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Polish Clitics: Consequences for the Analysis of Optionality in OT*

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1. Variation Pattern

For present purposes, variation (or optionality) can be defined as a situation in which one input corresponds to more than one output. The Polish monoconsonantal proclitic /z/ is involved in two types of variation. Whenever it attaches to a stem that begins with an alveolo-palatal or a postalveolar/retroflex fricative (i.e., [ʑ], [ɕ], [ʐ], or [ʂ]) followed by a vowel, or an alveolo-palatal or a postalveolar affricate (i.e., [d͡ʑ], [t͡ɕ], [d͡ʐ], or [t͡ʂ]), /z/ undergoes optional coronal place assimilation (CPA) (1a). On the other hand, when the stem begins with an alveolo-palatal or a postalveolar fricative followed by a consonant, CPA is blocked and /z/ can optionally surface with an epenthetic vowel (1b).

(1) *Variation pattern of the proclitic /z/*

a. *CPA ~ no CPA*
when the stem begins with {ʑ, ɕ, ʐ, ʂ}V *or* {d͡ʑ, t͡ɕ, d͡ʐ, t͡ʂ}

CPA		*no CPA*	**epenthesis*	
ʑ+ʑɛmi	~	z+ʑɛmi	*zɛ+ʑɛmi	‘from the ground’
ɕ+t͡ɕpʊnɛm	~	s+t͡ɕpʊnɛm	*zɛ+t͡ɕpʊnɛm	‘with a junkie’
ʐ+d͡ʐɛmɛm	~	z+d͡ʐɛmɛm	*zɛ+d͡ʐɛmɛm	‘with jam’
ʂ+ʂɔkʊ	~	s+ʂɔkʊ	*zɛ+ʂɔkʊ	‘from shock’

b. *Epenthesis ~ no CPA*
when the stem begins with {ʑ, ɕ, ʐ, ʂ}C

epenthesis		*no CPA*	**CPA*	
zɛ+ʑrʊdwɑ	~	z+ʑrʊdwɑ	*ʑ+ʑrʊdwɑ	‘from a spring’
zɛ+ɕfitɛm	~	s+ɕfitɛm	*ɕ+ɕfitɛm	‘with dawn’
zɛ+ʐvirʊ	~	z+ʐvirʊ	*ʐ+ʐvirʊ	‘from gravel’
zɛ+ʂpilkɔ̃	~	s+ʂpilkɔ̃	*ʂ+ʂpilkɔ̃	‘with a pin’

In this section I discuss in more detail the behavior of the clitic /z/, and show how the variation pattern in (1b) results from the interaction between two processes: obligatory epenthesis and optional CPA.

1.1 Obligatory processes

Polish has an obligatory process of regressive voicing assimilation that applies to obstruent clusters (e.g., Bethin 1992). The application of this process to the clitic /z/ is illustrated in (2).

(2) *Polish clitic /z/: voicing assimilation*

z+ŋaŋ̃	'with a nanny'	s+kfasɛm	'with acid'
z+bʑikɔva͡tɕ	'to become crazy'	s+plɛɕ͡tɕ	'to entwine together'
z+zɛgarka	'from a watch'	s+sun̄͡tɕ	'to slip down'

In Optimality Theory (OT) (Prince & Smolensky 1993/2004), it can be assumed that assimilation is triggered by the markedness constraint AGREE[voi], which penalizes adjacent obstruents that disagree in [± voice]. Accordingly, obstruents that change their voicing from input to output (in order to satisfy AGREE[voi]) violate the faithfulness constraint IDENT[voi]. Informal definitions of these constraints are provided in (3).

(3) *Informal definitions of constraints responsible for voicing assimilation*

AGREE[voi]	Adjacent obstruents must have the same value for voicing
IDENT[voi]	Correspondent consonants must have the same value for voicing

Voicing assimilation can only be enforced in a language by ranking AGREE[voi] above IDENT[voi], as illustrated in the tableau in (4).

(4) *Voicing assimilation*

/z+kfasɛm/	AGREE[voi]	IDENT[voi]
a. z+kfasɛm	*!	
b. → s+kfasɛm		*

In certain contexts the clitic /z/ surfaces with an epenthetic vowel, as in (5).

