)

Tableau 1

					WFC Prmpt	Temp
P1	☞	a	⇨	FFL → LFL → LHL		
		b	⇦	FFL → FHL		*
P2	☞	a	⇨	RRR → HRR → HHR		
		b	⇦	RRR → RHR		*
P3		a	⇨	FFF → LFF → LLF	*	
	☞	b	⇦	FFF → FLF → HLF		*
P4		a	⇨	LLL → RLL → RRL	*	
	☞	b	⇦	LLL → LRL		*
P5		a	⇨	RLL → RRL	*	
	☞	b	⇦	RLL → RRL → HRL		*
P6		a	⇨	LFF → LLF	*	
	☞	b	⇦	LFF → LLF → RLF		*
P7		a	⇨	FLL → HLL → HRL	*	
	☞	b	⇦	FLL → FRL		*

Key: ⇨, ⇦ indicate directionality of rule application
☞ indicates attested sandhi forms

(1.5) **Generalization**: By default rules apply from left to right -- unless such a mode of application produces an illformed output, in which case reverse the direction of operation.

(1.6) Temporal: Apply rules left to right
WFC: Output must obey OCP and OCP'
WFC >> Temporal

(1.7) Preempt: Dissimilation precedes Tonal Absorption

(1.8) WFC, Preempt >> Temporal

(1.9) NoBT: Do not backtrack

(1.10) WFC, Preempt, NoBT >> Temporal

Tableau 2

					WFC noBT	Temp
P3		a	⇨	FFF → LFF → LLF	*	
	☞	b	⇦	FFF → FLF		*
		c	BT	FFF → LFF → LLF → RLF	*	
P4		a	⇨	LLL → RLL → RRL	*	
	☞	b	⇦	LLL → LRL		*
		c	BT	LLL → RLL → RRL → HRL	*	

II. Constraints on derivation?

The derivational account sketched in section I makes crucial use of three constraints that are distinctly derivational or processual in character: 1. Extrinsic order (1.7); 2. Left to right directionality (stated as Temporal sequence, (1.6)); 3. No Backtracking (1.9). Before rejecting them out of hand, consider their a priori plausibility and empirical support. 1. Extrinsic order is something of an embarrassment in any account. If pushed, one might speculate that (1.7) reflects a gradient robustness of OCP effects: when a tonal string simultaneously violates OCP (total identity) and OCP' (partial identity), the tendency is to undo the more egregious OCP offense (by Dissimilation) before worrying about the minor OCP' violation (that can be fixed by Absorption). The parochial nature of OCP' is illustrated in (2.1), which shows that partial identities are freely tolerated elsewhere.

(2.1)
a.	FL = H<u>L.L</u>	*, → [H.L] by Tonal Absorption
b.	FR = H<u>L.L</u>H	ok
c.	LR = <u>L.L</u>H	ok
d.	RH = L<u>H.H</u>	ok

2. The bias for the left-to-right directionality accords with common sense. For instance, the parsing of syllables into feet is predominantly left-to-right (cf. Hayes 1995). This is certainly so in Chinese, where footing is diagnosed by means of tonal distribution (2.2). A right-to-left processing would require buffering of long stretches of speech (cf. Levelt 1989). For psycholinguistic evidence showing a left-to-right bias in speech organization (phonological encoding), see Meyers (1990, 1991).

(2.2) Shanghai tone/stress domain (Duanmu 1993, 1995)

a.	gao er ba qiao fu	'Gorbachev'
	(HL.LH)(HL.LH) HL	left to right footing (left-headed); no degenerate foot
	(HL. o) (HL. o) o	tone deletion (affecting stressless syllables)
	(H L)(H L) o	tone association (left to right), ok
b.	gao er ba qiao fu	
	HL(LH.HL)(LH.HL)	right to left footing
	o (LH. o)(LH. o)	tone deletion
	o (L H)(L H)	tone association, *

