An Optimality Theoretic Analysis of the Historical Development of Liquids from Late Common Slavic through Old Church Slavic and into Middle/ Modern Bulgarian

Christian Griffin

Yale University

Senior Essay in Linguistics

1 May 2009

Advisor Darya Kavistkaya

TABLE OF CONTENTS

1. Introduction

Generative phonology strived for years to account for complex phonological alternations using rule-based analyses with much success. These analyses rely upon rule ordering, cyclicity, and distinct levels of phonology associated with specific morphology. Optimality Theory (OT) evaluates candidates based on surface forms and generalised markedness preferences within a language. The rule-based model of linguistics has been the primary method of research in Historical Linguistics and also relies heavily on rule order to predict the correct results. Is there a way to model sound change in OT? The generalised form of constraints captures something more fundamental about language than the specific rules used in rule-based theory.

In this paper I will undertake to outline both a micro- and macro- model for how change procedes in OT. The micro-level involves using a probabilistic approach to OT (Stochastic OT) that accounts for each utterance and therefore model the gradual movement of constraints through a continuous ranking field. When complete re-ranking occurs there is then the possibility that the lexicon will encode the new output form as a new input. This lexicalization is what ultimately drives sound change. The macro-level uses partially ordered constraint rankings to demarcate and characterize the stage of variation predicted by the Stochastic OT. I will then apply this model to the development of liquid consonants from Late Proto-Slavic, into Old Church Slavic, also known as Old Bulgarian, and then into Middle/Modern Bulgarian. The liquids were conditioned by two major sound changes: metathesis during the 'Law of Open Syllables' and syllabification during the 'Fall of the Jers'. After the creation of the syllabic liquids and their subsequent prohibition from Bulgarian the syllabic liquids exhibit interesting vocalization patterns that led to opacity in the modern language.

2. Theoretical Background

In this section I will introduce the theoretical framework from which I will develop a model of linguistic change over time, namely Optimality Theory, the multiple grammars model, Stochastic OT, and the Gradual Learning Algorithm (GLA). I will also review previous historical OT analyses and the different mechanisms proposed to incorporate variation and change into OT.

2.1 Optimality Theory

Optimality Theory (Prince & Smolensky 1993, 2004) posits that there are no rules that govern synchronic alternations in language production. The mechanism of phonological alternations in OT is a set of violable and universal constraints that are related to each other in a ranking. This ranking prioritizes the more highly ranked constraints allowing less important constraints to be violated in order to satisfy more important constraints. In principle, constraint-based systems allow the linguist to describe complex layers of patterns using 'wide brush strokes'. Default preferences can easily be defined by the existence of very low ranked constraints that are often violated and therefore not active, but that also may surface to define the 'elsewhere' case. Rule-based phonologies strive to maintain the correct predictions about the 'elsewhere' case by producing multitudes of extremely specific rules that must be applied in a specific order and fashion (cyclic at points, others not; sensitive to prosody sometimes, others not). Constraints can capture simple universal preferences. These constraints can find their roots in physiological aspects of speech or other innate preferences enhancing the naturalness of the theory.

Production in OT posits that a mechanism GEN(ERATOR) creates an infinite list of candidates that may satisfy or violate any of the constraints in the the constraint hierarchy (CON). This infinite list is called the Richness of the Base. The candidates are evaluated by EVAL and the candidate that violates the fewest most highly ranked constraints is selected as the optimal candidate. GEN may produce any amount of structure in order to attempt to satisfy more constraints, but is de facto restricted by the amount of structure given to GEN in the input. EVAL must be able to take any possible input and map it to a grammatical output.

All constraints in traditional OT are universal and violable. This means that every language has the same finite set of constraints. Aside from lexical information (the phonological shape of each morph) the only distinctions cross-linguistically arise from a different ranking of the same set of constraints. Constraints are defined in two major categories: those that prefer a more stable, less marked form, or Markedness Constraints; and those that maintain the representation of the input in the output, or Faithfulness Constraints. Faithfulness constraints establish a correspondence between the input and the output and assign a violation for each minimal difference between the two. The concept of Markedness in language is not confined to OT. Languages have naturally more stable forms. Markedness arises when less stable forms are selected. Neither Markedness nor Faithfulness can control the patterns of language alone. A language where faithfulness was undominated would exhibit an impractical amount of phonological distinctions that bear a semantic value as every slight shade of difference encoded in the lexicon would surface in the output. A language with markedness undominated hardly fares better: all phonemes would collapse into the most unmarked form. There would not be enough phonological distinction to support a complex semantic system. Languages are therefore controlled by the conflict between the desire to encode distinct meaning (faithfulness) and the desire to collapse complex structures into a less marked form.

Candidates in OT are evaluated in parallel with a one step mapping from the input to the optimal output by means of a tableau. This parallelism predicts that forms will not procede through intermediate forms to get to the output. Consider the sample tableau below. Candidates label rows while constraints are listed across the top of the columns with the most highly ranked constraint to the left. Violations are notated by a * in the cell corresponding to the appropriate candidate and the appropriate constraint. When a candidate incurs a fatal violation it is no longer considered by EVAL and the fatal violation is marked by a !. The optimal candidate is denoted by a ☞.

(1) Sample Tableau 1:

/input/	Constraint A	Constraint B	Constraint C
☞ a. output		*	
b. output	*!		
c. output		*	*!