(5) *Polish clitic /z/: obligatory vowel epenthesis*
when the stem begins with {z, s}C

/z+zvʲɛʑ̃͡tɕi͡tɕ+ɕɛ̃/ [1]	→	zɛ+zvʲɛʑ̃͡tɕi͡tɕ+ɕɛ̃	'to become animal-like'
/z+znakʲɛm/	→	zɛ+znakʲɛm	'with a sign'
/z+staʑɛ͡tɕ+ɕɛ̃/	→	zɛ+staʑɛ͡tɕ+ɕɛ̃	'to become old'
/z+skawɔ̃/	→	zɛ+skawɔ̃	'with a rock'

It has been observed by many authors (e.g., Steele 1973, Laskowski 1975, Rubach 1977, Bethin 1992, Gussmann 2007) that this vowel insertion is conditioned phonologically. Epenthesis applies whenever /z/ attaches to a stem that begins with a 'similar' segment (i.e., [z] or [s], which differ from the clitic /z/ at most in voicing) followed by another consonant. A straightforward analysis of this pattern (following Baković 2005) is to say that epenthesis applies whenever – due to the independently motivated process of voicing assimilation – the result would otherwise be a sequence of completely identical segments (or geminates) followed by another consonant, as shown in (6).

(6) *Avoidance of identical consonants that begin a cluster: obligatory epenthesis*

/z+znɑkʲɛm/	⇉	*z+znɑkʲɛm	'with a sign'
		zɛ+znɑkʲɛm	
/z+stɑzʲɛt͡ɕ+ɕɛ̃/	⇉	*s+stɑzʲɛt͡ɕ+ɕɛ̃	'to become old'
		zɛ+stɑzʲɛt͡ɕ+ɕɛ̃	

In an OT analysis, three crucial constraints need to interact in order to yield the desired result: DEP(V) (which penalizes vowel epenthesis), NOGEM+C (which is violated by adjacent indentical segments, or geminates, followed by another consonant),[2] and AGREE[voi]. The informal definitions of the first two constraints are provided in (7).

(7) *Informal definitions of constraints responsible for vowel epenthesis*

NOGEM+C	No adjacent identical consonants (geminate) in a cluster
DEP(V)	No vowel epenthesis

The candidate with epenthesis surfaces in order to avoid geminates followed by another consonant that would otherwise arise due to the operation of voicing assimilation, which is independently active in the language. Therefore, DEP(V) is violated in an attempt to jointly satisfy the higher-ranked constraints NOGEM+C and AGREE[voi]. This leads to the following ranking: DEP(V) has to be dominated by both NOGEM+C and AGREE[voi]. The tableaux in (8) illustrate how this ranking yields the correct results. In both cases, the candidates assimilated in voicing (a) are eliminated by NOGEM+C, whereas the candidates that satisfy NOGEM+C by virtue of disagreeing in voicing (b) are eliminated by AGREE[voi]. The candidates with epenthesis (c), which violate DEP(V), surface in this situation as optimal assuring that neither NOGEM+C nor AGREE[voi] are violated.

(8) *Vowel epenthesis*

/z+znɑkʲɛm/	NOGEM+C	AGREE[voi]	DEP(V)
a. [z+znɑkʲɛm]	*!		
b. [s+znɑkʲɛm]		*!	
c. → [zɛ+znɑkʲɛm]			*

/z+stɑzʲɛt͡ɕ/	NOGEM+C	AGREE[voi]	DEP(V)
a. [s+stɑzʲɛt͡ɕ]	*!		
b. [z+stɑzʲɛt͡ɕ]		*!	
c. → [zɛ+stɑzʲɛt͡ɕ]			*

Another ranking is essential for the present analysis. Namely, the faithfulness constraint IDENT[voi] needs to be ranked below DEP(V) so that the candidate with epenthesis is eliminated in contexts where NOGEM+C is not at stake. This is illustrated in the tableaux in (9). Note that the motivation for this ranking comes from the second tableau only, where the clitic /z/ needs to change its underlying voicing in order to satisfy AGREE[voi] (a). In the first tableau, the candidate assimilated in voicing (a) does not violate any of the constraints.

(9) *No epenthesis*

/z+zɛgarkɑ/	NoGem+C	Agree[voi]	Dep(V)	Ident[voi]
a. → [z+zɛgarkɑ]				
b. [s+zɛgarkɑ]		*!		*
c. [zɛ+zɛgarkɑ]			*!	

/z+kfasɛm/	NoGem+C	Agree[voi]	Dep(V)	Ident[voi]
a. → [s+kfasɛm]				*
b. [z+kfasɛm]		*!		
c. [zɛ+kfasɛm]			*!	

Therefore, the complete ranking of constraints required for this analysis is the following: NoGem+C, Agree[voi] >> Dep(V) >> Ident[voi].

