OO-Correspondence as Cumulativity[*]

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Both Sympathy constraints and OO-correspondence constraints are types of correspondence constraints, and both can induce opaque phenomena. Yet, Sympathetic constraint interaction is mediated by a special type of correspondence constraints (cumulativity constraints), while OO-correspondence is mediated by ordinary correspondence constraints. This paper argues that cumulative constraints can also be used in OO-correspondence. It is also argued that this is desirable for two reasons: (i) It unifies these two kinds of non-IO-correspondence. (ii) Certain types of OO-correspondence induced opacity that are possible with ordinary correspondence constraints, are excluded if cumulative constraints are used. Cumulative OO-correspondence constraints therefore result in a more restrictive theory.

1. OO-correspondence and Sympathetic correspondence as sources of opacity

When a process applies in the phonology of some language, it means that there is a certain marked configuration of features that triggers a repair strategy. In Optimality Theory (Prince and Smolensky, 1993) a "process" translates into the ranking Markedness >> Faithfulness. That is, the markedness constraint against the specific marked configuration of features ranks higher than the faithfulness constraint that is violated by the change induced by the "process". Such a ranking therefore expresses a generalization about a language – whenever this marked configuration is encountered in an Input form, it is changed in a predictable way. However, generalizations such as these are not always true across the board. When there are some surface forms in language L that do not abide with such a generalization, then this generalization is said to be *opaque*. Two types of opacity can be distinguished (McCarthy, 1999:332):

(1) Types of opacity

(i) *Not surface-apparent opacity*. Unexpected unfaithfulness/over application. Process P applies in some surface forms although the relevant marked configuration of features that triggers process P is not present in these surface forms. Example: Tiberian Hebrew breaks up underlying consonant

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clusters by vowel epenthesis. /melk/ → [mele̲x]. Tiberian Hebrew also deletes [ʔ] in coda position. When the second member of a consonant cluster is [ʔ], then both processes apply: /dešʔ/ → [de.še] – i.e. the vowel is inserted even though there is no longer a consonant cluster.

(ii) *Not surface-true opacity*. Unexpected faithfulness/under application. Although process P typically applies in L, there are some surface forms in L in which the marked configuration targeted by P is present, but in which P does not apply. Example: In Bedouin Arabic an [a] in an open syllable usually raises to [i] – /katab/ → [ki.tab]. However, there are forms such as /badw/ → [ba.du] where an [a] is preserved in an open syllable.

In OT some opaque phenomena are explained by positing non-Input-Output correspondence relations, such as Output-Output correspondence (Benua, 1995, Benua, 1997b, Kager, 1999, Kenstowicz, 1996, Kiparsky, 1998, Kiparsky, to appear), and Sympathetic correspondence (McCarthy, 1999, McCarthy, to appear). In classic OT (with only IO-correspondence), the output candidates are evaluated for their similarity to only the Input. However, in each of the non-IO-correspondence versions of OT, there is an additional form that the outputs are compared to. In OO-correspondence this is some morphologically related form, and in Sympathy Theory it is the Sympathetic candidate. These comparisons are effected through correspondence constraints – i.e. there are correspondence constraints for each of these non-IO-correspondence relations. These non-IO-correspondence constraints demand similarity between the non-IO comparison form and the Output.

It is through these non-IO-correspondence relations that opacity effects can arise. If the marked structure that typically triggers some process P is present in any of these additional comparison forms, then P will apply transparently in these forms. Because of the correspondence constraints that demand similarity between the output and the comparison forms, this application of P can be transferred onto the Output even if the marked structure that triggers P is not present in the Output. This is not-surface apparent opacity.

If the marked structure that usually triggers process P is not present in the non-IO comparison form, then process will not apply in this form. This non-application can be transferred onto the actual Output via the non-IO-correspondence constraints. This is not-surface true opacity.

In both Sympathy Theory and OO-correspondence it is therefore necessary to have constraints that will demand similarity between Output candidates and the comparison form (the Sympathetic candidate and the Base). In OO-correspondence these constraints have typically been considered to be ordinary correspondence constraints – i.e. exactly like IO-correspondence constraints except that the comparison form is not the Input but the Base. In Sympathy Theory, there has been disagreement about what the nature of these constraints needs to be. On the one hand, Itô and Mester (Itô and Mester, 1997), De Lacy (de Lacy, 1998) and Walker (Walker, 1998) amongst others have argued that Sympathetic constraints should also be ordinary correspondence constraints. On the other hand McCarthy (McCarthy, 1999, McCarthy, to appear) has argued that this leads to wrong typological predictions. Specifically, he has shown that unattested opaque phenomena (the so-called multi-step Duke of York derivations) are possible if ordinary correspondence constraints are used to mediate Sympathetic interactions. He therefore introduces a special class of correspondence constraints, namely ❀CUMUL and ❀DIFF, to mediate the Sympathetic interactions. Based on McCarthy's work it is therefore assumed in this paper that Sympathetic constraints cannot be of the ordinary correspondence variety. McCarthy defines his Sympathetic constraints as follows:

(2) Sympathetic correspondence constraints

Let *❀cand* be the Sympathetic candidate and *E-cand* the Output candidate under evaluation.

❀CUMUL
E-cand is cumulative with respect to *❀cand*. That is *❀cand* has a subset of the faithfulness violations of *E-cand*.

❀DIFF
Every faithfulness violation incurred by *E-cand* is also incurred by *❀cand*.

As an example of how these constraints work, consider the Tiberian Hebrew example mentioned earlier.[1] The purpose of this example is only to illustrate how the violations of ❀CUMUL and ❀DIFF are determined. The ranking between the constraints, the choice of the sympathetic candidate, etc. are not relevant for this purpose.

(3) How ❀CUMUL and ❀DIFF work[2]

		/dešʔ/	❀CUMUL	*ʔ]$_\sigma$	*COMPLEX	❀DIFF	✭MAX	DEP
☞	a.	deše				*	*	*
☜	b.	deš	*!			*	*	
❀	c.	dešeʔ		*!			✓	*
	d.	dešʔ	*!	*!	*!		✓	

In this tableau candidate (c) is the Sympathetic candidate (indicated by ❀). Candidate (c) violates only one IO-correspondence constraint, namely DEP. All

[1] For the sake of this illustration, it is not relevant how the Sympathetic candidate is chosen. It is also not relevant how the constraints are ranked or why they are ranked as such. To see how ❀CUMUL and ❀DIFF work, it is really only the violations in terms of IO-correspondence constraints that are relevant.

[2] In Sympathy Theory the backwards pointing hand (☜) is used to indicate the candidate that would have won had it not been for the Sympathetic constraints. The flower (❀) indicates the Sympathetic candidate and the Sympathetic constraints. The star (✭) indicates the selector constraint. See McCarthy (McCarthy, 1999) for more on these conventions.

candidates not sharing this violation therefore do not accumulate the Sympathetic candidate's IO-correspondence violations, and consequently violate ❀CUMUL. Since (b) and (d) do not share the Sympathetic candidate's DEP-violation, they each earn a violation in terms of ❀CUMUL. Any candidates that violate an IO-correspondence constraint not violated by the Sympathetic candidate, will be penalized in terms of ❀DIFF. Both (a) and (b) violate MAX, which is not violated by the Sympathetic candidate. Therefore, both of them earn one violation in terms of ❀DIFF.

Because of the way in which these two constraints interact with the IO-correspondence constraints and markedness constraints, ❀CUMUL is the constraint that is relevant in cases of not surface-apparent opacity (over application), and ❀DIFF is decisive in not surface-true opacity (under application). Because ❀CUMUL demands that the Output candidate have at least all the faithfulness violations of the Sympathetic candidate, it can force the optimal candidate to undergo a process (violate a faithfulness constraint) for which the triggering environment is not present in the actual Output form (i.e. the marked configuration licensing the faithfulness violation is not present in the Output). ❀CUMUL can therefore cause a process to over apply in cases where its triggering environment is not present. ❀DIFF, on the other hand, favors candidates with fewer faithfulness violations not shared by the Sympathetic candidate. It can therefore force the Output form not to undergo some process (not violate some faithfulness constraint) even if the triggering environment is present in the Output form. This is possible when the Sympathetic candidate does not undergo this process because the triggering environment for the process is not met in the Sympathetic candidate.

