Bidirectional OT in morphology

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Classical OT, in particular Correspondence Theory, considers output candidates in relation to a given input, and thus aims at an optimization of expression. The reverse perspective is likewise possible; optimality theoretic semantics (Hendriks & de Hoop 1999) considers interpretation candidates for a given form, and thus aims at an optimization of interpretation.

Optimization I:	What is the optimal form (expression) for a given meaning? Some expressions for a given meaning are blocked.
Optimization II:	What is the optimal interpretation of a given form? Some interpretations of a given form are blocked.

Blutner (1999) proposed to integrate these two perspectives into one framework, considering pairs <f,m> of form and meaning as candidates for the evaluation. Jäger (2000) developed an algorithm for recursive evaluation of pairs, which requires that the ordering relation (induced by the constraint ranking) on the set of candidates is well-founded. <f,m> is optimal if there are no <f',m> and no <f,m'> that are better than <f,m>. This implies that in a tableau such as (1) for each pairing of a row and a column only one optimal pair can exist.

(1)

	m_1	m_2	m_3	...	m_k
f_1	☝	.	.		.
f_2	.	☝	.		.
f_3	.	.	☝		.
...					
$f_{k.}$	.	.	.		☝

The recursion starts with an optimal pair that involves the least number of relevant violations, henceforth called 'superoptimal'. All other members of the same row, as well as all other members of the same column, are no further candidates, so that the remaining table is reduced by one row and one column. Under the condition of *one* optimal pair in each of the evaluations, both ambiguity (where one form covers two meanings) and synonymy (where two forms have the same meaning) are excluded.

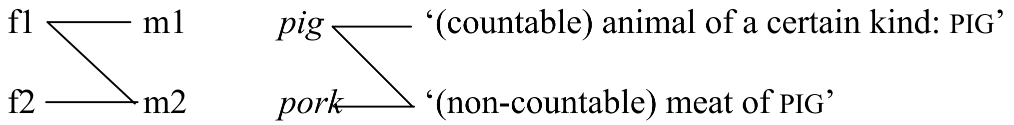
All individual evaluations are classical. Each pair is evaluated independently from information on others pairs. Besides faithfulness constraints, mapping meaning and form on each other, and surface constraints (such as markedness and alignment), comparing individual forms, bidirectional OT also allows to include constraints that relate meanings with each other (e.g. that anaphoric binding is preferred). Global constraints considering more than one pair at once cannot be incorporated. However, more global evaluation is sometimes desirable (e.g., for paradigm evaluation, see section 2); in such a case, one may consider more than one optimal pair at a higher level of evaluation ('supervaluation').

Theoretically, it is possible that two pairs of the same row or the same column are equally good. I have no information whether under these circumstances the general problem is decidable.

In the following, I first introduce a notation by which the challenging new spirit of bidirectional OT can be illustrated for discussion. In section 2, I discuss a case of paradigmatic syncretism, which varies cross-dialectally, and therefore calls for a more global consideration. Section 3 deals with an asymmetry in the Quechua subject-object paradigm; here, bidirectional OT sheds new light on some fundamental differences in the several harmonic alignment accounts of morphological asymmetries discussed in the literature. Section 4 illustrates how the notion of superoptimal pair can serve to predict preferences between pairs (such as active-passive) that are not in the same classical evaluation.

1. ‘Synonymengabel’

The workings of bidirectional OT can best be illustrated by the well-known ‘Synonymengabel’. It is exemplified by the English nouns *pig* vs. *pork* in sentences such as (3).

(2)


(3) a. A pig/*pork ran on the street.
b. I don’t eat pig/pork.

In this case, there exist three pairs, exhibiting both ambiguity and synonymy. f1 is ambiguous; and f1, f2 are synonyms with respect to m2. For the sake of illustration, I will use the format suggested by Dekker & van Rooy (2000), with the candidate pairs being the cells of a two-dimensional space. A fourth cell <f2,m1> is added here for completeness.

(4)

	m1	m2
f1	○	○
f2	○	○

Let us assume that *pork* is more specific than *pig* in expressing ‘meat of PIG’, hence, it is optimal in this respect. This is expressed in (5a) with an arrow indicating the preferred pair. All competing cells are, then, crossed out, as shown in (5b). The only remaining cell, itself not being dispreferred, is then optimal, too. Thus, under the given assumptions, two optimal forms remain, so that the ‘Synonymengabel’ disappears.

(5) a.

	m1	m2
f1	○	○
		↓
f2	○	❶

b.

	m1	m2
f1	○	⊗
f2	⊗	☝

c.

	m1	m2
f1	☝	
f2		☝

In addition, one might assume that the shortest form is preferred. Then the same result obtains, although here, <f1,m1> is the superoptimal pair.