3. As for NoBacktracking, virtually all sentence processing models (from both production and comprehension end) assume a left-to-right, incremental parsing of materials as soon as they are heard (rather than waiting until the end of the sentence). This occaionally gives rise to the classic garden-path phenomenon, whereby the hearer is misled into committing him/herself to a default analysis until the surprise ending, at which point s/he has to *backtrack* and reparse (for recent surveys, cf. Pritchett 1992, Clifton-Frazier-Rayner 1994, Tanenhaus-Trueswell 1995). Backtracking represents a particularly complex processing task. A phonological analog (outside of the Tianjin case) would be the English Rhythm Rule (2.3), which requires backtracking at step (c). However, empirical evidence for the speaker's ability to perform stress retraction on-line proves to be elusive (cf. Cooper-Eady 1986, Kelly-Bock 1988, Levelt 1989, Beckman et al.1990; for possible explanation, see Hayes 1995). On the other hand, MalakMalak clearly shows the avoidance of backtracking. Goldsmith's analysis is paraphrased in (2.4). Cast in OT

terms (Tableau 3), ex 2 demonstrates the ranking Prs-σ >> Left-headedness; but ex 3 calls for the reverse ranking (note in particular, multiple violation of Lft-Hd is irrelevant under the strict domination hypothesis). Hence ranking paradox. Restated in derivational terms (2.5), candidate b (= Tableau 3, 3c) is eliminated because it entails backtracking (symbolized by the current window (underlined) first moving leftwards, then rightwards).

(2.3) thirteen abstract paintings
- a. thir'TEEN ab'STRACT
- b. thir'TEEN 'ABstract 'PAINtings
- c. 'THIRteen 'ABstract 'PAINtings (xx = current window)

(2.4) MalakMalak (Birk 1976; Goldsmith 1990:173-7)
- a. Group syllables into left-headed feet, from right to left (weak prohibition on degenerate feet)
- b. Word-level prominence falls on the leftmost stressed syllable
- c. Stress clash resolution:
  - i. *either* apply 'trochaic reversal' ("restricted to *one step* in the repair" Goldsmith p.177)
  - ii. *or* delete the degenerate foot

Tableau 3 MalakMalak

					Clash	Prs-σ	Lft-Hd
1	/mu.nan.ka.ra/	☞		("MU.nan)('KA.ra)			
2	/mɛl.pa.pu/		a	("MɛL)('PA.pu)	*		
			b	mɛl.("PA.pu)		*	
		☞	c	("MɛL)(pa.'PU)			*
3	/ar.ki.ni.yaŋ.ka/		a	("AR)('KI.ni)('YAŋ.ka)	*		
			b	("AR)(ki.'NI)('YAŋ.ka)	*		*
		$	c	("AR)(ki.'NI)(yaŋ.'KA)			**
		☞	d	ar.("KI.ni)('YAŋ.ka)		*	

Key: "σ = primary stress; 'σ = secondary stress; Prs-σ = parse σ's into feet; Lft-Hd = left-headed foot; $ = expected winner; ☞ = attested winner;

(2.5) a. /mɛl.pa.pu/
- → mɛl.('PA.pu) R-to-L footing
- → ("MɛL).('PA.pu) R-to-L footing, Clash
- → ("MɛL).(pa.'PU) Trochaic reversal (1)

b. /ar.ki.ni.kaŋ.ak/
- → ar.ki.ni.('KAŋ.ka) R-to-L footing
- → ar.('KI.ni)('KAŋ.ka) R-to-L footing
- → ("AR)('KI.ni)('KAŋ.ka) R-to-L footing, Clash
- → ("AR)(ki.'NI)('KAŋ.ka) Trochaic reversal (1), Clash
- → ("AR)(ki.'NI)(kang.'KA) Trochaic reversal (2)

III. An Output-driven Account

Can we reconceptualize and recast the derivational analysis in declarative, output-driven terms? Dissimilation and Absorption can be reformulated as output constraints, if we extend the notion of I/O correspondence not only to prescribe identity (perfect match), but also to circumscribe a range of permissible deviations or alternations (3.1). (3.1) says that an input L may alternate with R, and F with either L or H, etc. Alternation (3.1) in conjunction with OCP and OCP" (an extended version of OCP') correctly picks the winner candidates in two-tone combinations (Tableau 4).