A question that needs to be answered is: If the same types of opacity are induced by Sympathetic correspondence and OO-correspondence, why do Sympathy Theory and OO-correspondence not employ the same kind of correspondence constraints? Why does Sympathy Theory use ❀CUMUL and ❀DIFF, while OO-correspondence uses ordinary correspondence constraints? We know that Sympathy Theory cannot use ordinary correspondence constraints (because that leads to multi-step Duke of York derivations). So, the real question is why OO-correspondence does not also use cumulative correspondence. There are only two possible reasons: Either the opacity induced by OO-correspondence cannot be achieved by CUMUL_{OO} and DIFF_{OO} (see (4) below for definitions) at all, or the type of opacity that ❀CUMUL and ❀DIFF are supposed to exclude from Sympathy Theory (multi-step Duke of York derivations) is indeed encountered in OO-correspondence.

It would be desirable from the viewpoint of theoretical simplicity if all non-IO-correspondence constraints were of the same type.[3] Since McCarthy has shown that Sympathy Theory cannot use ordinary correspondence constraints, the most likely way to collapse these two types of correspondence, is to use CUMUL_{OO} and

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[3] There is of course a third kind of non-IO-correspondence relation, namely that between a Reduplicant and its Base (McCarthy and Prince, 1995). Although BR-correspondence is not discussed in this paper, the implicit presupposition is that what is said about OO-correspondence here, applies to BR-correspondence also.

DIFF_{OO} also in OO-correspondence. This will of course only be possible if it can be determined that neither of the two possible reasons for using ordinary correspondence constraints in OO-correspondence is legitimate.

This paper argues that OO-correspondence should also be mediated by cumulative constraints. The first possible reason for using ordinary correspondence constraints in OO-correspondence is ruled out in §2 by showing that the opacity induced by OO-correspondence can be explained by CUMUL_{OO} and DIFF_{OO}. One example of each type of opacity is discussed to show that both CUMUL_{OO} and DIFF_{OO} can be employed in OO-correspondence. In §3 the second possible reason is considered. It is shown that using ordinary correspondence constraints in OO-correspondence can result in multi-step Duke of York derivations.[4] In fact, McCarthy (McCarthy, to appear:8) claims that this is necessary. It is then argued that this is not necessarily the case. The example that McCarthy uses to motivate the necessity of using ordinary correspondence constraints in OO-correspondence can be reanalyzed as a two level derivation, employing the Sympathetic constraints ❀CUMUL and ❀DIFF. It is suggested that other claimed examples of multi-step Duke of York derivations in OO-correspondence might also be subject to such reanalysis.

2. Using CUMUL_{OO} and DIFF_{OO} to mediate OO-correspondence

As explained above, in Sympathy Theory ❀CUMUL is responsible for deriving not surface-apparent opacity, and ❀DIFF for not surface-true opacity. In order to show that these constraints can also be used in OO-correspondence one example of each of these two types of opacity induced by OO-correspondence is discussed here. It is first shown how these opaque phenomena can be explained using ordinary correspondence constraints. Then it is shown that the same results can be attained with CUMUL_{OO} and DIFF_{OO}. The OO-correspondence versions of these two constraints is defined as follows:

(4) Cumulative OO-correspondence constraints

Let *Base* be the morphologically related Output form that functions as the comparison form, and *E-cand* the Output candidate under evaluation.

CUMUL_{OO}
E-cand is cumulative with respect to *Base*. That is, *Base* has a subset of the faithfulness violations of *E-cand*.

DIFF_{OO}
Every faithfulness violation incurred by *E-cand* is also incurred by *Base*.

The interaction of Polish raising with diminutive suffixes is convenient to use as an example, as both types of opacity is observed in the diminutive paradigm in

[4] In OO-correspondence these examples are of course not really "derivations". It is not that there is a serial derivation going from Input through the related Output form to the final Output. What is actually the case is that the form that in a classic multi-step Duke of York derivation is the crucial intermediary form, is now the actual Output of a morphologically related Input. However, in order to simplify the discussion the term "multi-step Duke of York derivation" is also used for this related OO-correspondence phenomenon.

Polish. The data is first presented, and then the OT explanations for the two types of opacity are discussed. The Polish data is from Kenstowicz (Kenstowicz, 1996), Gussman (Gussman, 1980) and Kraska (Kraska, 1994).

Polish has a regular process of raising /o/ to [u] before unrealized Yers. Yers are vowels that delete unless the following syllable also contains a Yer (realized or unrealized). The nominative and accusative singulars of masculine nouns are marked by a Yer vowel suffix, as are the genitive plurals of feminine and neuter nouns. In nouns with an /o/ vowel in the final root syllable and with no additional Yer-suffixes after the case endings, this /o/ vowel will therefore be raised to [u] in the nominative and accusative masculine singular, and in the genitive plural of the feminine and neuter. This is illustrated in the following three paradigms. The <Y> indicates a non-realized Yer.

(5) /o/ → [u] raising in Polish

		/doł/ ‘hole’	/krow/ ‘cow’	/pol/ ‘field’
		masculine	feminine	neuter
sg.	nom.	duł-<Y>	krow-a	pol-e
	gen.	doł-u	krow-y	pol-a
	dat.	doł-owi	krow-ie	pol-u
	acc.	duł-<Y>	krow-e	pol-e
	instr.	doł-em	krow-o	pol-em
	loc.	doł-e	krow-ie	pol-u
pl.	nom.	doł-y	krow-y	pol-a
	gen.	doł-ow	kruw-<Y>	pul-<Y>
	dat.	doł-om	krow-om	pol-om
	acc.	doł-y	krow-y	pol-a
	instr.	doł-ami	krow-ami	pol-ami
	loc.	doł-ach	krow-ach	pol-ach

This basic phonology is easily simulated in OT. What is required is a markedness constraint that will drive vowel raising before non-realized Yers. For convenience this constraint is stated as *[o]C<Y>, following Kenstowicz (Kenstowicz, 1996:388). This constraint needs to be ranked higher than the IO-correspondence constraint requiring faithful parsing of underlying vowel height, IDENT(Height)$_{IO}$.

Polish forms nominal diminutives by adding a suffix /-Yk/ to the nominal root before the attachment of the case ending. Since the diminutive contains a Yer, this suffix is sometimes realized as [-k-] (when the following case ending contains no Yer), and sometimes as [-ek-] (when the following case ending does contain a Yer). In the nominative singular of masculine nouns, the case ending used with diminutive forms, contains a Yer. In these words, the Yer in the diminutive suffix will therefore be realized, and in the root the /o/ vowel will no longer be induced to raise. Interestingly enough, in the rest of the masculine diminutive paradigm the root /o/ also does not raise, even though the Yer in the diminutive suffix is not realized in these forms. This is therefore an example of not surface-true opacity. The process of vowel raising which usually applies is suspended in these forms for non-IO-correspondence reasons.

In the genitive plural of feminine and neuter nouns, the Yer in the diminutive will also be realized (because the case endings in these words contain a Yer). In these words the environment for vowel raising will therefore not be met. However, these forms do show vowel raising. This is then an example of not surface-apparent opacity. A process applies in a form even though the triggering environment is not present in the form.