1.2 Optional processes

Polish has an optional process of regressive coronal place assimilation (CPA) (e.g., Rowicka 1994), which requires that adjacent coronal consonants agree in subcoronal place of articulation (i.e., the feature(s) distinguishing alveolars, alveolo-palatals, and postalveolars; henceforth [Cor-place] or simply [Cor]).[3] The examples in (10) show the application of CPA to the clitic /z/.

(10) *Polish clitic /z/: optional CPA*

z+d͡ʑivit͡ɕ	~	ʑ+d͡ʑivit͡ɕ	'to surprise'
s+ɕanɛm	~	ɕ+ɕanɛm	'with hay'
z+ʐɑbɔ̃	~	ʐ+ʐɑbɔ̃	'with a frog'
s+t͡ʂkɑfki	~	ʂ+t͡ʂkɑfki	'from hiccups'

In certain contexts vowel epenthesis applies to the clitic /z/ optionally (Rubach 1977: 119), and CPA is always blocked, as shown in (11). This happens whenever /z/ attaches to a word that begins with an alveolo-palatal or a postalveolar segment followed by another consonant.

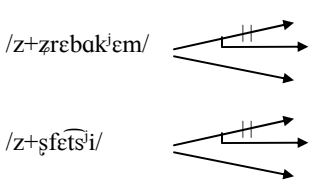
(11) *Optional epenthesis*
when the stem begins with {ʑ, ɕ, ʐ, ʂ}C

/z+ʑrɛbɑkʲɛm/	→	z+ʑrɛbɑkʲɛm	~	zɛ+ʑrɛbɑkʲɛm	'with a colt'
/z+ɕfʲɑtɛm/	→	s+ɕfʲɑtɛm	~	zɛ+ɕfʲɑtɛm	'with the world'
/z+ʐvirʊ/	→	z+ʐvirʊ	~	zɛ+ʐvirʊ	'from gravel'
/z+ʂfɛt͡sʲi/	→	s+ʂfɛt͡sʲi	~	zɛ+ʂfɛt͡sʲi	'from Sweden'

This pattern can be accounted for by building on Baković's (2005) work on other languages. Note that the input forms in (11) should be in principle able to undergo CPA. Being optional, CPA can either apply (12a) or not (12c). Crucially, however, if it applies (together with obligatory voicing assimilation), the result is a sequence of two identical segments followed by another consonant. As discussed in §1.1, such sequences are strictly forbidden in Polish and are obligatorily repaired by vowel epenthesis (12b). That is, epenthesis in (11) is not optional, but crucially *contingent* on the optionality of CPA (Baković

& Pająk 2008). Epenthesis applies obligatorily whenever – due to the independently motivated processes of CPA and voicing assimilation – the result would otherwise be a sequence of a geminate that begins a cluster. The form not assimilated in coronal place, on the other hand, does not contain disallowed sequences, and thus remains available as another option.

(12) *Avoidance of identical consonants that begin a cluster: optional CPA*



In my OT analysis I assume that CPA is triggered by the markedness constraint AGREE[cor], which penalizes sequences of coronal stridents that do not agree in subcoronal place of articulation. Underlying coronal segments that surface with a different place of articulation violate the faithfulness constraint IDENT[cor]. Note that this constraint is violated when a coronal segment changes its place to either another coronal (e.g., alveolar to alveolo-palatal) or a non-coronal (e.g., alveolar to dorsal). That is, IDENT[cor] requires that a coronal in the input remain the same type of coronal in the output. Informal definitions of these constraints are shown in (13).

(13) *Informal definitions of constraints responsible for CPA*

AGREE[cor]	Adjacent coronal consonants must have the same value for subcoronal place of articulation
IDENT[cor]	Correspondent consonants must have the same value for subcoronal place of articulation

In §2 I discuss possible ways in which the complete variation pattern of the clitic /z/ can be accounted for in OT.[4]

2. Accounting for Optionality

2.1 Ranking paradox

A common way of accounting for optionality in OT is by using the concept of 'ties' (see Müller 1999 for a review of different approaches to optionality in OT). Under this approach, two (or more) candidates can surface as optimal when the constraints that distinguish between them are tied, that is, crucially unranked with respect to each other.

Recall from §1.2 that the clitic /z/ is involved in two types of variation, as shown in (14).