Here we see how both a. and c. have a violation of Constraint B. This constraint cannot choose between the two candidates so the work falls to Constraint C which prefers a. Constraints can be typologically defined to assign more than one violation if necessary: EVAL handles these qualitative constraints in the same way as constraints that may only assign a single violation. Consider the following case:

(2) Sample Tableau 2:

/input/	Constraint A	Constraint B	Constraint C
☞ a. output		*	*
b. output	*!		
c. output		*	**!

Here a. is still preferred because it has fewer violations of Constraint C. Dashed lines separating constraint columns denotes an optional ranking.

Another OT notation that I will make use of in this analysis is that of the comparative tableau (or more specifically a combination tableau). A comparative tableau contains Ws and Ls placed to the left of the violations (or lack thereof) of the losing candidates. Each W or L compares that losing candidate with the winning candidate and asks one simple question: which candidate would this constraint (and this constraint only) prefer? If the constraint prefers the winner a W is placed in the cell. If the constraint prefers the loser an L is placed in the cell. After completion of the comparison, a simple test can tell whether or not the ranking portrayed in the tableau selects the correct candidate and also the minimal rankings needed. In each row the must be at least one W to the left of every L. Consider the sample tableau below:

(3) Sample Tableau 3

/input/	Constraint A	Constraint B	Constraint C
☞ a. output		*	*
b. output	W*!	L	L
c. output		*	W**!

Here it can be clearly seen in the row for candidate b. that Constraint A must dominate Constraint B.

The purest version of OT maintains the strict guidelines of parallelism and richness of the base outlined above. The OT tableau presents an extremely elegant snapshot of the mechanism of a single production of a single utterance. A language, however, does not consist of any single utterance or even one static state of affairs, but rather a constantly growing set of utterances by each speaker in the linguistic environment. There must be a theory that combines the elegance of synchronic, static OT with the living, changing sociolinguistic context that defines the population of native speakers of a language. We consider now a form of OT that reflects the changing linguistic input perceived by the speaker as well as the changing sociolinguistic context

2.2 The Multiple Grammars Model

The multiple grammars model accounts for the variation within one speaker by positing that multiple competing grammars may be selected for the production of an utterance (Anttila 2002, Kiparsky 1993). Support for this idea is not hard to come by: consider how a bilingual person navigates his/her L1 and L2 (two distinct grammars) fluently and often in quick succession. The distinct grammars of L1 and L2 must switch on and switch off to accommodate the speakers choice of language. On a more general level, speakers react to immediate context. Different registers of speech are chosen depending on social context. Factors such as mood, physical interference, and foreign language immersion can alter the way an utterance is produced in a speaker's native language. This ability to tailor production to the context (in a modal fashion) supports the concept of a set of possible grammars available for any given utterance.

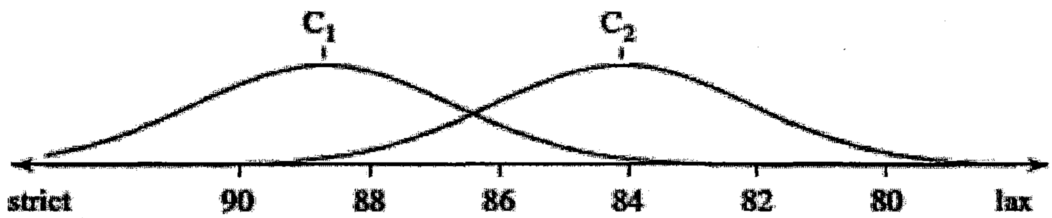
In terms of OT, the multiple grammars model predicts that one of many full rankings of CON can be chosen to produce an utterance. When taken to its most extreme form, the multiple grammars model predicts that each speaker has every possible ranking available to them at all times and production is regularized within a language when a certain subset of all possible constraint hierarchies is preferred over the rest. This set of preferred grammars is refined as more linguistic input is perceived. Errors and other non-standard productions cause rarely selected grammars to be selected and thereby strengthened. Thus variation can occur within a linguistic population. When different grammars that prefer different output forms are both activated a significant amount, both surface forms may be produced causing variation. The frequency of this variation depends on the relative preferences for different grammars, but also on the amount of grammars that predict a specific form. If the factorial typology of a certain set of constraints prefers output a. 33.3% of the time and output b. 66.6% of the time and if the grammars are equally weighted, we expect to see these percentages reflected in actual production: a. will surface in one out of three cases and b. the other two.

The multiple grammars model in its purest form make some unappealing predictions about cognitive processing. It seems implausible to predict that all possible grammars are constantly encoded in the speakers brain. The logical extension of this objection is to encode the ability to use any grammar in the functional mechanics of OT.

2.3 Stochastic OT and the Gradual Learning Algorithm

Consider a form of OT where each constraint is placed on a continuous ranking scale with respect to its peers as opposed to being categorically ranked with every other constraint. Each constraint is ranked over a set of values in the shape of a bell curve representing different productions with slightly different ranking for each constraint. These distribution may overlap creating potential productions with differing relative rankings of the two constraints enabling variation. Each production has a selection point where they access the rankings of the constraints. When this point falls in the domain of an overlapping ranking distribution it will sometimes select a selection point with C1 >> C2 and other times with C2 >> C1. This is the locus of variation.