(3.1) Alternation: L ~ R ('~' = alternates with)
R ~ H
F ~ L, H

Tableau 4

					OCP	OCP"	Alt
1	FL		a	LL	*		
		☞	b	HL			
2	FF	☞	a	LF (= L.HL)			
			b	HF (= H.HL)		*	
3	LL		a	HL			*
		☞	b	RL			

It is not as straightforward to capture the derivational constraints by non-derivational means. We will consider four possibilities. (Other suggestions most welcome).
1. OT can mimic directionality effects via Alignment (McCarthy-Prince 1993), as in (3.2) and (3.3). However, unlike footing and syllabification, tone sandhi does not create structures with constituent edges to align with some reference point.
2. Output conditions, i.e. WFC, underdetermine the choice of winner candidates: for every input there are at least two possible wellformed outputs, depending on the directionality of rule application, as illustrated in Tableau 5. In particular P7a [HRL] is perfectly wellformed, in fact the attested output corresponding to three different inputs (3.4).
3. Faithfulness: pick the most faithful candidate consistent with WFC. This works for P4,7 of Tableau 5, but makes counterfactual predictions for P1-2.
4. *Struc (which disfavors complex/contour tones) correctly picks P3b, P1a, P2a, but makes the wrong choice in P7 (Tableau 6).

(3.2) directional footing (Crowhurst-Hewitt 1995, cf. Hayes 1995)

	Pintupi				
	⇨	All-feet-Left		All-feet-Right	
a.	(σ σ) (σ σ) σ	0+2	☜	3+1	(measured in σ)
b.	σ (σ σ) (σ σ)	1+3		2+0 ☜	
	⇦				
	Yakan	(⇦, ⇨ encode directional footing/syllabification; e = epenthetic)			

(3.3) directional syllabification (Mester-Padgett 1993, Davis 1995)

	Cairene Arabic ⇨	All-σ-Right	All-σ-Left	
a.	(CVC)(Ce)(CV)	2+1+0 ☜	0+2+3	(measured in μ)
b.	(CV)(CeC)(CV)	3+1+0	0+1+3 ☜	

⇦ Iraqi Arabic

(3.4)	/HRL/ = [HRL]	[*niu jiao*] *jian*	'splitting hairs' (lit. tip of a horn)
	/HLL/ → [HRL]	*pi* [*shu bao*]	'leather briefcase'
	/RRL/ → [HRL]	*lao* [*mu ji*]	'old hen'

Tableau 5

			WFC Altern	Faith
P7		/FLL/	**	
	a	HRL		**
☞	b	FRL		*
P4		/LLL/	**	
	a	RRL	*	**
☞	b	LRL		*
	c	HRL	*	**
P1		/FFL/	**	
☞	a	LHL		**
	b	FHL		*
P2		/RRR/	**	
☞	a	HHR		**
	b	RHR		*

Tableau 6

			WFC Altern	*Struc	Faith
P3		/FFF/	**		
	a	LLF	*		
☞	b	HLF		*	**
	c	RLF	*	**	**
P1		/FFL/	**		
☞	a	LHL			**
	b	FHL		*	
P2		/RRR/	**		
☞	a	HHR		*	**
	b	RHR		**	*
P7		/FLL/	**		
	a	HRL		*	**
☞	b	FRL		**	*

IV. Cross-level constraints

Technically it is possible to derive the desired outputs by means of declarative statements of correspondence along the lines of two-level rules developed by Koskenniemi (1983), Karttunen (1993), Kaplan-Kay (1994), Orgun (1995), and McCarthy-Prince (1995), inter al. The two-level rules of (4.1)[1] are interpreted as in Table 2.