(14) *Variation pattern of the proclitic /z/*

CPA		*no CPA*	**epenthesis*	
z̬+d͡z̬ɛmɛm	~	z+d͡z̬ɛmɛm	*zɛ+d͡z̬ɛmɛm	'with jam'
epenthesis		*no CPA*	**CPA*	
zɛ+ʑrʊdwɑ	~	z+ʑrʊdwɑ	*ʑ+ʑrʊdwɑ	'from a spring'

Applying ties to this variation pattern leads to a ranking paradox. Consider first the tableaux in (15). In order to account for the variation between the 'CPA' and 'no CPA' forms, the constraints AGREE[cor] and IDENT[cor] need to be tied (i). Note that DEP(V) must be ranked higher so that the candidate with epenthesis (i-c) is eliminated. However, this arrangement of constraints predicts only one optimal candidate in the second type of variation (between the 'epenthesis' and 'no CPA' forms) (ii). Crucially, the candidate with epenthesis in (ii-c) is eliminated due to the ranking DEP(V) >> AGREE[cor].

(15) *Tie between AGREE[cor] and IDENT[cor]*

i. *CPA ~ no CPA*

/z+d͡z̬ɛmɛm/	NOGEM+C	DEP(V)	AGREE[cor]	IDENT[cor]
a. → [z+d͡z̬ɛmɛm]			*	
b. → [ʒ+d͡z̬ɛmɛm]				*
c. [zɛ+d͡z̬ɛmɛm]		*!		

ii. *Epenthesis ~ no CPA*

/z+ʑrʊdwɑ/	NOGEM+C	DEP(V)	AGREE[cor]	IDENT[cor]
a. → [z+ʑrʊdwɑ]			*	
b. [ʑ+ʑrʊdwɑ]	*!			*
c. !!! [zɛ+ʑrʊdwɑ]		*!		

This problem might be thought to be solvable by assuming that the constraints DEP(V) and AGREE[cor] are also tied, as in the tableaux in (16). Now, two optimal candidates are correctly predicted for the second type of variation (ii). However, this solution leads to an incorrect result in the first tableau (i), where the candidate with epenthesis is now predicted as a possible option, when in fact it should be eliminated.

(16) *Tie between DEP(V) and AGREE[cor]*

i. *CPA ~ no CPA*

/z+d͡z̬ɛmɛm/	NOGEM+C	DEP(V)	AGREE[cor]	IDENT[cor]
a. → [z+d͡z̬ɛmɛm]			*	
b. → [z̬+d͡z̬ɛmɛm]				*
c.!!!→ [zɛ+d͡z̬ɛmɛm]		*		

ii. *Epenthesis ~ no CPA*

/z+ʐrʊdwɑ/	NoGem+C	Dep(V)	Agree[cor]	Ident[cor]
a. → [z+ʑrʊdwɑ]			*	
b. [ʑ+ʑrʊdwɑ]	*!			*
c. → [zɛ+ʐrʊdwɑ]		*		

Therefore, the tied-constraint approach induces a paradox because the constraints Dep(V) and Agree[cor] must be simultaneously ranked and crucially unranked with respect to each other in order to account for the two types of variation.

2.2 Partially Ordered Grammars (POG)

More complex models can be employed to account for variation in OT. The model of POG (Anttila 1997, 2002) allows for the constraints to be crucially unranked with respect to each other. The basic claim is that a grammar can be defined as a set of ordered pairs of constraints. Variation arises within grammars whose constraints are only partially ordered (unless the unordered constraints do not interact).

In order to account for the variation pattern of the clitic /z/, it could be first assumed that there is no order between the three crucial constraints, Dep(V), Agree[cor], and Ident[cor] (assuming that the constraint NoGem+C is always higher-ranked). As shown in (17), this would yield six possible rankings, each selecting different output forms for the two variation types. However, this grammar needs to be restricted in order to disallow unattested outputs (circled).

(17) *No ordered pairs and the predicted outputs of the clitic /z/*

Ranking	Input-Output Mapping	
	/z+d͡ʒɛmɛm/	/z+ʐrʊdwɑ/
i. Dep(V) >> Agree[c] >> Ident[c]	CPA	no CPA
ii. Dep(V) >> Ident[c] >> Agree[c]	no CPA	no CPA
iii. Agree[c] >> Dep(V) >> Ident[c]	CPA	epenthesis
iv. Ident[c] >> Dep(V) >> Agree[c]	no CPA	no CPA
v. Agree[c] >> Ident[c] >> Dep(V)	epenthesis	epenthesis
vi. Ident[c] >> Agree[c] >> Dep(V)	epenthesis	epenthesis

There is one ordered pair of constraints that, if added to the grammar, eliminates the unattested outputs and predicts all the attested forms: Dep(V) >> Ident[cor]. As shown in (18), adding this ordered pair reduces the number of possible rankings to three, and yields outputs that are all attested in Polish. The tableaux with the three rankings and their corresponding outputs are provided in (19). Therefore, POG correctly captures the data under discussion.