(3) Overlapping ranking distributions (Bresnan, Dew, and Sharma 2007: 333)



A certain amount of variation is expected within a linguistic population as we see variation between speakers and between utterances produced by the same speaker. This natural 'noise' is the imperfection in the stability of the language that allows linguistic change to occur. This noise is essential to the continuous ranking scale described above. This makes this model a stochastic form of OT. The Gradual Learning Algorithm (GLA) (Boersma & Hayes 1999) proposes that every new utterance that is perceived affects the relative ranking of the active constraints. When a non-standard production is heard, the active constraints weaken or strengthen a little bit to accommodate the new data. As more linguistic input is considered the distributions of the constraints shifts to take the shape of the adult language. The GLA and Stochastic OT model variation in a probabilistic fashion, allowing for new linguistic input to influence subsequent productions. Much research has gone into developing successful analyses with a Stochastic approach. An analysis of variation in the development of English as a second language in Brazilian Portuguese. This variation can be modeled well in a Stochastic OT using lots of data collected in a small amount of time. Stochastic OT requires a plethora of frequency data with a good amount of temporal resolution and lends itself to analyses of modern linguistic experiments rather than historical sound change.

The GLA is a model for acquisition in children which predicts things such as acquisition order of syllable structure according to a factorial typology of simple syllable structure constraints. The GLA can be extended to include a view of an adult grammar that is constantly changing with the entire linguistic community (Adam 2002). As certain distributions of the constraints are increasingly favoured in the language the entire community begins to reflect this preference. In the cases of language change over time, the distributions of the constraints have shifted so far that the constraints are fully re-ranked. Once constraint re-ranking occurs a new surface form replaces the old one completely. There is no longer any variation.

At this point a process called Lexicon Optimization takes place to choose the most logical underlying representation for a given input. The speaker chooses an underlying representation (UR) that when mapped to the correct output violates the least faithfulness constraints. This concept has existed since the genesis of OT as it was originally proposed by Prince & Smolensky (1993), but plays a special role in an historical analysis by defining when the UR changes. Stochastic OT, the GLA, and Lexicon Optimization consist of the mechanisms that drive linguistic change on a micro-level. As preferences throughout a linguistic community shift, each speaker adjusts their constraints to conform to the full linguistic contact they have experienced. Over time variation can move the language in one direction or another by slowly demoting or promoting constraints. As constraints move in the continuous ranking hierarchy, their relative relationships change. When constraint ranking domains separate after a period of variation the constraints are fully re-ranked and lexicon optimization may occur. Lexicon optimization reduces the number of faithfulness violations by eliminating features in the input that are no longer ever present in the output. This theory promotes the idea that URs should be as specified as possible. Features that exhibit alternations remain under-specified in the UR, while all stable aspects of output forms are encoded directly in the input. This view is contradicted by many traditional generative frameworks that strive to keep the UR as under-specified as possible, driving most of the heavy lifting of phonology to the processes of cyclicity and ordering of rules. OT leaves most of the specification up to features directly seen in the input and not the process outlines by markedness and faithfulness constraints.

2.4 Partially Ordered Constraint Sets

The multiple grammars model in its purest form predicts the ability to select any grammar containing the same set of constraints. The grammars are not organizationally related. They, of course, have many logical implications between them as the set of all possible grammars is simply a factorial typology, but the relations are not specified in that form of the theory. Fully specified hierarchies of constraints, however, can be represented as a set of binary minimal rankings. If one minimal ranking is eliminated a partially ordered constraint set results (Anttila & Cho 1980). This hierarchy encompasses two distinct possible fully specified ranking hierarchies. When the partially ordered hierarchy is selected there is an equal chance of producing an output with one fully ranked grammar or the other. Here the locus of variation is an entire stage of variation where one (or more) minimal rankings are weakened or eliminated. The possible grammars available at any one time are only one minimal ranking away.

The entire set of possible grammars can be visualised in a grammar lattice. Anttila & Cho analyse r-∅ alternation in English. Lexical r is deleted word finally if followed by a consonant, but is maintained is followed by a vowel. An epenthetic r is inserted postvocalically in word final position when followed by another vowel, but is not when followed by a consonant. Both of these processes exhibit variation in certain dialects of English. Three dialects of English exhibit stable versions of these processes and two exhibit variation. The constraints Anttila uses to capture these alternations are as follows:

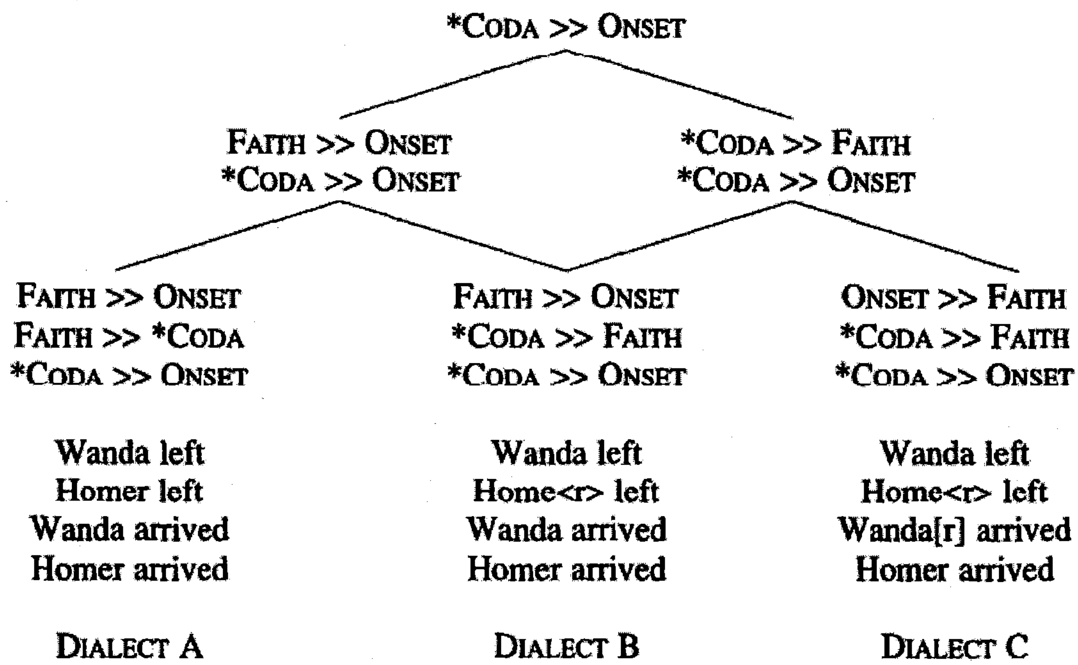
(4) FAITH: Corresponding segments from the input should remain unchanged in the output. Do not delete or epenthsise