(6)

	m1		m2			m1	m2
f1	❶		○		f1	☝	
	↑		↑↓				
f2	○		○		f2		☝

One could also assume that countable concepts are more natural than mass concepts. Under this assumption there will be little chance that a mass noun such as *pork* appears, because all cells with m2 are dispreferred. However, together with the assumption of specificity (*pig* is more specific than *pork* in expressing animal beings, and *pork* is more specific than *pig* in expressing meat), again, the same result obtains as above.

(7)

	m1		m2			m1	m2
f1	❶	←	○		f1	☝	
			↓				
f2	○	←	○		f2		☝

If we had a situation such as (8), no decision can be made; such a circular situation is not well-founded.

(8)

	m1		m2		*!
f1	○	→	○		
	↑		↓		
f2	○	←	○		

In a situation such as (9), three pairs are equally good, so that the ‘Synonymengabel’ will remain.

(9)

	m1		m2			m1	m2
f1	○	↔	○		f1	☝	☝
	↑	↗	↑↓				
f2	○	→	○		f2		☝

Finally, we can sketch the scenario under which only *pig* survives as an ambiguous item.

(10)

	m1		m2			m1	m2
f1	○	↔	○		f1	☝	☝
	↑		↑				
f2	○		○		f2		

(10) also illustrates the situation of ambiguity to which we turn now.

2. Paradigmatic syncretism

Paradigmatic syncretism puts a problem for birectional OT if only *one* optimal pair were allowed. The advantage of bidirectional OT to include also preferences among meanings often cannot be taken because meaning preferences do not always exist in morphological paradigms. The more interesting question in what sense paradigms may suffer from syncretism can only be answered if one pursues evaluation on a higher level.

In order to express plurality of either subject or object, Cajamarca Quechua has only one plural morpheme, *-llapa*, while Cuzco Quechua has two, *-ku* and *-chis* (where the latter only applies if a 2nd person precedes). They are distributed in the subdialects of Cuzco in various ways. I only consider here suffix sequences for 2/1 settings (expressed by verb forms such as *rika-wa-nki-chis* 'you (pl) see me'), where *-wa* signals 1st person object, and *-nki* 2nd person (Lakämper 2000).

(11)

	a. Cajamarca	b. Cuzco 2	c. Cuzco 3 & 4	d. Cuzco 1
m1: 2pl/1	-wa-nki-llapa	-wa-nki-chis	-wa-nki-chis	-wa-nki-chis
m2: 2pl/1pl	-wa-nki-llapa	-wa-nki-ku	-wa-nki-chis	-wa-nki-chis-ku
m3: 2/1pl	-wa-nki-llapa	-wa-nki-ku	-wa-nki-ku	-wa-nki-ku

Note that all these dialects except Cuzco 1 are subject to a *PL-PL constraint that forbids more than one plural morpheme. As Lakämper has shown, in considering also the other pl/pl settings of the input, it is the person higher on the hierarchy 1 > 2 > 3 that is preferably marked for plural in Cuzco 2, while it is the more specific plural morpheme (*-chis*) that is preferably applied in Cuzco 3, and even more complex conditions hold in Cuzco 4.

(12)

	a. Cajamarca	b. Cuzco 2		c. Cuzco 3		d. Cuzco 1		
	-llapa	chis	ku	chis	ku	chis	ku	chis-ku
m1	○	○ ←		○ ←		○ ←		
m2	○		↔ ○	○ ←				→ ○
m3	○		○		○		○	

Bidirectional OT, but as well the classical input-output account, can explain why there is a 1:1 mapping between meaning and form in Cuzco 1. Bidirectional OT can also explain why the choice of *-chis* (which is more specific than *-ku*) blocks *-ku* in Cuzco 2. In Cuzco 3, however, the first two pairs with *-chis* are equally better than *-ku*, so that some syncretism remains in the two most optimal pairs. Here, the same result can easily be attained in the classical account, too. By contrast, no relevant competition of forms arises in Cajamarca; *-llapa-llapa* is blocked here because of haplology.

None of these approaches accounts for the intuitive observation that Cajamarca suffers most from syncretism, while Cuzco 1 is the best system in this regard, however, for the price of more morphemes and more articulated forms. The three-fold ambiguity in Cajamarca is reduced to a two-fold ambiguity in both Cuzco 2 and 3. Only in a higher-level evaluation one can determine whether some of the systems are better than others. Let us assume the constraints in (13).