(18) *A partially ordered grammar and the correctly predicted outputs of the clitic /z/*

Ordered pair: DEP(V) >> IDENT[cor]	INPUT-OUTPUT MAPPING	
RANKING	/z+d͡ʒɛmɛm/	/z+ʐrʊdwɑ/
i. DEP(V) >> AGREE[c] >> IDENT[c]	CPA	no CPA
ii. DEP(V) >> IDENT[c] >> AGREE[c]	no CPA	no CPA
iii. AGREE[c] >> DEP(V) >> IDENT[c]	CPA	epenthesis

(19) *Three possible rankings and their outputs*

i. DEP(V) >> AGREE[cor] >> IDENT[cor]

/z+d͡ʑɛmɛm/	NOGEM+C	DEP(V)	AGREE[cor]	IDENT[cor]
a. [z+d͡ʑɛmɛm]			*!	
b. → [ʑ+d͡ʑɛmɛm]				*
c. [zɛ+d͡ʑɛmɛm]		*!		

/z+ʐrʊdwɑ/	NOGEM+C	DEP(V)	AGREE[cor]	IDENT[cor]
a. → [z+ʐrʊdwɑ]			*	
b. [ʐ+ʐrʊdwɑ]	*!			*
c. [zɛ+ʐrʊdwɑ]		*!		

ii. DEP(V) >> IDENT[cor] >> AGREE[cor]

/z+d͡ʑɛmɛm/	NOGEM+C	DEP(V)	IDENT[cor]	AGREE[cor]
a. → [z+d͡ʑɛmɛm]				*
b. [ʑ+d͡ʑɛmɛm]			*!	
c. [zɛ+d͡ʑɛmɛm]		*!		

/z+ʐrʊdwɑ/	NOGEM+C	DEP(V)	IDENT[cor]	AGREE[cor]
a. → [z+ʐrʊdwɑ]				*
b. [ʐ+ʐrʊdwɑ]	*!		*	
c. [zɛ+ʐrʊdwɑ]		*!		

iii. AGREE[cor] >> DEP(V) >> IDENT[cor]

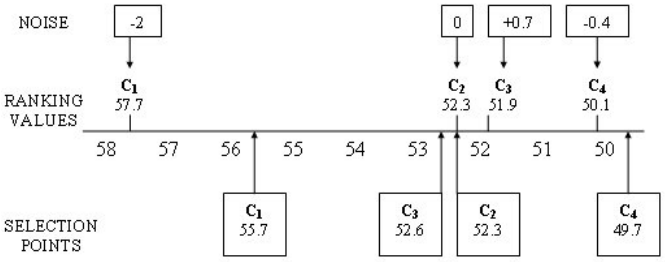
/z+d͡ʑɛmɛm/	NOGEM+C	AGREE[cor]	DEP(V)	IDENT[cor]
a. [z+d͡ʑɛmɛm]		*!		
b. → [ʑ+d͡ʑɛmɛm]				*
c. [zɛ+d͡ʑɛmɛm]			*!	

/z+ʐrʊdwɑ/	NOGEM+C	AGREE[cor]	DEP(V)	IDENT[cor]
a. [z+ʐrʊdwɑ]		*!		
b. [ʐ+ʐrʊdwɑ]	*!			*
c. → [zɛ+ʐrʊdwɑ]			*	

2.3 Stochastic OT

Another model that can account for variation is Stochastic OT (Boersma 1998, Boersma and Hayes 2001). In this model it is assumed that all the constraints are situated on a continuum, and each constraint is associated with a fixed numeric value ('ranking value'), as shown in (20). The numbers are completely arbitrary; what is important is the relative distance between the constraints. In each speaking event, a so called 'stochastic candidate evaluation' takes place. At the moment of this evaluation some 'noise' is temporarily added to the ranking value of each constraint. 'Noise' is just a random numeric value that is normally distributed with mean zero (i.e., zero is the most probable value of noise). The result of adding noise to the ranking values is called 'selection points.' Selection points determine the ranking of constraints used in a particular speaking event.

(20) *Continuous ranking scale and stochastic candidate evaluation*



Note that if the constraints are close to each other on the continuum, as the constraints C_2 and C_3 are in (20), then even a small amount of noise may reverse their original ranking. Such changes in the ranking of constraints constitute the source of variation in Stochastic OT.