(6) Over and under application of /o/ → [u] raising in the diminutives

		masculine	feminine	neuter
sg.	nom.	doł-ek-<Y>	kruw-<Y>k-a	pul-<Y>k-o
	gen.	doł-<Y>k-a	kruw-<Y>k-i	pul-<Y>k-a
	dat.	doł-<Y>k-owi	kruw-<Y>c-e	pul-<Y>k-u
	acc.	doł-<Y>k-e	kruw-<Y>k-e	pul-<Y>k-o
	instr.	doł-<Y>k-iem	kruw-<Y>k-o	pul-e<Y>k-iem
	loc.	doł-<Y>k-u	kruw-<Y>c-e	pul-<Y>k-u
pl.	nom.	doł-<Y>k-i	kruw-<Y>k-i	pul-<Y>k-a
	gen.	doł-<Y>k-ow	kruw-ek-<Y>	pul-ek-<Y>
	dat.	doł-<Y>k-om	kruw-<Y>k-om	pul-<Y>k-om
	acc.	doł-<Y>k-i	kruw-<Y>k-i	pul-<Y>k-a
	instr.	doł-<Y>k-ami	kruw-<Y>k-ami	pul-<Y>k-ami
	loc.	doł-<Y>k-ach	kruw-<Y>k-ach	pul-<Y>k-ach

These opaque phenomena can be explained as the consequence of OO-correspondence. What is necessary is to assume that the nominative singular is the Base in each case. If raising is licensed in the Base (in the feminine and neuter), then raising occurs throughout the paradigm. When raising is not licensed in the Base (in the masculine), then raising is absent from the complete paradigm.

2.1 Not surface-apparent opacity

Not surface-apparent opacity is encountered in the genitive plural of the feminine and neuter nouns in (5) above. In these forms it is more important for the optimal candidate to agree in vowel height with its Base than with its Input. Ranking the OO-correspondence constraint that requires Affiliates to agree with the Base in vowel height, IDENT(Height)$_{OO}$, higher than the corresponding IO-correspondence constraint will get the desired result. The feminine is used as an example here, but the neuter can be explained in the exact same way. The tableaux for three members of the paradigm are given: the nominative singular (the Base), the nominative plural (an Affiliate in which raising is licensed transparently), and the opaque genitive plural. Only candidates in which the Yers are correctly realized are considered.

(7) Opaque raising in the feminine diminutive using ordinary correspondence

(i) Base: Nominative singular

/krow+Yk+a/ Base: none	IDENT (Height)$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-<Y>k-a			*
b. krow-<Y>k-a		*!	

(ii) Transparent Raising Affiliate: Nominative plural

/krow+Yk+i/ Base: kruw-<Y>k-a	IDENT (Height)$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-<Y>k-i			*
b. krow-<Y>k-i	*!	*!	

(iii) Opaque Raising Affiliate: Genitive plural

/krow+Yk+Y/ Base: kruw-<Y>k-a	IDENT (Height)$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-ek-<Y>			*
b. krow-ek-<Y>	*!		

These data can straightforwardly be reanalyzed using CUMUL$_{OO}$ and DIFF$_{OO}$ instead of ordinary correspondence constraints to mediate the OO-correspondence. Whatever the constraint is that is used to mediate the OO-correspondence, what is necessary is that candidate (b) in tableau (iii) does violate this constraint (to force vowel raising), and that candidate (a) in tableau (ii) does not violate it (otherwise vowel raising will incorrectly be blocked). Since this is an example of not surface-apparent opacity, it falls within the domain of CUMUL$_{OO}$. The correct result will therefore be obtained if candidate (b) from tableau (iii) does not accumulate the IO-correspondence violations of the Base, while candidate (a) from tableau (ii) does. This is indeed the case. The Base, candidate (a) from tableau (i), has only one faithfulness violation – in terms of the constraint IDENT(Height)$_{IO}$. Candidate (a) from tableau (ii) shares this faithfulness violation with the Base, and therefore accumulates the Base's faithfulness violations. However, candidate (b) from tableau (iii) is the fully faithful candidate, and as such it cannot accumulate the Base's faithfulness violations. Replacing IDENT(Height)$_{IO}$ with CUMUL$_{OO}$ makes no difference to the outcome. This is shown in the tableaux below.

(8) Opaque raising in the feminine diminutive using cumulative correspondence

(i) Base: Nominative singular

/krow+Yk+a/ Base: none	CUMUL$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-<Y>k-a			*
b. krow-<Y>k-a		*!	

(ii) Transparent Raising Affiliate: Nominative plural

/krow+Yk+i/ Base: kruw-<Y>k-a	CUMUL$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-<Y>k-i			*
b. krow-<Y>k-i	*!	*!	

(iii) Opaque Raising Affiliate: Genitive plural

/krow+Yk+Y/ Base: kruw-<Y>k-a	CUMUL$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ kruw-ek-<Y>			*
b. krow-ek-<Y>	*!		

2.2 Not surface-true opacity

The masculine diminutive paradigm presents an example of not surface-true opacity. In the Base (the nominative) of this paradigm raising of the /o/ is not licensed (because the Yer in the diminutive suffix is realized). In the rest of the paradigm, the /o/ also does not raise, even though the Yer in the diminutive suffix is not realized in the rest of the paradigm. This under application of /o/-raising can be explained by the requirement that the Affiliates agree with the Base in vowel height. The same ranking and constraints used in (6) above for the feminine and neuter can also be used here. Since there are no examples of transparent non-raising in an Affiliate, only two examples are discussed here – the nominative singular Base and the nominative plural as an example of an Affiliate. Again, only forms in which the Yers have been correctly realized are considered.

(9) Opaque non-raising in the masculine diminutive using ordinary correspondence

(i) Base: Nominative singular

/doł+Yk+<Y>/ Base: none	IDENT (Height)$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+ek+<Y>			
b. duł+ek+<Y>			*!

(ii) Opaque non-raising Affiliate: Nominative plural

/doł+Yk+i/ Base: doł+ek+<Y>	IDENT (Height)$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+<Y>k+i		*	
b. duł+<Y>k+i	*!		*

This is an example of under application of an expected process, and as such an example of not surface-true opacity. In Sympathy Theory this type of opacity is handled by ❀DIFF. The OO version of this constraint penalizes Affiliates for faithfulness violations that are not shared by the Base. Since the Base, candidate (a) in tableau (i), is the fully faithful candidate, it does not violate any faithfulness constraint. An Affiliate will therefore receive one violation of DIFF$_{OO}$ for each of its faithfulness violations. This correctly predicts that candidate (b) in tableau (ii) will violate DIFF$_{OO}$. Replacing IDENT(Height)$_{OO}$ with DIFF$_{OO}$, will therefore produce the desired results. This is shown in the tableaux below.

(10) Opaque non-raising in the masculine diminutive using cumulative correspondence

(i) Base: Nominative singular

/doł+Yk+<Y>/ Base: none	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+ek+<Y>			
b. duł+ek+<Y>			*!

(ii) Opaque non-raising Affiliate: Nominative plural

/doł+Yk+i/ Base: doł+ek+<Y>	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+<Y>k+i		*	
b. duł+<Y>k+i	*!		*

2.3 Summary

The last detail that still needs to be checked is whether the correct candidates are still chosen as optimal when both CUMUL$_{OO}$ and DIFF$_{OO}$ are included in the tableaux above. McCarthy (McCarthy, 1999:353) argues for the following universally fixed ranking between these two constraints: CUMUL >> DIFF. The relevant tableaux from the previous sections are repeated below, with both CUMUL$_{OO}$ and DIFF$_{OO}$, ranked relative to each other according to their universally fixed ranking. These tableaux show that using both constraints together does not negate the results attained in the previous two sub-sections.

(11) Opaque raising in the feminine diminutive using both CUMUL$_{OO}$ and DIFF$_{OO}$

(i) Base: Nominative singular

/krow+Yk+a/ Base: none	CUMUL$_{OO}$	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞kruw-<Y>k-a				*
b. krow-<Y>k-a			*!	

(ii) Transparent Raising Affiliate: Nominative plural

/krow+Yk+i/ Base: kruw-<Y>k-a	CUMUL$_{OO}$	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞kruw-<Y>k-i				*
b. krow-<Y>k-i	*!		*	

(iii) Opaque Raising Affiliate: Genitive plural

/krow+Yk+Y/ Base: kruw-<Y>k-a	CUMUL$_{OO}$	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞kruw-ek-<Y>				*¡
b. ☜krow-ek-<Y>	*!			