(13) a. *PL-PL. At most one plural morpheme applies. (Syntagmatic economy)
b. NOSYNCR. Avoid syncretism in a paradigm. (Distinctivity)
c. MINMORPH. Minimize the number of morphemes. (Lexical economy)

With these constraints one can evaluate the given paradigmatic systems as follows. One can see that each of the systems suffers from two violations of a lower-ranked constraint, so that they all are equally imperfect.

(14) Paradigm evaluation

a.	Cajamarca:	*PL-PL, MINMORPH	»	NOSYNCR
				**
b.	Cuzco 2/3:	*PL-PL	»	MINMORPH, NOSYNCR
				* *
d.	Cuzco 1:	NOSYNCR	»	MINMORPH, *PL-PL
				* *

3. The asymmetry of subject and object

My central point here is that bidirectional OT also sheds new light on the conceptual nature of the hierarchies assumed by Aissen (1999) and Bresnan et al. (2001) on the one hand, and by Stiebels (2000) and Wunderlich (2001) on the other. Aissen and Bresnan claim that the ordering subject > object is basic, while Stiebels and Wunderlich argue for the opposite, more precisely, for the ordering [+hr] > [+lr] (where +hr is an object feature, and +lr is a subject feature). I will claim here that these two perspectives can be integrated in bidirectional OT. The subject outranks the object semantically (and, possibly, also syntactically), while the object outranks the subject morphologically.

The example to be discussed concerns the Object-Subject-Constraint proposed in Lakämper & Wunderlich (1998) in order to account for certain morphological asymmetries in Quechua. Obviously, this constraint, as it is originally stated, is not an elementary constraint.

(15) Subject-Object Constraint. The object may be marked separately from the subject only if it refers to a person that is higher on the hierarchy of person than the person to which the subject refers. Hierarchy of person: 1 > 2 > 3.

The following table shows the singular forms of transitive verbs in Ayacucho Quechua, together with some additional forms that are blocked. 'O' is short for the accusative feature [+hr].

(16)

		ni	nki	n	yki	wa-n	wa-nki	su-nki	su-ni	su-n
		1	2	3	1/2	1O-3	1O-2	O-2	O-1	O-3
direct	m1: 1/3	☝								
	m2: 2/3		☝							
	m3: 3/3			☝						
	m4 : 1/2				☝					
inverse	m5: 3/1					☝				
	m6: 2/1						☝			
	m7: 3/2							☝		

The first four settings (m1 to m4) are called 'direct', while the remaining settings (m5 to m7) are called 'inverse'. Note that the direct settings are paired with single morphemes, while the inverse settings are paired with morpheme-combinations. This fact gives us the key to a proper understanding of the distribution of forms.

Let us assume the person hierarchy in (17a). One way to implement this hierarchy is the ordering of Max-Constraints shown in (17b). Besides being faithful to the person features, it is also necessary to preserve the association between person and role, which is expressed by the identity constraint in (17c).

(17) a. Person hierarchy: 1 > 2 > 3
b. Faithfulness: Max(1) » Max(2) » Max(3)
Every person feature in the input is preserved in the output.
c. Identity: Id(pers)/role
For each role, the person feature associated with it in the output does not differ from that in the input.

Another way to implement the person hierarchy is harmonic alignment with the role hierarchy. The salience hierarchy in (18a) states a difference between local person (1st or 2nd) and nonlocal person (3rd). The role hierarchy in (18b) states that the feature [+hr] 'there is a higher role' is more relevant than the feature [+lr] 'there is a lower role' (see Stiebels 2000). By harmonic alignment of these two scales, the two contextualized markedness hierarchies in (19) are derived: the constraint (19a) is relevant in Quechua because there it is in fact the case that 3rd person objects are never expressed, while (19b) is irrelevant because neither ergative nor dative exist in Quechua.

(18) a. Salience: loc > 3 (a semantic relation)
b. Role: +hr > +lr (a morphological relation)

(19) a. *3/+hr »*3/+lr
b. *loc/+lr » *loc/+hr (irrelevant for Quechua)

Stiebels (2000) notes the contextualized constraints reversely (*+hr/3). However, the notation (a/x or x/a) does not play any role as long as the two scales to be aligned consist of just two values.

Like role, the salience hierarchy can also be expressed by means of relational features, with [+hs] for 'there is an argument with higher salience', see (20a). By means of harmonic alignment, shown in (20c), then, the more general markedness hierarchy in (20d) can be derived; note that (19a) is a specific instance of (20d). The contextualized features used in (20c,d) are identical with the definitions for 'direct' and 'inverse', as given in (21) (Wunderlich 1996). Thus, (20d) correctly expresses that the appearance of a direct morpheme is more marked than the appearance of an inverse morpheme. [Just to make a small refinement: It would be more appropriate for Quechua to define 'direct' as –hs/+lr, thereby including the setting 3/3 under 'direct', but this doesn't matter for the following.]