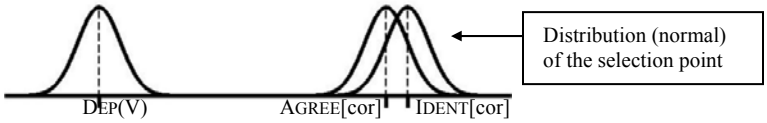
In order to account for the variation pattern of the Polish clitic /z/, the constraints used in the analysis must be arranged on the continuum in a very particular way. Note that for each type of variation there are two different conditions on the constraint ranking. For the variation between the 'CPA' and 'no CPA' forms (as shown in (14)), DEP(V) must dominate either IDENT[cor] or AGREE[cor] (21a-i), so that the candidate with epenthesis is always eliminated. Additionally, AGREE[cor] and IDENT[cor] need to overlap significantly (21a-ii) to enable the optional application of CPA. That is, they must be sufficiently close to each other on the continuous ranking scale to allow for their variable ranking from one speaking event to another due to the application of noise. This is illustrated in (21a). Each constraint is associated with a distribution of selection points, which determine its position in the ranking. Due to the fact that the distributions of AGREE[cor] and IDENT[cor] overlap, either of these constraints might precede the other in a given speaking event.

There are two different conditions that need to be fulfilled in order to account for the variation between the 'epenthesis' and 'no CPA' forms. NOGEM+C must be ranked higher than DEP(V) (21b-i), so that the candidates with a geminate in a cluster can be repaired by vowel epenthesis. Moreover, there needs to be a significant overlap between DEP(V) and AGREE[cor] (21b-ii) in order to enable the variation. This is shown in (21b). Again, since the distributions of DEP(V) and AGREE[cor] overlap, the ranking between these constraints varies from one speaking event to another.

(21) *Conditions on the arrangement of constraints*

a. *CPA ~ no CPA*

Conditions: (i) DEP(V) >> IDENT[cor] / AGREE[cor]
(ii) AGREE[cor] ~ IDENT[cor]



b. *Epenthesis ~ no CPA*

Conditions: (i) NOGEM+C >> DEP(V)
(ii) DEP(V) ~ AGREE[cor]

When the conditions for both types of variation are considered together, as shown in (22), it follows that AGREE[cor] has to overlap with both DEP(V) and IDENT[cor] (22a), but, crucially, DEP(V) and IDENT[cor] cannot overlap (22b).

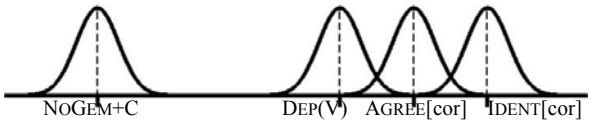
(22) *Conditions on the arrangement of constraints*

a. AGREE[cor] ~ IDENT[cor] (22a-ii)
AGREE[cor] ~ DEP(V) (22b-ii)

b. DEP(V) >> IDENT[cor] / AGREE[cor] (22a-ii)
DEP(V) ~ AGREE[cor] (22b-ii)
} DEP(V) >> IDENT[cor]

This can only be achieved by arranging the constraints in the way illustrated in (23). The three critical constraints, DEP(V), AGREE[cor] and IDENT[cor], must be placed sufficiently close to each other to allow for the required overlaps between AGREE[cor] and DEP(V), and between AGREE[cor] and IDENT[cor], but at the same time sufficiently far apart to minimize the overlap between DEP(V) and IDENT[cor].

(23) *Arrangement of constraints on the continuous ranking scale*



Arranging the constraints as in (23) results in three possible rankings, shown in (24) (the higher-ranked constraint NoGem+C is omitted). The ranking in (24a) is chosen whenever the value of noise is relatively small, and the original order of constraints is preserved. In cases when noise is larger and the selection points of both Agree[cor] and Dep(V), or Agree[cor] and Ident[cor] fall within their overlap region, there is a chance of their switching places, which in turn results in using the ranking in (24b) (when Agree[cor] and Ident[cor] change places) or in (24c) (when Agree[cor] and Dep(V) change places).

(24) *Three possible rankings and the correctly predicted outputs of the clitic /z/*

Ranking	Input-Output Mapping	
	/z+d͡ʒɛmɛm/	/z+ʐrʊdwa/
a. Dep(V) >> Agree[c] >> Ident[c]	CPA	no CPA
b. Dep(V) >> Ident[c] >> Agree[c]	no CPA	no CPA
c. Agree[c] >> Dep(V) >> Ident[c]	CPA	epenthesis

Note that the three rankings in (24) are exactly the rankings predicted by POG, as discussed in §2.2. Therefore, similarly to POG, Stochastic OT resolves the ranking paradox induced by the tied-constraint approach, and correctly accounts for the data under discussion.

3. Predicting Probabilities

In addition to accounting for variation, both POG and Stochastic OT are claimed to predict the probabilities of the varying forms. In this section I show that this claim is in fact problematic.