(12) Opaque non-raising in the masculine diminutive using CUMUL$_{OO}$ and DIFF$_{OO}$

(i) Base: Nominative singular

/doł+Yk+<Y>/ Base: none	CUMUL$_{OO}$	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+ek+<Y>				
b. duł+ek+<Y>				*!

(ii) Opaque non-raising Affiliate: Nominative plural[5]

/doł+Yk+i/ Base: doł+ek+<Y>	CUMUL$_{OO}$	DIFF$_{OO}$	*[o]C<Y>	IDENT (Height)$_{IO}$
a. ☞ doł+<Y>k+i			*¡	
b. ☜ duł+<Y>k+i		*!		*

These examples show that it is indeed possible to explain both types of opacity induced by OO-correspondence by using cumulativity rather than ordinary correspondence constraints. Since using cumulativity constraints results in a more restrictive theory (see §3) and since it unifies Sympathy Theory and OO-correspondence, the onus is on proponents of ordinary correspondence to show that there are opaque phenomena induced by OO-correspondence that cannot be explained by using cumulativity constraints.

3. Multi-step Duke of York derivations in OO-correspondence

Duke of York derivations are characterized by two phonological processes with contradictory effects, ordered such that the one undoes the effects of the other. In a multi-step Duke of York derivation a third process is involved that applies between the two contradictory processes. Application of the first process creates the triggering environment for the middle process, and the last process then destroys this triggering environment. In the final form the middle process has therefore applied, but the motivation for this application is not visible because the last process has destroyed the triggering environment. An abstract example will make this clear.

[5] The backwards pointing hand (☜) here has the same interpretation that it does in Sympathy Theory – that is it indicated the candidate that would have won had it not been for the non-IO-correspondence. See footnote 2 for more.

(13) A three-step Duke of York derivation

Process 1:	C → D / AB ____	(ABC → ABD)
Process 2:	B → E / __ D	(ABD → AED)
Process 3:	D → C / E ___	(AED → AEC)

Process 1 sets up the context for the application of Process 2 – it is only because Process 1 applied that B is now followed by D. Process 3 then undoes the effect of Process 1, changing the D back to C. This destroys the triggering environment for Process 2. In the final form AED the process B → E has applied, but the motivation for this process is no longer visible.

Such multi-step Duke of York derivations therefore result in not surface-apparent opacity. McCarthy (McCarthy, 1999) shows that multi-step Duke of York derivations such as those in (12) can be simulated in Sympathy Theory when ordinary correspondence constraints are used to mediate Sympathetic interaction. However, such derivations do not exist in natural language. Using ordinary correspondence constraints in Sympathy Theory therefore makes the wrong typological predictions. Since multi-step Duke of York derivations are not found in natural language, phonological theory should systematically exclude them from being possible. It is with this purpose in mind that McCarthy introduced cumulative correspondence. With ❀CUMUL and ❀DIFF mediating Sympathetic constraint interaction, multi-step Duke of York derivations are not possible.

Although these multi-level Duke of York derivations do not occur in Sympathetic constraint interaction, McCarthy claims elsewhere (McCarthy, to appear:8) that they do in fact occur in OO-correspondence. He refers to spirantization in Tiberian Hebrew as an example. Therefore, it seems necessary that OO-correspondence should be mediated by ordinary correspondence constraints.

It is argued in this section that multi-step Duke of York derivations probably also do not occur in OO-correspondence-induced opacity. The Hebrew spirantization example is reanalyzed as an example of ordinary not surface-apparent Sympathy induced opacity. It is then suggested that other claimed examples of multi-step Duke of York derivations in OO-correspondence might be subject to similar kinds of reanalysis.

This section of the paper is structured as follows: In §3.1 a hypothetical three-step Duke of York derivation induced by OO-correspondence is discussed. It is shown that it is possible to simulate this process using ordinary correspondence constraints to mediate the OO-correspondence relation. It is then also shown that it is impossible to simulate this derivation with CUMUL_{OO} and DIFF_{OO}. In §3.2 Tiberian Hebrew spirantization is discussed to show that it can be explained without recourse to a multi-step Duke of York derivation.

3.1 A three-step Duke of York derivation

One of the Sympathy examples that McCarthy discusses as an impossible three-step Duke of York derivation is briefly reviewed here. This serves only an intermediary purpose – to aid in constructing a similar example that can be induced by OO-correspondence.

(14) An impossible opaque derivation (McCarthy, 1999:378)

UR		ma:t
Epenthesis	$\varnothing \rightarrow$ i / CV:C]$_\sigma$ ___	ma:ti
Palatalization	t $\rightarrow$ č / ___ i	ma:či
Apocope	V $\rightarrow \varnothing$ / ___ #	ma:č
Shortening	V: $\rightarrow$ V / ___ C]$_\sigma$	mač

Epenthesis counts as the first process that creates the context for the in-between process of palatalization to apply. And then after palatalization had its chance to apply, the third process of apocope comes along and undoes the effect of initial epenthesis, thereby destroying the triggering environment for palatalization. The palatalization on the final form cannot be motivated by any features that are present in this form – the inserted [i] that triggered the palatalization has been deleted. This is the trademark of a multi-level Duke of York derivation – certain phonological processes must crucially happen at some intermediate stage.

In an OT framework the crucial intermediate stage is [ma:či]. The only way in which the palatalization in the Output can be motivated is through correspondence with this form. In the example here this intermediate form is only a candidate in the candidate set of Input /ma:t/. However, it is possible that this intermediate form can be another independently occurring word – the Output of another morphologically related Input. The palatalization in [mač] can then be motivated by OO-correspondence with this other Output form. Below, such a hypothetical example, based on the example in (14), is discussed.

Let L be a language with the same basic phonology as that of the language in (14), except that L does not have apocope. Suppose that L marks its singular verbs by a zero suffix, and its plural verbs by the suffix [-u]. Consider now what will happen to a verbal root /ma:t/ in L. In the singular the environment for palatalization will be met – because an [-i] will be inserted to get rid of the super heavy syllable. In the plural, the environment for palatalization is not met – the plural suffix [-u] blocks [i]-epenthesis. If the phonology of L is fully transparent, then the singular will have a palatalized [č], and the plural an ordinary [t]. However, if there is an OO-correspondence relation between the singular and the plural with the singular as the Base, then it is possible to transfer the palatalization of the singular onto the plural.[6] Palatalization will then apply opaquely in the plural. An opaque version of L will thus look as follows:

[6] Only if ordinary correspondence constraints are used to mediate the relationship between the Base and the Affiliate. This pattern cannot be achieved with cumulative correspondence constraints. See below.

(15) Language L: A three-step Duke of York derivation in OO-correspondence

		sg.	pl.
UR		ma:t	ma:t + u
Epenthesis	∅ → i / CV:C]$_σ$ ___	ma:ti	–
Palatalization	t → č / ___ i	ma:či	–
OO agreement		–	ma:ču

This is exactly the type of opacity that McCarthy claims to be possible in OO-correspondence. The difference between this example and that in (14) is that the crucial intermediate stage (the form that induces the opacity) is another independent word. A phenomenon such as this cannot be simulated if OO-correspondence is mediated by cumulative correspondence constraints. If patterns such as these do indeed exist, it will be a strong argument in favor of using ordinary correspondence constraints in OO-correspondence. Below it is first shown that the pattern in (15) can be simulated with ordinary correspondence constraints, and then that it is not possible with cumulativity constraints.

The same basic constraints that McCarthy (McCarthy, 1999:379) used for the hypothetical language in (14) can also be used for language L in (14) – with a few changes in ranking and with the addition of an OO-correspondence constraint.

(16) Basic phonology for (15) in OT terms

*[μμμ]$_σ$ >> DEP-V$_{IO}$	Trimoraic syllables are repairable by epenthesis.
MAX-μ $_{IO}$ >> DEP-V$_{IO}$	Shortening not possible as repair for trimoraic syllables.
*ti >> ID(hi)$_{IO}$	There is palatalization.
ID(hi)$_{OO}$ >> ID(hi)$_{IO}$	Palatalization is transferred from the Base to the Affiliate.