(20) a. Relational salience: –hs > +hs
b. Role: +hr > +lr
c. +hs/+lr > +hs/+hr
d. *(+hs/+hr) » *(+hs/+lr)

(21) a. direct: +hs/+hr
b. inverse: +hs/+lr

It is important to note that the role hierarchy +hr > +lr expresses what is more relevant for the morphology, that is, roles with the feature [+hr] should preferably be marked by morphology. This statement conflicts with a purely semantic hierarchy, saying that logical subjects are better than logical objects for semantic reasons (e.g., being controller of an action, easier accessible in control structures, or possible antecedents). Similarly, (20c) (based on the assumption of the role hierarchy +hr > +lr) conflicts with the strong semantic intuition that direct transitive settings are more natural than inverse transitive settings; but it is therefore that inverse settings should more easily be marked.

Thus, concerning the naturalness of settings, the hierarchy in (22b) should be assumed rather than (20c). Furthermore, one may state that (computationally) less complex forms are better than more complex forms, even if the less complex form is a portmanteau morpheme (hence more compact) and the more complex form gets a transparent reading, see (22a). By harmonic alignment, then, the markedness hierarchies in (23) can be derived.

(22) a. Complexity of forms: compact > transparent (a morphological relation)
b. Naturalness of settings: direct > inverse (a semantic relation)

(23) a. *compact/inverse » *compact/direct
b. *transparent/direct » *transparent/inverse

With these constraints, the actual Quechua forms given in (16) turn out to be optimal under a classical OT analysis, without using the above-mentioned Object-Subject constraint. However, the classical OT does not allow us to take simultaneously two conflicting perspectives on the role of logical subjects and objects. The markedness constraint *3/[+hr] in (19a) is derived under the perspective of [+hr] > [+lr], regarding formal features, while the constraints in (23) are derived under the perspective logical subject > logical object, regarding meanings. It is the bidirectional OT account that allows us to integrate these two perspectives.

(24)

	m1 1/3		m2 3/1	m1 1/3	m2 3/1
f1 (unmarked)	❶	←	○	☝	
	↑		↓		
f2 (marked)	○	←	○		☝

← : The direct setting is more natural than the inverse setting.
↑ : The unmarked form is preferred for a direct setting.
↓ : The marked form is preferred for an inverse setting.

It should be noted that Quechua lacks a passive, except the (non-productive) stative passive formed with *-raya* (van de Kerke 1996: 19). Therefore, there is for each setting only one optimal form. Bidirectional OT allows us to compare pairs of a setting and a verb form as to which is preferred semantically. Thus, the asymmetry in the verb forms reflects the distinction between direct and inverse settings, which are purely semantic notions here.

The same is true for a salience type language such as Arizona Tewa (Kroskrity 1985). Consider the examples in (25); here, only the more salient argument can be marked on the verb. However, if the lower argument is marked on the verb, the higher argument must receive an oblique suffix in the syntax.

(25) Arizona Tewa

a. he'i-n sen-en **dó**-k^{hw}ɛ́di
this-pl man-pl 1sg.AGT-hit
'I hit these men'

b. he'i-n sen-en-di **dí**-k^{hw}ɛ́di
this-pl man-pl-OBL 1sg.PAT-hit
'These men hit me'

Here, again, one can compare the two forms with the two meanings to be expressed in a bidirectional tableau, which is nearly identical to that in (23).

(26)

	m1		m2	m1	m2
	1/3		3/1	1/3	3/1
f1 (1.AGT)	➊	←	○	☝	
	↑		↓		
f2 (1.PAT; OBL)	○	←	○		☝

4. The comparison of active and passive.

If passive morphology exists, there are two forms available for each setting, and these forms also differ semantically in that the higher argument is existentially bound or not. Therefore, the bidirectional OT scenario leaves us with four optimal forms.

(27)

	m1	m2	m3	m4
	1/3	(1)/3	3/1	(3)/1
f1 (active)	☝			
f2 (passive)		☝		
f3 (active)			☝	
f4 (passive)				☝

It is not possible to compare these optimal pairs directly, so there is no way to block one of them. However, bidirectional OT offers a way to assign preferences to the individual pairs for semantic-pragmatic reasons. Let us consider an English type language.

(28) a. 1/3: I saw him.
b. (1)/3: He was seen (by me).
c. 3/1: He saw me.
d. (3)/1: I was seen (by him).