ONSET: Syllables must have onsets.

NOCODA (*CODA): Syllables should not have consonants in coda position.

The three stable dialects each have a fully specified grammar, while the two variable grammars are represented as the conjunctions of two dialects. The grammar lattice for this alternation is as follows:

(5) Grammar Lattice



The grammar lattice makes certain predictions about the possible direction of sound change over time. A change with an initial state being Dialect A must proceed to a variable stage that incorporates both Dialect A and Dialect B. From here a fully specified grammar can be chosen, either Dialect A or B. If Dialect B is selected there is a possibility for lexicon optimization to occur and thus full historical change.

The partially ranked constraint set is the locus of variation. The period of partial ordering can correspond to the period of overlap in the Stochastic model of variation and change. The Stochastic model requires lots of frequency data in order to yield interesting analyses, a challenging task when dealing with historical data. I propose that the partially ordered constraint set analysis can serve to demarcate the major periods of development that would be predicted in a finer-grained investigation utilizing some probabilistic theory of language acquisition. This makes the prediction that all linguistic change is accompanied by a period of variation. The opposite, however, is not true: variation does not necessarily give way to linguistic change. Variation may be constant where two constraints stay closely ranked for a long period of time or variation may reverse direction and revert back to the initial state.

Analyses of variation have utilized the partial ordering theory to account for variation in Vimeu Picard (Auger 2002, Cardoso 2001). Auger discusses variation of the insertion of epenthetic vowels to break up consonant clusters. She proposes an analysis that requires a crucial non-ranking to derive variation in the spirit of the partially ranked constraint. She performs a corpus-based study noting that variation across the entire linguistic population is greater than within one speaker. This is a predictable situation: there is more chance for variable production when the set of utterances is categorically larger. Auger points out that an individual's grammar is a subset of the community grammar. This is harmonious with the GLA prediction that a specific speaker only ever has access to a certain subset of all utterances in a language. While the entire language population may obey certain grammars, smaller groups often characterize specific subsets (dialects, sub-dialects, etc) and are the primary source of variation within the whole linguistic population.

2.5 Previous OT Analyses of Variation and Sound Change

2.5.1 Zubritskaya (1997) - The Mechanism of Sound Change in Optimality Theory

Zubritskaya proposes that sound change should proceed as fixed sub-hierarchies of the constraint ranking that are weakened or strengthened as a whole over time. These sub-hierarchies are markedness scales such as the sonority sequence. Zubritskaya analyses the loss of regressive palatal assimilation across consonant clusters in Modern Russian. She proposes the following three constraints in a fixed ranking that militate against coarticulation with each place of articulation:

(6)

*Dor	>>	*Lab	>>	*Cor
|		|		|
Cor		Cor		Cor

The following constraint drives the regressive assimilation:

(7) PAL: If there is a dependent feature, then it must be maximally associated

PAL begins highly ranked: above all of the *Co-articulation constraints in order to trigger the full assimilatory spreading. As the roces is deleted form the language, PAL weakens down through the fixed heirarchy. We see [+dorsal] blocking the assimilation first and then [+labial] and then [+coronal] in accordance with her prediction about the direction of change.

Zubritskaya is analysing an very prevalent aspect of linguistic change: a sensitivity to natural markedness scales in the Universal Grammar (UG). This generalisation is easily captured in OT because the typological nature of the constraints targets markedness and relative markedness. A potential prediction of this analysis, however, is that language change is directed or goal driven. Prima facie continuous movement down markedness scales would produce an extremely efficient unmarked language, especially after this much time. The reality is in fact very different. Sound change can procede circularly because different markedness constraints can be satisfied in many different ways violating many other different markedness constraints, providing a new direction of movment (Boersma 2000, Zuraw 2005).

2.5.2 Nagy & Reynolds - OT and Variable Word-Final Deletion in Faetar

Nagy and Reynolds propose a system of floating constraints to account for the variation in Faetar. They propose that floating constraints spend an equal amount of time in every position within the specified domain. The model predicts a large amount or potential grammars, but many predict the same forms. The floating constraints they employ account for the frequency of each form in Faeter. This idea is another approximation of the way that a Stochastic system would account for change: the floating constraint has a wide distribution over a group of constraints. The theory predicts the floating constraint to be equally in every available position, which seems to be counterintuitive to a theory of distribution such as Stochastic OT.