With these constraints and the rankings between them, the pattern in (15) can be simulated. This is shown in the tableaux below. The singular acts as the Base for the plural.

(17) Simulating L's opacity with ordinary correspondence constraints

(i) Singular: /ma:t/ → [ma:či]

/ma:t/ Base: none	ID(hi)$_{OO}$	*[μμμ]	MAX-μ $_{IO}$	*ti	DEP-V$_{IO}$	ID(hi)$_{IO}$
a. ☞ ma:či					*	*
b. ma:t		*!				
c. ma:ti				*!	*	
d. mat			*!			

(ii) Plural: /ma:t + u/ → [ma:ču]

/ma:t + u/ Base: ma:či	ID(hi)$_{OO}$	*[μμμ]	MAX-μ $_{IO}$	*ti	DEP-V$_{IO}$	ID(hi)$_{IO}$
a. ☞ ma:ču						*
b. ma:tu	*!					

When ordinary correspondence constraints are used to mediate OO-correspondence, then any arbitrary feature of the Base can be transferred to the Affiliate. An OO-correspondence constraint that refers to any feature of the Base can be invoked. As a result, it is possible to transfer an unfaithful feature from the Base to the Affiliate without also transferring the environment that motivated the unfaithfulness in the Base. This is exactly what makes this an example of not surface-apparent opacity. It is an example of a Duke of York derivation, because the trigger for the unfaithfulness in the Base (the unfaithfulness that was transferred to the Affiliate), is the result of another unfaithful mapping in the Base (the [i] insertion) that is not transferred to the Affiliate.

Similar to Sympathy Theory, this pattern cannot be simulated if cumulative correspondence constraints are used. Since this is an example of not surface-apparent opacity, it is the domain of CUMUL$_{OO}$. If this pattern were to be possible with CUMUL$_{OO}$ instead of IDENT(high)$_{OO}$, then candidate (b) in tableau (ii) must violate CUMUL$_{OO}$ and candidate (a) not. However, both of these candidates will violate CUMUL$_{OO}$. The comparison form, candidate (a) from tableau (i), violates two IO-correspondence constraints, DEP-V$_{IO}$ and IDENT(high)$_{IO}$. Not one of the candidates in tableau (ii) violates both of the constraints. Neither of them therefore accumulates the IO-correspondence violations of the comparison form, and both of them will violate CUMUL$_{OO}$. Cumulative correspondence can therefore not simulate this pattern. To confirm this, the tableaux are repeated below, this time with the constraints CUMUL$_{OO}$ and DIFF$_{OO}$ instead of IDENT(high)$_{OO}$.

(18) But L is impossible with cumulative correspondence constraints

(i) Singular: /ma:t/ → [ma:či]

/ma:t/ Base: none	CUMUL$_{OO}$	*[μμμ]	MAX-μ $_{IO}$	*ti	DEP-V$_{IO}$	ID(hi)$_{IO}$	DIFF$_{OO}$
a. ☞ ma:či					*	*	
b. ma:t		*!					
c. ma:ti				*!	*		
d. mat			*!				

(ii) Plural: /ma:t + u/ → [ma:ču]

/ma:t/ Base: ma:či	CUMUL$_{OO}$	*[μμμ]	MAX-μ $_{IO}$	*ti	DEP-V$_{IO}$	ID(hi)$_{IO}$	DIFF$_{OO}$
a. ☹ ma:ču	*!					*	
b. ma:tu	*!						
c. ☞ma:čiu					*	*	

Because CUMUL$_{OO}$ requires that the Output candidate share all of the faithfulness violations of the comparison form, neither candidate (a) nor (b) in tableau (ii) obeys CUMUL$_{OO}$. Candidate (c) with two unmotivated IO-correspondence violations comes out victorious. In this candidate the motivation for the palatalization has also been transferred from the Base. The palataliztion is therefore not opaque anymore.

Clearly, if such multi-step Duke of York derivations do occur in the domain of OO-correspondence, then ordinary correspondence constraints must be used to mediate OO-correspondence. However, if such derivations do not occur, then it will be necessary to use cumulative correspondence constraints also in OO-correspondence. A theory in which OO-correspondence is also mediated by cumulativity constraints is more restrictive (in ruling out multi-step Duke of York derivations). Such a theory is also more appealing from the viewpoint of theoretical simplicity – non-IO-correspondence is then treated more uniformly. However, in order to claim that OO-correspondence can also be mediated by cumulative constraints, it will have to be shown that those examples that have been claimed to be multi-level Duke of York derivations in OO-correspondence, can be analyzed differently. In the next section this is done for one of these examples, namely Tiberian Hebrew spirantization. This example is particularly relevant, since McCarthy uses this example as a motivation that OO-correspondence must be mediated by ordinary correspondence constraints (McCarthy, to appear:8).

3.2 Spirantization in the Tiberian Hebrew infinitive

In Tiberian Hebrew stop and fricative consonants are in complementary distribution, with fricatives occurring after vowels, and stops elsewhere. Below is a summary of the alternations, with examples of each.

(19) Stop ~ fricative alternations in Tiberian Hebrew[7]

After Vowel	Elsewhere		
v	b	b̲eθ-ʔel	"Bethel"
		bə-v̲eθ-ʔel	"in Bethel"
ɣ	g	g̲am	"also"
		wə-ɣ̲am	"and also"
ð	d	d̲ɔwið	"David"
		lə-ð̲ɔwið	"to David"
x	k	k̲ɔθav	"he wrote"
		yi-x̲tov	"he will write"
f	p	p̲ɔqað	"he searched"
		yi-f̲qoð	"he will search"
θ	t	yi-xt̲ov	"he will write"
		kɔθ̲av	"he wrote"

Complementary distribution is easily accounted for in OT by using a general markedness constraint against the allophone with the restricted distribution, a special markedness constraint against the allophone with the elsewhere-distribution, and an IO-correspondence constraint that penalizes a change from the one allophone to the other. The ranking below can therefore explain this basic pattern.

(20) Basic ranking for Tiberian Hebrew spirantization

* V [-cont] >> *[+cont] >> IDENT(cont)$_{IO}$

The tableau below shows how this ranking accounts for the general pattern of spirantization in Tiberian Hebrew.[8]

(21)

			* V [-cont]	*[+cont]	IDENT(cont)$_{IO}$
/gam/	(a)	☞ gam			
	(b)	ɣam		*!	*
/wa+gam/	(c)	wəgam	*!		
	(d)	☞weɣam		*	*

[7] All Tiberian Hebrew examples are from Gesenius (1910).

[8] In this and further tableaux the Input forms used agree with that presupposed by Malone (1993), unless stated differently. Only candidates relevant to the constraints under consideration will be included in the tableaux. Many of the IO-correspondence violations of the Output candidates are therefore not explained in the tableaux.

3.2.1 The problem

Up to this point the phonology of spirantization is transparent. However, the spirantization process of Hebrew is notoriously opaque.[9] There are many systematic examples of both not surface-true and not surface-apparent opacity with regard to spirantization. In fact, this process is so opaque that Idsardi has claimed that it cannot be dealt with in a satisfactory way in surface oriented parallel OT (Idsardi, 1998). Although Idsardi sees problems for a parallel correspondence explanation of many aspects of Tiberian Hebrew spirantization, there is one specific set of data that for him drives the nail in the coffin of a parallel OT explanation. He says about this set of data that it "indicates that no correspondence account of spirantization will suffice" (p. 68). It is this set of data that will be the focus of the rest of this section. These data concern the pattern of spirantization observed in the infinitive with different prefixes. The examples below illustrate the problem. Note specifically the underlined [t, θ] sounds.