The two following tableaus illustrate the comparison of active and passive for the two settings; the active pair is superoptimal in the direct setting (29), while the passive pair is superoptimal in the inverse setting (30). In each case, one could include more candidate forms, which, however, never would be better than the two forms chosen here.

(29)

	m1		m2	m1	m2
	$\lambda y^3\ \lambda x^1$		$\lambda y^3\ \exists x^1$		
f1 (1.NOM-3.ACC)	➊	←	○	☝	
	↑		↓		
f2 (PASS; 3.NOM)	○	←	○		☝

← : The more salient argument should not be bound existentially.
↑ : The NOM-ACC pattern is preferred for the transitive setting.
↓ : The PASS;NOM pattern is preferred for the intransitivized setting.

(30)

	m1		m2	m1	m2
	$\lambda y^1\ \lambda x^3$		$\lambda y^1\ \exists x^3$		
f1 (3.NOM-1.ACC)	○	→	○	☝	
	↑		↓		
f2 (PASS; 1.NOM)	○	→	➊		☝

← : The more salient argument should be associated with the higher theta role.
↑ : The NOM-ACC pattern is preferred for the transitive setting.
↓ : The PASS;NOM pattern is preferred for the intransitivized setting.

The same result yields if one compares the two settings in the active or the passive.

(31)

	m1		m2	m1	m2
	$\lambda y^3\ \lambda x^1$		$\lambda y^1\ \lambda x^3$		
f1 (1.NOM-3.ACC)	➊	←	○	☝	
	↑		↓		
f2 (3.NOM-1.ACC)	○	←	○		☝

(32)

	m1		m2	m1	m2
	$\lambda y^3\ \exists x^1$		$\lambda y^1\ \exists x^3$		
f1 (PASS; 3.NOM)	○	→	○	☝	
	↑		↓		
f2 (PASS; 1.NOM)	○	→	➊		☝

It is interesting to note that, under some circumstances, an inverse type language with obviative marking also allows four different forms rather than two.

(33) Obviative in Plains Cree (Wolfart & Carroll 1981:30)

a.	waapam-**eew**	naapeew	siisiip-**a**	'The man sees the duck (obv)'
	see-DIRECT	man	duck-OBV	
b.	waapam-**ik**	naapeew	siisiip-**a**	'The duck (obv) sees the man'
	see-INVERSE	man	duck-OBV	
c.	waapam-**eew**	naapeew-**a**	siisiip	'The duck sees the man (obv)'
	see-DIRECT	man-OBV	duck	
d.	waapam-**ik**	naapeew-**a**	siisiip	'The man (obv) sees the duck'
	see-INVERSE	man-OBV	duck	

Here, we have the interaction of two semantic relations: sortal salience (in terms of the human/non-human distinction), and discourse prominence, which overrides sortal salience in that the more prominent discourse argument triggers the choice between direct and inverse marker. The more prominent argument in the discourse is underlined in the semantic representations given in (34).

(34)	m1		m2	m3		m4	
	$\lambda y^{nh}\ \underline{\lambda x^{h}}$		$\underline{\lambda y^{h}}\ \lambda x^{nh}$	$\lambda y^{h}\ \underline{\lambda x^{nh}}$		$\underline{\lambda y^{nh}}\ \lambda x^{h}$	
f1 (DIR; duck-OBV)	❶	⇐←	○	*○	⇐→	*○	(33a)
	↑		↓	↑		↓	
f2 (INV; duck-OBV)	○	⇐←	❹	*○	⇐→	*○	(33b)
f3 (DIR; man-OBV)	*○	⇐←	*○	❷	⇐→	○	(33c)
	↑		↓	↑		↓	
f4 (INV; man-OBV)	*○	⇐←	*○	○	⇐→	❷	(33d)

←, → : The sortally more salient argument (human) should be the higher argument.
⇐ : The more prominent argument in the discourse should be the higher argument.
* : The less prominent argument in the discourse should be marked obviative (violated in the respective items).
↑ : With the higher argument being more prominent, the direct marker is necessary.
↓ : With the lower argument being more prominent, the inverse marker is necessary.

It is obvious from (34) that the pair identified as '❶' is superoptimal, while each of the two pairs identified as '❷' violates one of the semantic constraints, and the pair identified as '❹' violates both semantic constraints and, therefore, is least preferred. In the classical OT all four forms would come out as optimal for the respective reading. However, bidirectional OT allows us to derive preferences between these pairs, according to whether they violate semantic constraints or not. Thus, the asymmetry of arguments often is not reflected in the forms themselves, but nevertheless can be captured by semantic preferences.

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