2.5.3 Hutton (1996) - The Synchronic Base Hypothesis

Hutton proposes the following hypothesis about the input cadidates:

> (8) The Synchronic Base Hypothesis: All input candidates produces by GEN are based on the current output form. Earlier forms of the language are no longer available as underlying representations.

This is also very harmonious with the view of the GLA. Perception drives production here: once a UR has been eliminated from the language via Lexicon Optimization it cannot influece output forms anymore. (Holt 1998)

2.5.4 Kostakis (2009) - Vestige Theory

Andrew Kostakis proposes Vestige Theory which functions very much like a regular Output-Output Correspondence constraint. When ever a constraint is demoted in the ranking, it leaves behind a vestigal copy that enforces the same preference as seen historically, but much more weakly than before. The constraint relates the output of the modern tableau with that of the historical tableasu. Kostakis has proposed a theory of some variation caused by historical constraints by explicitly making a typological reference to an older form. While this analysis is worthwhile, it contradicts the basic tenent of the Synchronic Base Hypothesis.

2.6 Summary of Theory

The most viable way to account for synchronic variation in a speaker is using a Stochastic approach allowing constraints to be ranked on a continuum over a set of values. As the linguistic inputs change to prefer certain forms in variation. Constraints change their distributions over the continuum through a constant process of re-averaging the full linguistic input. This mechanism of change proceeds along markedness scales and can be captured using the re-ranking of very general preferences in a language. As constraints finally re-rank themselves, lexicon optimization may take place to simplify the UR of the output form, enforcing the Synchronic Base Hypothesis.

Stochastic OT is challenging to perform in a historical context due to the lack of specific acoustic data. In order to model the shape of change that the GLA predicts, I employ the mechanism of partially ranked constraint sets and change through a grammar lattice as in Anttila (1998). The particular use of OT is to define markedness and allow many different faithfulness constraints to repair the markedness in many different ways. I will show how in an OT framework related phenomena triggered by the same markedness constraints can be visualised in parallel, relating them for the first time.

3. A Historical OT Analysis of Liquid Metathesis, Syllabicity, and Vocalisation From Late Common Slavic, through Old Church Slavic, and finally into Middle/Modern Bulgarian

Proto-Slavic sound changes can be grouped into two broad groups resultng from two very broad preferences. First, regressive assimilation of palatalisation caused the quality of consonants to change drastically during this period in three shifts, known as the First, Second, and Third, Palatalizations of the Velars. The other preference that emerged toward the end of the Slavic unity was a movement towards only rising sonority within a syllable. This change has been known as 'The Law of Open Syllables'. This term is somewhat of a misnomer as there was not a unique repair that satisfied this preference for rising sonority, but rather a group of repairs came together to accomplish the task.

3.1 The Law of Open Syllables

The trend towards rising sonority was satisfied in many different ways over a long period of time: starting in the late 6th Century and continuing until the late 9th Century. First, consonant clusters throughout Proto-Slavic were greatly simplified through deletion or dissimilation. Geminate fricatives were reduced to singleton consonants. Geminate consonants and some stop clusters such as tt/dt/kt underwent dissimilation to yield st. Clusters beginning with a stop consonant were also mostly resolved through deletion. Second, almost all diphthongs were reduced to a singleton vowels, changing their quality. Other, more sonorous segments, that were not subject to the stop deletion also participated in alternations with their adjacent vowels. Nasal consonants after a vowel and in the initial position of a cluster were deleted and their resulting nasal feature was spread onto the adjacent vowel resulting in a new set of nasal vowels. The last notable development that finally resolved the Law of Open Syllables was the Metathesis of the Liquids.

3.2 The Liquid Metathesis

Liquid consonants, r and l underwent an interesting repair to satisfy the Law of Open Syllables. Singleton liquids were unaffected as they occupied onset positions and did not interrupt the necessary rising pattern in each syllable. The sequences we are specifically examining are those closed syllables ending in a liquid in the shape of the following: CoRC, where C is any consonant and R is any liquid. Proto-Slavic tolerates these 'diphthong-like' sequences, but as rising sonority became a stronger force in the language there arose a need to clear the liquid out of the coda position. This was accomplished through metathesis of the vowel and the liquid with an accompanying change in quality of the vowel. This change in quality is not the subject of analysis here and thus will not be included in the tableau presentation.

First let us examine the constraints that will be active in this historical sound change. First I will introduce the set of faithfulness constraints that help govern these alternations:

(9) Faithfulness Constraints:

MAX: No deletion.

DEP: No epenthesis.

LINEARITY: The precedence structure of the input must be maintained in the output. (No metathesis)

These faithfulness conatraints refer to a relationship between the input and the output. Any minimal differences between the input and the output will incur a violation.

Now let us consider the markedness constraints that will help to govern this change. A set of standard syllable structure constraints is as follows:

(10) Syllable Structure Markedness

*COMPLEXONSET: Onset consonants should not be complex.

*ComplexCoda: Coda consonants should not be complex.

Onset: Syllables must have onsets

NoCoda: Syllables must not have consonants in coda position.