In POG, the probability of a given candidate is equal to the number of tableux in which this candidate wins divided by the total number of possible tableaux (i.e., total rankings consistent with specified ordered pairs). This means that the predicted probabilities are sensitive to the exact number of intervening constraints (a problem originally noted by Smolensky 2007). Since the complete set of constraints is far from being well-understood, I simply assume that POG cannot at this point make any conclusive predictions regarding the probabilities of the varying forms.[5]

Stochastic OT can account for variation due to the assumption that random 'noise' interferes with the constraint ranking. However, not all values of noise are equally probable. Rather, the assumption is that noise is normally distributed with mean zero, which means that most of the time the value of noise falls exactly on zero or within a close range around zero. As a consequence, selection points generally oscillate around the ranking values of each constraint, and therefore, the ranking that arranges the constraints exactly according to their ranking values has the highest probability of being used.

As discussed in §2.3, in order to account for the variation pattern of the Polish proclitic /z/, the crucial constraints have to be arranged on the continuous

ranking scale in a particular order, as in (23). Since the overlap between the constraints is very small, clearly the ranking with the highest probability is just the one consistent with the order of the constraints, as in (25a). Yet, since there is some overlap between some of the constraints, there are two other relevant rankings with lower probability, where AGREE[cor] switches places with either IDENT[cor] (25b) or DEP(V) (25c).

(25) *Probabilities of the rankings and their predicted outputs*

RANKING	INPUT-OUTPUT MAPPING /z+d͡ʒɛmɛm/	/z+ʐrʊdwɑ/
Ranking with the highest probability		
a. DEP(V) >> AGREE[c] >> IDENT[c]	CPA	no CPA
Rankings with lower probability		
b. DEP(V) >> IDENT[c] >> AGREE[c]	no CPA	no CPA
c. AGREE[c] >> DEP(V) >> IDENT[c]	CPA	epenthesis

Since rankings are associated with certain probabilities, it is possible to estimate the probabilities of the outputs they select as optimal. In the ranking in (25a), the winning outputs are [ʑ+d͡ʑɛmɛm] (CPA) and [z+ʐrʊdwɑ] (no CPA). Therefore, these are the forms that are predicted to be the most frequent in the language. Note that this claim is made even stronger by the fact that one of the rankings with lower probability also selects these outputs as optimal.

More precise predictions regarding the probabilities can also be made by using the Gradual Learning Algorithm (GLA) (Boersma 1998, Boersma & Hayes 2001) as implemented in OTSoft (Hayes, Tesar & Zuraw 2003). When provided with the data that simply specify the optimal outputs (without making any reference to their actual frequencies), the GLA learns the pattern and returns the predicted probability of each output form. The result of this learning problem is shown in (26). As can be seen, the forms [ʑ+d͡ʑɛmɛm] and [z+ʐrʊdwɑ] are indeed predicted to have the highest probabilities of occurrence.[6] However, a comparison with the actual relative frequencies of these forms (in (27)) reveals that this prediction is incorrect. In reality, the forms [z+d͡ʑɛmɛm] (no CPA) and [zɛ+ʐrʊdwɑ] (epenthesis) are the most frequent ones.[7]

(26) *Mean probabilities predicted by GLA (computed over 30 runs)*

/z+d͡ʑɛmɛm/		/z+ʐrʊdwɑ/	
output	*mean probability*	*output*	*mean probability*
ʑ+d͡ʑɛmɛm (CPA)	**0.50** *sd=.048*	**z+ʐrʊdwɑ (no CPA)**	**0.65** *sd=.046*
z+d͡ʑɛmɛm (no CPA)	0.34 *sd=.046*	zɛ+ʐrʊdwɑ (epenthesis)	0.35 *sd=.046*
*zɛ+d͡ʑɛmɛm (epenthesis)	0.16 *sd=.029*	*ʐ+ʐrʊdwɑ (CPA)	0.00 *sd=.000*

(27) *Actual relative frequencies*

/z+d͡ʑɛmɛm/		/z+ʐrʊdwɑ/	
output	*frequency*	*output*	*frequency*
ʑ+d͡ʑɛmɛm (CPA)	36%	z+ʐrʊdwɑ (no CPA)	1%
z+d͡ʑɛmɛm (no CPA)	**64%**	**zɛ+ʐrʊdwɑ (epenthesis)**	**99%**

In conclusion, while Stochastic OT seems to be able to predict the correct output forms in the variation pattern of the clitic /z/ (even disregarding the GLA's difficulty in assigning zero probability to the epenthetic candidate in the first type of variation), it clearly fails to predict the correct probabilities of the varying forms. The problem cannot be easily solved because it impinges on the fact that epenthesis must be eliminated in one context, but remain optimal in another context.