(4.1) **Two-Level Rules**

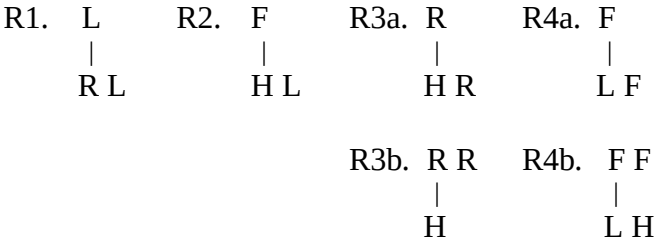

Table 2 (= illicit pairing)

	⇨	⇦	⇨, BT
P1	a. FFL || LHL ☜	b. FFL | FHL	
P2	a. RRR || HHR ☜	b. RRR | RHR	
P3	a. FFF | LLF	b. FFF || HLF ☜	c. FFF | RLF
P4	a. LLL | RRL	b. LLL | LRL ☜	c. LLL | HRL
P5	a. RLL | RRL	b. RLL || HRL ☜	c = b
P6	a. LFF | LLF	b. LFF || RL ☜	c = b
P7	a. FLL | HRL	b. FLL | FRL ☜	

[1] I owe the formulation of (4.1) to Orhan Orgun.

Conceptual and theoretical problems associated with the two-level rule analysis:

1. Given the nature of the sandhi processes (with context on the right), one can mimic directionality by imposing the condition on the context-sensitive rules either on the input or on the output: (a) condition on the *input* forces a left-to-right rule application: as long as the requisite condition is met at the input level, rules apply regardless of what happens ('subsequently') to the context; (b) conversely, by imposing the condition on the output, one forces a right-to-left mode of implementation: since one needs to 'antecipate' what eventually happens to the right context before deciding whether the it licenses a particular correspondence. See (4.2-3, condition in boldface). Since the hallmark of two-level rules is their ability to stipulate at will conditions on the input and/or output, the implication is that directionality is a rule-specific idiosyncracy. By contrast, in a derivational account directionality follows from the ranking WFC >> Temporal sequence (see (4.4)).

2. Rule ordering and opacity effect: in a derivational account, Dissimilation precedes Absorption (by virtue of Preempt (1.7), illustrated in (4.5)); in other words, Absorption 'counterbleeds' Dissimilation. In general, two-level rules handle opaque relations by stipulating conditions on the input (to signal the fact that a correspondence/rule is not 'surface-true'). But one cannot simply restate R4b as R4c (as in (4.6)), simply because it wrongly predicts P3 /FFF/ will emerge as [LLF] (4.7). Instead, R4b must define the condition jointly on the input *and* the output. Clearly, R4b is a notational variant of R4d (4.8), since the only context in which a tone is F at input but H at output is where this F is followed by a L (by virtue of R2 in (4.1)). R4d brings into focus three types of conceptual problems: (a) One forfeits the locality condition; (b) R4d redundantly repeats R2 -- the classic argument for rule ordering in conventional rule-based phonology. (c) R4d telescopes two separate, elementary processes R2 and R4a into one complex correspondence. Given R2 and R4a, there is no need for R4b -- if R2 and R4a are allowed to interact in some principled fashion (in this case, consistent with Temporal). Argument here is the flipside of McCarthy's (1993) objection against breaking up functionally related chain shifts into formally distinct rulres (4.9). In this sense, two-level rules are curiously anti-analytical and non-explanatory.

				⇨		⇦	
(4.2)	P2	RRR	☞	a. HHR	b. HRH		Rule 3b
	P4	LLL		a. RRL	b. LRL	☜	Rule 1

(4.3) R3b

R **R**	R1	L
|		|
H		R **L**

(4.4)	P2	⇨	RRR → HRR → HHR = ok
	P4	⇨	LLL → RLL → RRL = *
		⇦	LLL → LRL = ok

(4.5)	a.	FFL			b.	FFL	
		LFF	Dissimilation			FHL	Absorption
		LHL	Absorption			n/a	Dissimilation

(4.6) R4c. F F
|
L

(4.7) F F F
| |
L L F = *

(4.8) R4b. F F = R4d. F F L
|
L H
|
L

(4.9) Hijazi Bedouin Arabic (McCarthy 1993, Orgun 1995, Kirchner 1995)
R1 i → ∅
R2 a → i

One can dispense with the ungainly R4b/d of (4.8) in a three-level model (Goldsmith 1993, Lakoff 1993) by stipulating that R2 is a W:P rule (while all other rules function as M:W constraints), in effect mimicking rule ordering effect (Dissimilating precedes Absorption). This approach is illustrated in (4.10). Objection: there is no indipendent motivation for this level separation: specifically, both R4 and R2 apply indifferently at lexical and phrasal levels (4.11) (Similar objection raised by Padgett 1995).