(22) Spirantization in the infinitive with prefixes: from the root /k-t-b/

(a)	kəθov	"to write" (infinitive)
(b)	lixt̲ov	"to write" (predicative form of infinitive)
(c)	bixθ̲ov	"while writing" (preposition + infinitive, literally "in writing")

In (c) the underlying /t/ of the verbal root spirantizes even though it occurs in a post-consonantal position. In (b) the underlying /t/ is preserved faithfully in a phonologically identical context. The problem is the unexplained spirantization in (c). Within a correspondence theory version of OT two possible explanations present themselves immediately – either the /t/ spirantizes under pressure from a Sympathetic candidate, probably [bixəθov]; or the /t/ spirantizes under OO-correspondence pressures in order to be more similar to the isolation form [kəθov]. However, neither of these explanations seems adequate. If the /t/ in [bixθ̲ov] spirantizes, then surely the same factors should also cause the /t/ in [lixt̲ov] to spirantize.

Prince (Prince, 1975) presents the first detailed discussion of this problem. He explains the difference between [bixθ̲ov] and [lixt̲ov] as a consequence of a difference in the strength of the boundaries associated with the prefixes *bi-* and *li-*. Prince therefore considers the underlying forms of these two prefixes to be /ba#/ and

[9] See also Benua (Benua, 1995, 1997b), Keer (Keer, 1998)and McCarthy (McCarthy, 1996, to appear) for treatments of aspects of Tiberian Hebrew spirantization within an OT framework. Idsardi (Idsardi, 1998) represent a recent non-OT approach to this problem. There are countless discussions of this phenomenon in pre-OT literature, including but not limited to Malone (Malone, 1993) and Prince (Prince, 1975).

/la+/[10] respectively. It is then possible to set up a classical three-step Duke of York derivation to explain the difference between [bixθ̲ov] and [lixt̲ov]. Early in the derivation a process is necessary that creates the context for spirantization in the derivation of [bixθ̲ov] but not [lixt̲ov]. Spirantization then applies. And finally, a process that undoes the effect of the first process applies, destroying the triggering context for spirantization. This derivation can be represented as follows:

(23) The Prince-explanation for the data in (19): A three-step Duke of York derivation

UR		la+ktob	ba#ktob
Cluster Break-Up	∅ → ə / # C __ C	–	ba#kətob
Spirantization	[-stop] → [+stop] / V ___	la+xtov	ba#xəθov
Schwa Deletion	ə → ∅ / V#C __ C V	–	ba#xθov
Other rules		lixtov	bixθov

Since this is a three-step Duke of York derivation, it is indeed impossible to account for it in Sympathy Theory with cumulativity constraints. However, if ordinary correspondence constraints can be used in OO-correspondence, then it should be possible to explain why the /t/ in [bixθov] spirantizes – in order to be more similar to the isolation form [kəθov]. What needs explaining then is why the same process does not happen in [lixtov].

McCarthy (McCarthy, to appear:8) suggests a straightforward solution for the difference between [bixθ̲ov] and [lixt̲ov] within the framework of OO-correspondence. He suggests that the two prefixes *bi-* and *li-* are of different classes, similar to the well-known English Level I/Level II distinction. Benua (Benua, 1997a, Benua, 1997b) has argued for the English Affix classes, that each Affix class induces its own set of OO-correspondence constraints. If this same principle is transferred to the Tiberian Hebrew example, *bi-* and *li-* activates different OO-correspondence constraints, and through the ranking of these constraints it can be explained easily why *bi-* induces spirantization and *li-* does not. An OO-correspondence explanation is therefore possible. However, since this is a three-step Duke of York derivation, it is not possible to explain this phenomenon with cumulative constraints. And it is exactly this example that prompts McCarthy to accept that OO-correspondence does not work with cumulativity constraints.

3.2.2 An alternative explanation: Sympathetic constraint interaction

The thesis of this paper is that OO-correspondence is also mediated with cumulativity constraints. If this is correct, then an alternative explanation must be found for the Tiberian Hebrew data in (21). The rest of this section presents such an alternative

[10] The symbols # and + were used in early generative phonology to designate different kinds of morphological boundaries – see Chomsky and Halle (Chomsky and Halle, 1968:364-372) and Malone (Malone, 1993:31-32) for more discussion.

explanation. The data in (21) are reinterpreted in such a way that it can be explained as the consequence of Sympathetic constraint interaction, using only cumulative correspondence constraints. The crux of the analysis also centers around the difference between *li*- and *bi*-. However, unlike Prince and McCarthy the relevant difference between these two prefixes is not considered to be a morphological one, but a lexical one. It is claimed that *li*- has a vowel in its underlying form /la-/, but that *bi*- is purely consonantal /b/. This difference in Input forms then leads to different faithfulness violation profiles for the two candidate sets. Since the choice of the Sympathetic candidate is governed by faithfulness violations, Sympathetic constraint interaction has different consequences for the two Inputs – for [bix$\underline{\theta}$ov] a Sympathetic candidate is chosen that spirantizes the underlying /t/, while the Sympathetic candidate in [lix$\underline{t}$ov] faithfully parses underlying /t/.

Since so much of the analysis rests on the difference in underlying form for *bi*- and *li*-, the first part of the discussion below presents a motivation for this difference. After that, the differences between [bix$\underline{\theta}$ov] and [lix$\underline{t}$ov] are explained in a Sympathy Theoretic framework.

Both *bi*- and *li*- are traditionally considered to be prepositions. At first glance they share the same syntactic distribution – both can occur before DP's and before infinitives. However, Prince (Prince, 1975:104-107) argues that the situation is more complicated than this. He claims that there is only one morpheme that can surface as *bi*-, and that this morpheme is indeed a preposition. But there are actually two separate morphemes that can surface as *li*-. One of these is also a preposition with the same syntactic distribution as *bi*-. The other morpheme is not a preposition, but rather a prefix used to mark the infinitive in certain syntactic environments (similar in function to the English "to").

He then shows that there are syntactic, semantic and phonological differences between these two *li*-'s. (i) Syntactically, the infinitive with the infinitive marker *li*- cannot take an overt subject (similar to the English infinitive),[11] while infinitives with true prepositions can. (ii) Also, the infinitive marker *li*- has a limited syntactic distribution. It is used with verbs that Prince dubs "equi-type" (verbs like *be able*, *begin*, *cease*, *finish*, *be willing to*, *desire*, *expect*, *continue*), to express purpose and result, and together with the verb "to be" to express modal meanings such as incipience, possibility and obligation. The prepositions plus infinitive have no such restrictions – they can be used with any kind of verb. (iii) The infinitive marker *li*- has no lexical meaning. It is a purely functional item. The preposition *li*- contributes lexical meaning to the sentence. Like other prepositions that combine with the infinitive, it adds adverbial meaning, usually of time (Gesenius et al., 1910:348, n. 1).

This discussion of the syntactic and semantic differences between the infinitive marker *li*- and the preposition *li*- is intended to show that there are indeed two distinct, albeit historically identical, lexical items. More relevant for the purpose

[11] This is a fact that has gone unnoticed in the grammars of Biblical Hebrew. However, Segal (Segal, 1927) does mention this fact for Mishnaic Hebrew.

of this paper, are the phonological differences between these two lexical items. Aside from the difference in the spirantization of the following infinitive, there are also differences in the vowel associated with these two lexical items. When the infinitive marker is added to a polysyllabic infinitive with initial stress, the vowel of the infinitive marker surfaces as [ɔ], cf. [lɔšéveθ] = the infinitive of /y-š-b/. Unfortunately none of the infinitives to which the preposition *li*- attaches has initial stress.[12] However, when this preposition attaches to a noun with initial stress, the vowel associated with the preposition surfaces as a *schwa* (similar to the prepositions *b* and *k*) – cf. [ləmélex] = "for a king".[13]

(24) Differences between prepositional prefix *li*- and infinitive marker prefix *li*-

	Preposition	**Infinitive marker**
a.	Can take overt subject	Cannot take subject
b.	Can occur with any verb	Limited syntactic distribution
c.	Contributes lexical meaning, usually adverbial expression of time	Contributes no lexical meaning, fulfils grammatical function
d.	Vowel [ə] before polysyllabic initial stressed morpheme	Vowel [ɔ] before polysyllabic initial stressed morpheme

This leads Prince to conclude that there are indeed two different lexical items, both of which can surface as [li-] preceding an infinitive. He distinguishes between them on underlying level by associating junctures of different strength with the two lexical entities: /la#/ for the preposition and /la+/ for the infinitive marker. However, he also states elsewhere (Prince, 1975:91) that his analysis of Tiberian Hebrew phonology is compatible with a view that holds that the mono-consonantal prepositions *b*, *l*, and *k* are vowelless in their lexical forms. It is possible to derive the surface vowels of these prepositions as the consequence of regular epenthetic

[12] This is one of the unfortunate realities the linguist is faced with when dealing extinct languages – often the crucial examples are not attested in the available corpus. In this particular instance, the facts that the preposition /l/ is not used with the infinitive very frequently, that the infinitives of Tiberian Hebrew are usually not stress-initial, and that the available corpus of Tiberian Hebrew is very limited, combine to lead to the result that no examples are attested of the preposition /l/ combining with a stress-initial infinitive.