Now let us consider the initial situation in Proto-Slavic. Here we see that complex onsets are perfectly acceptable in Proto-Slavic (consider a PrSl form such as *bratrъ) and so we assume an extremely low ranked *ComplexOnset. Consider now the input /borda/ 'beard':

(11)

/borda/	Max	Dep	Linearity	NoCoda	*CompOns
☞a. bor.da.				*	
b. bro.da.			W*!	L	W*
c. bo.da.	W*!			L	
d. bo.ro.da.		W*!		L	

Here we see that to maintain the shape of the input, we must have all of our Faithfulness constraints ranked completely above any of our Markedness constraints. There are no necessary rankings between the faithfulness at this point. What we do see there is that candidates such as c. /d. that resolve our markedness violation via deletion or epenthesis are blocked. These process are not active in this situation. The minimal rankings we have now for PrSl are as follows:

{Max, Dep, Linearity} >> NoCoda

In this initial state the coda r is maintained because NoCoda is not ranked above any faithfulness constraints.

The rankings that drive the rising sonority preferences going into Old Church Slavic are precisely these three minimal rankings. At the beginning of rising sonority, consonant clusters were reduced by deletion and dissimilation. The two faithfulness constraints governing these are MAX and IDENT(PLACE). NOCODA became preferred the language for some sociolinguistic reason. As errors and other non-standard utterances placed NOCODA higher on the continuous ranking scale, the overall average distribution of the constraint began to shift upwards towards the lower ends of these faithfulness constraints. By the late 8th Century, when the liquid metathesis was occurring NOCODA had an overlapping distribution with LINEARITY. I will represent this intermnediate stage of variation using a partially ranked constraint set. The minimal ranking that is deleted here is that between:

LINEARITY >> NOCODA

Consider then the same input but with this minimal ranking missing:

(12)

/borda/	MAX	DEP	LINEARITY	NOCODA	*COMPONS
☞a. bor.da.				*	
☞b. bro.da.			*		*
c. bo.da.	W/W*!		e/L	L/e	e/L
d. bo.ro.da.		W/W*!	e/L	L/e	e/L

Here we see that there is no way to decide between candidates a. and b. definitively. This representation implies a total equality of ranking, as there is no concept of qualitative ranking in the partial ranking model. This is an illustration of the state of the grammar when the most variation is experienced. We predict both a. and b. 50% of the time. This is representative of the period of variation, when the distributions of these two contraints are passing through each other.

Now consider a fully re-ranked grammar, one after the Law of Open Syllables was in full force:

(13)

/borda/	MAX	DEP	NOCODA	LINEARITY	*COMPONS
☞a. bra.da.				*	*
b. bar.da.			W*	L	L
c. ba.da.	W*			L	L
d. ba.ra.da.		W*		L	L

Here we see a full ranking of

NOCODA >> LINEARITY

This simple case is mirrored by a case involving an l. Consider the PrSl input /kolda/:

(14a)

/kolda/	LINEARITY	NOCODA	*COMPONS
☞a. kol.da.		*	
b. klo.da.	W*!		*

The PrSl form is optimal because no markedness can affect change here.

(14b)

/kolda/	LINEARITY	NOCODA	*COMPONS
☞a. kal.da.		*	
☞b. kla.da.	*		*

Variation opccurs becuase of the overlapping ranking distribution between LIN and NOCODA.

(14c)

/kolda/	NOCODA	LINEARITY	*COMPONS
a. kal.da.	*		
☞b. kla.da.		*	*

The metathesis is complete.

This metathesis is regular throughout the language when the correct environment is present. Consonants to the right of the liquid will be maintained as the onset of the folowing syllable if the resulting syllable does not violate the Sonority Sequencing Principle, embodies by the following constraint:

(15) SONSEQ: Consonant clusters must rise in sonority in the onset and fall in the coda.

The sonority scale is a markedness scale ordering types of segments in terms of how sonorous they are. The scale can be divided into coarse or fine distinctions depending on the typology of the language. Here we will work with a rather coarse definition for a particular reason. Many of the clusters allowed in OCS started with fricatives then stops. In a fine-grained view of sonority stops are less sonorous that fricatives. For this analysis we employ the following scale:

(16) vowels >> nasals >> liquids >> obstruents

This typological distinction specifically allows sequences such as st and zd. Consider now the PrSl input /borzda/ 'furrow':

/borzda/	SONSEQ	LIN	NOCODA	*COMPCOD	*COMPONS
☞a. bor.zda.			*		*
b. broz.da.		W*!	*		*
c. bro.zda.		W*!	L		W**
d. borz.da.			*	W*!	L

Here we see the effect of *COMPCOD for the first time, which prefers the fricative-initial syllable parsing to avoid a complex coda. You also see the minimal ranking for PrSl:

*COMPCOD >> *COMPONS

NOCODA should be sufficient to drive the metathesis in this case. Consider the intermediate stage where variation occurs:

(17)

/borzda/	SONSEQ	LIN	NOCODA	*COMPCOD	*COMPONS
☞a. bar.zda.			*		*
b. braz.da.		W/e*	e/W*!		*
☞c. bra.zda.		*			**
d. barz.da.		e/L	e/W*	W/W*!	

In the above tableau there are two sets of comparative tableau markings. The left symbol denotes the relationship with candidate a. and the right symbol denotes the relation ship with candidate c. From first glance at this tableau you notice an L to the left of a W in the row for candidate d. This is not the case, however: the right side comparative tableau is only relevant when c. is going to win. This will occur when the speaker chooses the fully ranked grammar with NoCoda >> Lin for that utterance. When candidate a. wins b. crashes at Lin and d. at *CompCod. When candidate c. wins, both b. and d. crashes at NoCoda.