There are two possible reactions to this result that I plan to explore in future research. The first is to abandon the claim that grammar is in fact responsible for predicting the absolute probabilities of the varying forms. This has already been suggested by Coetzee (2004), who claims that grammar only dictates which variant is more probable than another, but does not calculate the exact proportion in which they should occur in the language. However, even this moderated claim does not solve the problem of predicting the probabilities of the variants of the clitic /z/ because the predicted proportions are the opposite of what is actually observed in the language. Therefore, one would have to take a more radical step by saying that grammar only predicts possible output forms, but does not say anything about their probabilities, which are determined by extragrammatical factors (e.g., morpheme perceptibility; an idea originally due to Matt Goldrick, p.c.).

Another reaction is to assume that the analysis itself is deficient in some way. In fact, the problem can be solved by adding just one constraint to the analysis. The ranking paradox is avoided if there is some additional constraint X that is violated by the 'no CPA' candidate in the 'epenthesis' ~ 'no CPA' variation, but, crucially, it is not violated by the 'no CPA' candidate in the 'CPA' ~ 'no CPA' variation.[8] In this way each type of variation is accounted for by a separate pair of overlapping constraints: IDENT[cor] ~ AGREE[cor], and X ~ DEP(V).[9] I leave for further research determining whether there is in fact independent motivation for such a constraint in the language.

4. Conclusion

In this paper I discussed a unique variation pattern of vowel epenthesis in the Polish proclitic /z/, which relies on the interaction between obligatory and optional processes. While on the surface vowel epenthesis might seem to be optional in some contexts, I argued that it is in fact always obligatory, and its apparent optionality arises from it being contingent on the optionality of another process. Furthermore, I discussed different approaches to optionality and concluded that POG and Stochastic OT are able to capture the data correctly, but they cannot predict the correct probabilities of the varying forms. I outlined the implications of this result that might be explored in future research.

Notes

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[1] Here and throughout the paper the forms enclosed in slashes are simplified underlying representations in that they only reliably show the underlying forms of segments that are relevant for discussion.

[2] For more elaboration on the definition of this constraint see Pająk (2008).

[3] I adopt the term coronal place assimilation (CPA) to describe assimilatory processes that affect coronal clusters. In previous literature the same processes have also been referred to as 'palatal assimilation' (e.g., Rowicka 1994) or 'strident assimilation' (e.g., Rubach 1984).

[4] See Baković & Pająk (2008) for a discussion on how this pattern is problematic for a rule-based analysis.

[5] See Pająk (2008) for a more elaborate discussion on how POG makes inconsistent predictions in this respect.

[6] Note that the GLA also gives some probability to the unattested form *[zɛ+d͡ʒ̬ɛmɛm] (as shown in (26)), even though the data submitted to the program did not allow it as a possible output. The result does not improve with increasing the number of learning trials (e.g., from 1,000,000 to 4,000,000). This problem is due to the necessary proximity of the constraints DEP(V) and IDENT[cor] on the ranking scale, which allows them to switch places (though relatively rarely).

[7] The relative frequencies of the 'CPA' and 'no CPA' forms are based on a production study by Osowicka-Kondratowicz (2004) on 90 subjects. In general, non-application of CPA was found more common than its application. The clitic /z/ (9 tokens) underwent CPA with an average frequency of 36%. The relative frequencies of the 'epenthesis' and 'no epenthesis' forms are based on a search through a written corpus, the IPI PAN Corpus of Polish (available at http://korpus.pl), containing over 250 million words and about 44,000 occurrences of the clitic /z/ in the context that triggers optional epenthesis, of which the non-epenthetic forms constitute less than 1%. Note that this proportion might be different in spoken language. However, the magnitude of the obtained result suggests that the frequency of the epenthetic form in speech is still higher than the frequency of the non-epenthetic form. This is confirmed by consultations with native speakers of Polish, who generally show higher preference for the form with epenthesis. While the exact frequencies might not be accurate, the arguments presented in this section rely on the *relative* frequencies of the forms. That is, they point to the fact that the epenthetic form of the clitic is always more frequent than the non-epenthetic form. Therefore, the same would be true if the actual frequencies were, for instance, 60% (epenthesis) and 40% (no epenthesis).

[8] I am indebted to Lucien Carroll (p.c.) for this idea.

[9] In Pająk (2008) I show in more detail how adding such a constraint solves the ranking paradox, and discuss a possible definition of the constraint X.

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