[13] This is a slight over simplification of the facts, which Prince (Prince, 1975:88) also admits to. There are actually a few examples of the preposition also surfacing with an [ɔ] – see Gesenius (Gesenius et al., 1910:299) for a list. Most of these are examples where the preposition is prefixed to a monosyllabic morpheme (i.e. different from the infinitives discussed above): [bɔze] *in this*, [lɔfe] *to a mouth*. There are also a very small number of examples where the preposition occurs with [ɔ] before polysyllabic nouns. These are all examples of fixed expressions where it can be argued that the combination of preposition + noun has been lexicalized: [lɔveṭaḥ] *peacefully*.

processes. Therefore, although Prince opts to consider the underlying segmentism of the preposition *l* to be /la/, he admits that this is a somewhat arbitrary choice and that /l/ would have done equally well. It is this second option that is assumed in this paper – that is, it is assumed here that the infinitive marker has the underlying form /la/, while the preposition has the form /l/. The preposition *b* having the same syntactic distribution, as well as the same surface vowels as the preposition *l*, is also assumed to be vowelless in underlying form, i.e. /b/.[14]

One other deviation from Prince is that the infinitives are assumed to have a vowel between the first two consonants in underlying representation. There is some support from the literature on Tiberian Hebrew for this. Although Prince initially treats the infinitives as if they derive from forms with initial underlying clusters,[15] he does later state that nothing hinges on this assumption – as with the question of whether the prepositions *b*, *l*, *k* have an underlying vowel or not (Prince, 1975:91). In addition, Idsardi uses underlying forms with vowels between the initial consonants (see p. 68 for instance). In this paper it is therefore assumed that the infinitive has an underlying *schwa* between the first two consonants.

Everything necessary to explain the difference between [bixθ̠ov] and [lixt̠ov] is now in place. The assumptions made here about these two forms are summarized schematically below.

(25)			
	UR	/b + kətob/	/la + kətob/
	"Phonology"	↓	↓
	Output:	[bixθ̠ov]	[lixt̠ov]
		opaque	*transparent*

First consider the explanation of the transparent form [lixt̠ov]. Aside from the transparent spirantization, two other processes apply in this form: (i) the /a/ in the infinitive marker raises to [i]; and (ii) the /ə/ between the first two root consonants delete. The raising of /a/ in a closed syllable to [i] is a widely attested phenomenon in Hebrew phonology.[16] Since this process is not relevant to the problem discussed in this paper, it is ignored in the rest of the discussion. Only candidates that have this raised vowel when required, are considered.

The driving force behind the deletion of the /ə/ is a little more complicated. It is necessary to consider the /a/ in the infinitive marker again to understand the reasons

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[14] Idsarsi (Idsardi, 1998) also treats the prepositions as vowelless. However, he does not distinguish between the infinitive marker and the preposition, and he therefore also posits /l/ as underlying form for what is treated here as the infinitive marker /la/.

[15] See the version of his explanation for the spirantization problem in infinitives in (22) above.

[16] In Malone (1993) this is a two-step process, with /a/ first raised to /ɛ/ via "Checked Midding" (p. 70), and then later raised further to [i] by "General Raising" .(p. 74). For more on this process see also Malone (Malone, 1972).

that the *schwa* in the infinitive deletes. Short, unstressed vowels in open syllables in Hebrew often reduce to *schwa*. This process interacts with many other phonological processes, and also with morphology – see Malone (Malone, 1993:87) for some discussion. Its application is therefore also fraught with opacity. Since the focus of this paper is not on vowel reduction, a rather simplistic view is taken here. A constraint against short vowels in open, unstressed syllables is assumed, and is ranked above the IO-correspondence constraint on vowel featural identity

(26) Ranking for vowel reduction

*v]$_\sigma$ >> IDENT-V$_{IO}$

Speaking in a serialist idiom, once the vowel in the first syllable has reduced to *schwa*, the intermediate form /ləkətob/ results. Such a sequence of *schwa*'s is not allowed – probably as a consequence of a constraint like *LAPSE (Elenbaas and Kager, 1999). When such a sequence is encountered in Hebrew, the second *schwa* typically deletes and the first one turns into an [i].[17] This means that the following ranking is necessary:

(27) Rankings for dealing with sequences of *schwa*

*LAPSE >> MAX$_{IO}$

With these constraints and rankings, it is possible to predict [lixtov] correctly as the Output form for /la + kətob/. This is shown in the tableau below:

(28) /la + kətob/ → [lixtov]

la + kətob	*v]$_\sigma$	*LAPSE	*V[-cnt]	ID-V$_{IO}$	MAX$_{IO}$	*[+cnt]	ID(cnt)$_{IO}$
(a) la.xə.θov	*!					***	***
(b) lə.kə.tob		*!	*!**	*			
(c) lə.xə.θov		*!		*		***	***
(d) ☞ lix.tov				*	*	**	**
(e) lix.θov				*	*	***!	***
(f) la.kə.tob	*!		*!**				

[17] The reason for the first *schwa* to be realized as [i] is probably related to the universal tendency that closed syllables do not tolerate reduced vowels. Since this is not relevant to the problem discussed in this paper, an explanation for this is not included in the discussion here. See also Garr (Garr, 1989) and Coetzee (Coetzee, 1999:122-126) for a some discussion of the relation between schwa and [i].

Faithful candidate (f) loses out due to its unreduced [a], and also due to its three post-vocalic stops. Candidate (a) spirantizes all the stops, but still loses due to its unreduced [a]. Candidate (b) reduces the [a]-vowel, but keeps the stop consonants. It loses due to the stop consonants, and due the violation of *LAPSE introduced by the vowel reduction. Candidate (c) reduces the [a] and spirantizes the stop. However, because of the vowel reduction it now fatally violates *LAPSE. Candidate (e) avoids the *LAPSE-violation by deleting a vowel. However, it then spirantizes a stop without reason, and loses because of this. Therefore candidate (d) with vowel deletion and spirantization only in post-vocalic position is chosen as output.

Now consider the opaque form [bixθov]. To explain the transparent part of the phonology of [bixθov], only two more constraints are needed. Tiberian Hebrew allows no tautosyllabic consonant clusters. The underlying initial cluster in the input form /bkətob/ must therefore be resolved through either deletion or epenthesis. Hebrew opts for epenthesis. For this the following ranking is needed:

(29) Ranking for epenthesis

MAX$_{IO}$, *COMPLEX >> DEP$_{IO}$

However, simply adding these constraints will not result in the selection of the desired Output. The transparent winner [bixtov] will be selected. This is shown in tableau (30) below. The faithful candidate (e) loses because it has stops post-vocalically and also because of its tautosyllabic consonant cluster. Candidate (a) spirantizes the stops, but still loses due to its consonant cluster. Candidate (b) avoids all of the fatal violations of the faithful candidate by spirantizing post-vocalic stops and by inserting a vowel to break up the consonant cluster. As a result of the epenthesis, it fatally violates *LAPSE. Both candidates (c) and (d) avoid the consonant cluster by vowel epenthesis. In both of these candidates the second vowel is then deleted to avoid the *LAPSE-violation (cf. candidate (c) without this deletion). Both candidates (c) and (d) avoid the *V[-cnt] violations of the faithful candidate by spirantizing the underlying stops. However, in candidate (d) the underlying /t/ is spirantized even though it does not occur in post-vocalic position in this candidate – i.e. spirantization applies where it is not licensed by the environment. Because of this, candidate (c) is chosen as the winner. But this is not the desired outcome. Candidate (d) with its unmotivated/opaque spirantization is the actually observed output form.