Consider finally the full metathesis:

(18)

/borzda/	SonSeq	NoCoda	Lin	*CompCod	*CompOns
a. bar.zda.		W*!	L		L*
b. braz.da.		W*!	*		L*
☞c. bra.zda.			*		**
d. barz.da.		W*!	L	W*	L

3.2.1 Lexical Optimization Occurs

At the end of the liquid metathesis I propose a round of lexical optimization that encodes the metathesized form. This is in accordance with the process of sound change proposed in an Stochastic OT framework. This optimisation prohibits the reversal of the metathesis when NoCoda returns back to its former position within the hierarchy.

3.3 The Fall of the Jers and the Rise of Syllabic r̥ and l̥

Jer vowels were [-tense] vowels that disappeared from Slavic around the 12th century. Jers in the CoRC sequences above pattern the same way as normal vowels exhibited metathesis.

the metathesized jer sequences persist in OCS until the fall of the jers. These two weak vowels, ь and ъ, either vocalised and were realised as full vowels or were deleted according to the following rule:

(19) A jer would vocalize if there was a jer immediately to its right on the vowel tier.

A jer will delete otherwise

This pattern was interrupted by all jer+liquid and liquid+jer sequences which collapsed to become moraic, and syllabic l̥ and r̥. This analysis does not account for the full jer pattern and so I propose a general constraint militating against the jer vowel:

(20) *JER: Do not have jer vowels.

Consider the PrSl input /gъrbъ/ 'back' going into OCS. This tableau represents the final state of the grammar right before lexicon optimization

(21)

/gъrbъ/	NOCODA	LINEARITY	*COMPONS
☞a. grьbъ		*	*
b. gъrbъ	W*	L	L

Lexicon Optimization applies creating a new UR for OCS: /grьbъ/. This input is then subject to the jer loss. It is unclear when and how NOCODA is demoted back to its original place below LIN, but it must occur sometime after lexicon optimization and before the fall of the jers becuase a plethora of new clusters resulted from all of the vowel loss. This shift marked the end of rising sonority in OCS. Consider the effect of the fall of the jers on all CRьC and CRъC:

(22)

/grъbъ/	*JER	MAX	NOCODA
☞a. gr̥b		**	*
b. grъbъ	W**!		

The final jer deletes because there is no jer to its right and the initial jer collapses with the liquid to become syllabic.

Consider a related input without a final jer, /gъrba/ 'hump:

(23a) Metathesis into OCS:

/gъrba/	NOCODA	LINEARITY	*COMPONS
☞a. grъba		*	*
b. gъrba	W*!	L	L

(23b) Rise of r̥:

/grъba/	*JER	MAX	NOCODA
☞a. gr̥ba		*	
b. grъba	W*!		

You see in this input a final vowel instead of a final jer. This vowel does not delete, creating the di-syllabic form gr̥ba. This stage exists between OCS and the development of Middle Bulgarian around the same time I propose another Lexicon Optimization to occur.

3.4 Lexicon Optimization and the Cause of Opacity in Modern Bulgarian

The forms above give rise to alternations in Modern Bulgarian where syllabic liquids cannot act as syllable nuclei. These segments were in the process of being eliminated when I propose the Lexicon Optimization to have taken place. I propose the following constraint to militate against the syllabicity of r̥ and l̥:

(24) σ-LIQUID: Liquids should not be syllable nuclei.

The repair that will satisfy this markedness constraint will be the epenthesis of a vowel on one side of the syllabic liquid. For some forms in Bulgarian, such as the two above, these alternations are predictable assuming a syllabic liquid still in the UR. Consider the following two tableau that track 'back' and 'hump' into Modern Bulgarian:

(25a)

/gr̥b/	*σ-LIQUID	DEP	*COMPCOD	*COMPONS
☞a. grab		*		
b. gr̥b	W*!	L		
c. garb		*	W*!	L

(25b)

/gr̥ba/	*σ-LIQUID	DEP	*COMPCOD	*COMPONS	NOCODA
☞a. garba		*			*

/gr̥ba/	*σ-Liquid	Dep	*CompCod	*CompOns	NoCoda
b. gr̥ba	W*!	L			
c. graba		*		W*!	L

Here we see the following minimal rankings:

*σ-Liquid >> Dep

*CompOns >> NoCoda

As mentioned earlier, NoCoda has been demoted to a low position (lower than in PrSl).

Some forms in Modern Bulgarian exhibit this alternation, but there are also many forms that resist alternation now even in the same contexts. I propose that the fixed forms had vocalized already when Lexicon Optimization occurred, encoding those fixed forms as part of the input. Forms such as those above were lexicalized with the syllabic liquid and alternate according to the surrounding syllable structure. This is a source of opacity in Modern Bulgarian where metathesis and/or epenthesis depending on your analysis. (Barnes 1998). Many attempts have been made to account for this opacity in Bulgarian (Pertova 1994, Hermans 1999) but none have yet to capture the data without positing a syllabic form underlyingly in the fashion of Barnes.

5. Conclusions

We have seen that the a mechanism for sound change can be modeled within an OT framework by working with a Probabilistic form of OT known at Stochastic OT. This model places constraints on a continuous ranking with extra noise so that each constraint constitutes a distribution of rankings. As linguistic input changes, the distribution of perceived utterances changes and so do the subsequent productions from that speaker. As certain constraints are more preferred in the productions, the move up and down the ranking continuum. When full re-ranking occurs there is an opportunity for Lexicon Optimization to take place and re-encode the underlying form.