(4.10) **Three-level rules**

	P7		P1		P3	
M:	F L L		F F L		F F F	
	|	R1	|	R4	|	R4
W:	F R L		L F L		F L F	
			|	R2	|	R2
P:	F R L		L H L		H L F	

(4.11)

	R4 FF → LF	R2 FL → HL
Lexical	*lang fei* 'wasteful'	*jiao shi* 'teacher'
Phrasal	*song xin* 'to deliver a letter'	*diao gui* 'to catch a turtle'

V. Concluding remarks

1. Major argument against serialist derivation: dubious status of intermediate representations as in (5.1b). In a derivational account, the 'theoretical' intermediate step in (5.1a, containing a substring [...LL...]) 'explains' why the third tone /L/ surfaces as [R] (5.1b, [...RR...]), which in turn explains why the second tone /L/ surfaces as [H] (5.1c). But the intermediate form (5.1b) is not attested. Interestingly, such theoretically postulated intermediate forms do occasionally surface, as shown in (5.2b), which survives with an offending RR (in boldface), presumably because the ideally expected (5.2c) involves two successive steps of backtracking.

2. Directionality effect is by no means limited to tonal processes. Directional syllabification/epenthesis (e.g. Itô 1986, 1989) is conventionally reinterpreted as Alignment (Mester-Padgett 1993). But when we juxtapose left-to-right epenthesis with

right-to-left syncope (5.3), we run into an alignment paradox (Tableau 7, based on Davis (1995)). Furthermore, alignment does not always translate directionality effect in a straightforward and intuitively satisfactory way. Thus, the direction of alignment in (3.2a,b) must be reversed if degenerate feet are allowed (cf. Crowhurst-Hewitt 1995).

(5.1)

older-brother smokes 'Zhangdou' (brand) cigarettes
dage chou zhangdou yan
(F L L) (F F L)
(F R L) (L F L)

a.	(F R **L**) (**L** H L)	Dissim Absorption	(p-word)attested
b.	(F **R R** L H L)	Dissim	not attested
c.	(F H R L H L)	Dissim	(p-phrase) attested

(5.2)

telephone emits strange noise
dianhua fachu guai jiao
(F F) (L L) (F F)

a.	(L F) (R **L**) (**L** F)	p-word level	attested
b.	(L F **R R** L R)	p-phrase level (Backtrack-1)	attested
c.	(L R H R L R)	p-phrase level (Backtrack-2)	not attested

(5.3) Cairene Arabic (Davis 1995)
Epenthesis: insert V to satisfy syllabic template (modulo Itô 1986, 1989)
Syncope: unstressed high V → ∅ / CV.C__ .σ

		⇨		⇦
1.	a.	?ult-lu	b.	?ult-lu
		?ul.		.lu
		?ul.t_.		.l_t.lu
	☞	?ul.t_.lu		?u.l_t.lu
		⇨		⇦
2.	a.	ma.bi.yi.zaa.kir<š>	b.	ma.bi.yi.zaa.kir<š>
		mab._yi.zaa.kir<š>		ma.biy._zaa.kir<š> ☜

Tableau 7 Cairene Arabic (Davis 1995)

				OK-σ, *O-O	Fill, Prs-Hi	AlignL	AlignR
/?ult-lu/		a	?ult.lu	*!			
'I said to him'	☞	b	?ul.t_.lu (⇨)		*	0-2-3	2-1-0
		c	?u.l_t.lu (⇦)		*	0-1-3	**3!**-1-0
/ma-bi-yi-zaakir-š/		a	ma.bi.yi.zaa.kirš	*!			
'he doesn't study'		b	mab._yi.zaa.kirš (⇨)		*	0-**2!**-3-5	5-4-2-0
	☞	c	ma.biy._zaa.kirš (⇦)		*	0-1-3-5	6-4-2-0

*O-O: no sequence of two open syllables
OK-σ: core syllable template = CV(V)C

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