This tableau makes it easier to see which candidate must be chosen as the Sympathetic candidate and which constraint must be the selector constraint. To select candidate (d) in tableau (30), it is necessary to have a constraint that is violated by (c) but not (d). The only difference between these two candidates is that (d) spirantizes the post-consonantal /t/ while (c) does not. This earns (d) an additional violation in terms of IDENT(cnt)$_{IO}$. Both of candidates (a) and (b) also spirantize this /t/, and therefore they share candidate (d)'s IDENT(cnt)$_{IO}$-violation. If either of (a) or (b) are selected as the Sympathetic candidate, then the additional violation of candidate (d) in terms of IDENT(cnt)$_{IO}$ can be motivated via Sympathetic constraint interaction.

With ✭DEP$_{IO}$ as the selector constraint, candidate (a) is chosen as the Sympathetic candidate. This is illustrated in tableau (31). Between the candidates obeying the selector constraint ✯$\text{D}{\scriptsize \text{EP}}_{IO}$, candidate (a) is the most harmonic and is therefore chosen as the Sympathetic candidate. Candidate (c) does not accumulate the faithfulness violations of candidate (a),[18] while the desired winner (d) does. By ranking ❀CUMUL above *[+cnt], the correct winner is chosen.

The last detail to be checked, is to ensure that additions and changes made since [lixtov] was last discussed in tableau (28) do not cause problems for this form. Tableau (32) re-evaluates this form with all the changes and additions, and shows that the correct winner is still predicted there. In this tableau all of the candidates obey the selector constraint. The Sympathetic candidate is therefore the most harmonic candidate, which will also be the actual output. The Sympathetic candidate (d) violates IDENT(cnt)_{IO} twice, and also violates each of MAX_{IO} and DEP_{IO} once. The faithful candidate (f) of course does not violate any of these constraints, and therefore does not accumulate the faithfulness violation of the Sympathetic candidate. Candidate (f) therefore violates ❀CUMUL. Not one of candidates (a), (b) or (c) share the MAX_{IO}-violation of the Sympathetic candidate, and therefore all three of them also violate ❀CUMUL. For the rest this tableau is the same as (28).

[18] When ❀CUMUL evaluates a candidate, it does not simply count the number of violations in terms of faithfulness constraints. It actually requires every specific faithfulness violation in the Sympathetic candidate to be shared by the candidate under evaluation – see McCarthy (McCarthy, to appear:21-26) for discussion. Although candidate (d) has the same number of violations as Sympathetic (a) in terms of IDENT(cnt)_{IO}, one of (a)'s violations is for unfaithful realization of /t/ as /θ/. This is not shared by (d), and therefore (d) violates ❀CUMUL.

(30) Not quite yet /b + kətob/ → [bixθov]

b + kətob	*v]σ	*LAPSE	*V[-cnt]	*COMPLEX	ID-V$_{IO}$	MAX$_{IO}$	*[+cnt]	ID(cnt)$_{IO}$	DEP$_{IO}$
(a) bkə.θov				*!			**	**	
(b) bə.xə.θov		*!					***	***	*
(c) ☞ bix.tov						*	**	**	*
(d) ☹ bix.θov						*	***!	***	*
(e) bkətob			*!*	*!					

(31) /b + kətob/ → [bixθov] with Sympathetic constraint interaction

b + kətob	❀CUMUL	*v]σ	*LAPSE	*V[-cnt]	*COMP	ID-V$_{IO}$	MAX$_{IO}$	*[+cnt]	ID(cnt)$_{IO}$	✯DEP$_{IO}$
(a) ❀ bkə.θov					*!			**	**	✓
(b) bə.xə.θov			*!					***	***	*
(c) ☜ bix.tov	*!						*	**	**	*
(d) ☞ bix.θov							*	***¡	***	*
(e) bkətob	*!			*!*	*					✓

(32) /la + kətob/ → [lixtov] with Sympathetic constraint interaction

	la + kətob	❀CUMUL	*v]$_\sigma$	*LAPSE	*V[-cnt]	*COMP	ID-V$_{IO}$	MAX$_{IO}$	*[+cnt]	ID(cnt)$_{IO}$	✩DEP$_{IO}$
(a)	la.xə.θov	*!	*!						***	***	✓
(b)	lə.kə.tob	*!		*!	*!**		*				✓
(c)	lə.xə.θov	*!		*!			*		***	***	✓
(d)	☞☜❀lix.tov						*	*	**	**	✓
(e)	lix.θov						*	*	***!	***	✓
(f)	la.kə.tob	*!	*!		*!**						✓

By postulating different underlying forms for the infinitive marker /la/ and for the preposition /b/, it was possible to explain the differences in spirantization in the infinitives associated with these two morphemes in a way that does not involve a three-step Duke of York derivation. Because of this, it was possible to use cumulative correspondence constraints rather than ordinary correspondence constraints.

4. Conclusion

Under the standard view of OO-correspondence constraints, they make exactly the same type of comparisons as ordinary IO-correspondence constraints. The only difference between OO and IO-correspondence constraints has been the comparison form. In IO-correspondence it is the Input, and in OO-correspondence it is the Output of a morphologically related Input. The types of comparison that OO-correspondence constraints can do, are exactly the same as that that IO-correspondence constraints can do. They can demand that the Output candidate under evaluation (the Affiliate) agrees with the comparison form (the Base) in any individual arbitrary feature.

The same is not true of Sympathy constraints and IO-correspondence constraints. Although Sympathy constraints were initially also viewed as being the same as IO-correspondence constraints with only a different comparison form, McCarthy (McCarthy, 1999, McCarthy, to appear) has later shown that this is not correct. Using ordinary correspondence constraints to mediate Sympathetic correspondence predicts that so-called multi-step Duke of York derivations are possible. Since such derivations are most probably not attested in natural language, a more restricted version of correspondence constraints is necessary to mediate Sympathetic interaction. This is why cumulative constraints were introduced. These constraints are still able to simulate the kind of Sympathetic correspondence that is actually observed, but they cannot simulate multi-level Duke of York derivations.

However, in the same way that ordinary correspondence constraints can induce multi-level Duke of York derivations in Sympathy theory, ordinary correspondence constraints in OO-correspondence can also do this. For this reason it has been argued in this paper that OO-correspondence must also be mediated by cumulative constraints. Using cumulative constraints in OO-correspondence excludes the trans-derivational version of a multi-step Duke of York derivation. This move is desirable in at least two respects: First, it results in a more restrictive theory – by the exclusion of trans-derivational multi-step Duke of York derivations. Secondly, it unites OO-correspondence and Sympathetic correspondence – both versions of non-IO-correspondence. A third kind of non-IO-correspondence, Base~Reduplicant correspondence, has not been discussed in this paper. However, it is proposed that BR-correspondence should also be mediated by cumulative correspondence constraints, rather than ordinary correspondence constraints. All non-IO-correspondence will then be united.

For the proposal of this paper to be correct, there cannot be any examples of non-IO-correspondence induced phenomena that require ordinary correspondence constraints. One possible example of such a case, spirantization in the Tiberian Hebrew infinitive, was reanalyzed here in such terms that cumulative constraints can be used to explain the process. This is only one example, however, and it remains to be determined whether all similar examples of OO and BR-correspondence can be reanalyzed in a similar way.

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