We then modeled the liquid metathesis from PrSl into OCS using a partially ranked constraint set to demarcate the stages of development predicted by the Stochastic approach to variation and change. This metathesis leads to an interaction with the jer vowels, creating syllabic liquids that are prohibited in Modern Bulgarian. Predictable vowel epenthesis occurs in some cases, but this vocalisation process is a source of opacity in Modern Bulgarian.

BIBLIOGRAPHY

Adam, G. (2002). From variable to optimal grammar: Evidence from language acquisition and language change [dissertation]. (DPhil, Tel-Aviv University). (Available at: http://roa.rutgers.edu/view.php3?roa=567).

Anttila, A. (1995). Deriving variation from grammar: A study of Finnish genitives. Ms. Stanford University and Rutgers Optimality Archive.

Anttila, A. (2002). Variation and phonological theory. In Chambers, J. K., Trudgill, Peter,Schilling-Estes, Natalie (Ed.), The handbook of language variation and change (pp. 206-243). Malden, MA: Blackwell.

Anttila, A., & Cho, Y. Y. (1998). Variation and change in optimality theory. Lingua, 104(1-2), 31-56.

Auger, J. (2001). Phonological variation and optimality theory: Evidence from word-initial vowel epenthesis in vimeu picard. Language Variation and Change, 13(3), 253-303.

Barnes, J. (1998). Bulgarian Liquid Metathesis and Syllabification in Optimality Theory. Workshop on Formal Approaches to Slavic Linguistics (6th : 1997 : Storrs,Conn.). (1998). Annual workshop on formal approaches to slavic linguistics. the connecticut meeting, 1997. Ann Arbor: Michigan Slavic Publications.

Birnbaum, H. (1979). Common slavic : Progress and problems in its reconstruction. Columbus, Ohio: Slavica Publishers.

Birnbaum, H. (1985). Recent advances in the reconstruction of common slavic. Columbus, Ohio, USA: Slavica Publishers.

Boersma, P. (2000). The odds of eternal optimization in OT.

Bresnan, Joan, Ashwini Deo, and Devyani Sharma. 2007. Typology in variation: A probabilistic approach to be and n't in the survey of English dialects. English Language and Linguistics 11-2: 301-346.

Cardoso, W. (2001). Variation patterns in across-word regressive assimilation in picard: An optimality theoretic account. Language Variation and Change, 13(3), 305-341.

Cardoso, W. (2007). The variable development of english word-final stops by brazilian portuguese speakers: A stochastic optimality theoretic account. Language Variation and Change, 19(3), 219-248.

Carlton, T. R. (1991). Introduction to the phonological history of the slavic languages. Columbus, Ohio: Slavica Publishers.

Derksen, R. (2008). Etymological dictionary of the slavic inherited lexicon. Boston: Brill.

Hermans, B. (1999). Opaque Insertion Sites in Bulgarian. Workshop on Formal Approaches to Slavic Linguistics (7th : 1998 : Seattle,Wash.). (1999). Annual workshop on formal approaches to slavic linguistics. the seattle meeting, 1998. Ann Arbor: Michigan Slavic Publications.

Holt, D. E. (1998). The role of the listener in the historical phonology of spanish and portuguese: An optimality-theoretic account [dissertation]. (DPhil, Georgetown University).

Hutton, John. 1996. Optimality Theory and historical language change. Paper presented at the 4th Phonology Workshop, Manchester, England, May 1996.

Kostakis, A. (2009). On the sociolinguistic application of the paradigm uniformity model. Unpublished manuscript.

Kiparsky, Paul. 1993. An OT perspective on phonological variation. Handout from Rutgers Optimality Workshop 1993, also presented at NWAV 1994, Stanford University. (Available at http://www.stanford.edu/~kiparsky/Papers/nwave94.pdf).

Nagy, N., & Reynolds, B. (1997). Optimality theory and variable word-final deletion in faetar. Language Variation and Change, 9(1), 37-55.

Petrova, R. (1994). Prosodic Theory and Schwa Metathesis in Bulgarian. Workshop on Formal Approaches to Slavic Linguistics (1993 : Massachusetts Institute of Technology). (1994). Annual workshop on formal approaches to slavic linguistics : The MIT meeting, 1993. Ann Arbor: Michigan Slavic Publications.

Prince, Alan & Smolensky, Paul (2004). Optimality Theory: Constraint Interaction in Generative Grammar. Malden, MA and Oxford, UK: Blackwell. [Revision of 1993 technical report, RUCCS. Available on Rutgers Optimality Archive, ROA-537].

The Slavonic Languages (1993). Ed. Comrie, B., Corbett, G. London; New York: Routledge.

Sussex, R. (2006). The slavic languages. Cambridge, UK ; New York: Cambridge University Press.

Townsend, C. E. (1996). Common and comparative slavic : Phonology and inflection : With special attention to russian, polish, czech, serbo-croatian, bulgarian. Columbus, Ohio: Slavica Publishers.

Velcheva, B. (1988). Proto-slavic and old bulgarian sound changes. Columbus, Ohio: Slavica Publishers, Inc.

Zubritskaya, K. (1997). Mechanism of sound change in optimality theory. Language Variation and Change, 9(1), 121-148.

Zuraw, K. (2005). Probability in language change.