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Mapping the spatial relationship between sub-basins and language variation in Thewo Tibetan

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ABSTRACT

Thewo Tibetan is a Tibetic language of China spoken along the Bailong River in Northern Sichuan Province and Southern Gansu Province. Although typically listed as a dialect of Choni Tibetan (ISO 639-3 cda), Thewo is reported to have a high degree of internal variation (Renzengwangmu 2013). The goal of this paper is to examine whether or not this internal variation can be explained in part by Chamberlain's (2015) hypothesis of linguistic watersheds. Chamberlain (2015) argues that the distribution of watersheds on the Qinghai-Tibet Plateau provides a spatial model through which we can predict the geographical spread of language variation. This paper's research reveals some spatial correlation between the distribution of the watersheds and dialectal variation in the Thewo speaking region of Diebu County. These results can neither disprove Chamberlain's hypothesis nor fully explain the spatial distribution of language variation in Thewo Tibetan. However, the results do demonstrate how watersheds could be a useful model for predicting the location of language documentation needs on the Qinghai-Tibet Plateau.

KEYWORDS

Thewo Tibetan, Edit distance, Sub-basin

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Mapping the spatial relationship between sub-basins and language variation in Thewo Tibetan: Sub-basins and language variation in Thewo Tibetan

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1 Introduction

Chamberlain (2015) argues that the geographical distribution of watersheds on the Qinghai-Tibet Plateau provides a spatial model through which we can predict the location of language variation found within the same region. He shows how the major Tibetic linguistic groupings, as identified by Tournadre (2014), each match spatially with one or more watersheds:

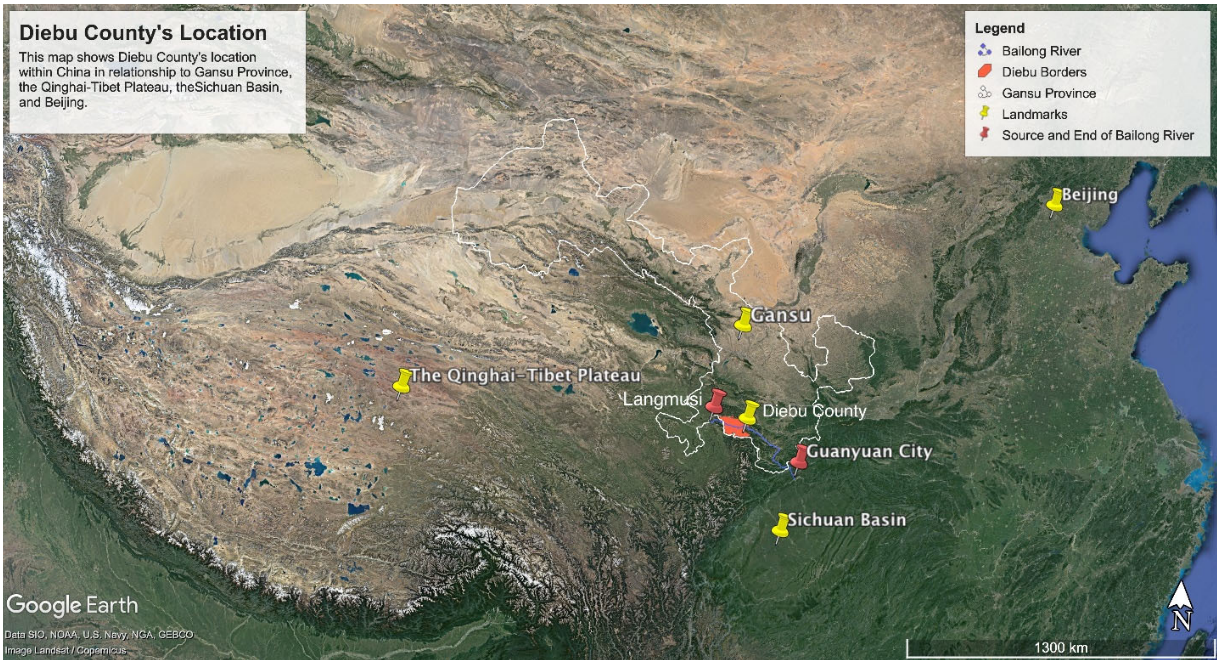
1. The Northeastern Language Area falls within the Yellow River Watershed
2. The Eastern Language Area falls within the Yangtze Watershed
3. The Southeastern Language Area falls within the Mekong and Salween Watersheds
4. The Central Language Area falls within the Tshangpo River Watershed
5. The Southern Language Area falls within the Wang and Koshi River Watersheds
6. The Southwestern Language Area falls within the Gandaki and Kamali River Watersheds
7. The Western Language Area falls within the Stlej River Watershed
8. The Northwestern Area falls within the Indus River Watershed.

In addition to this, Chamberlain gives a case study of the spatial relationship between watersheds and language variation in the small (38,394 km^2) Himalayan country of Bhutan. Chamberlain demonstrates that the geographical distribution of watersheds in Bhutan and the geographical distribution of the languages spoken in Bhutan match. These two unique examples indicate how powerfully the geography of this region has influenced the spatial distribution of language variation found therein. Although, this is certainly not the first study to document how the environment has affected language variation, nor is it the only one to explore how rivers in particular can play an important role, it is an intriguing observation.[1] The purpose of this paper is to test

[1] Alexander Smith and Taraka Rama's paper "Environmental factors affect the evolution of linguistic subgroups in Borneo" provides an interesting analysis of how the environment of world's third largest island has had a unique impact on the languages spoken therein.

whether or not Chamberlain's hypothesis can be used to help explain the spatial distribution of Thewo Tibetan's dialectal variation within Diebu County (5,108 square kilometers).

By exploring the spatial relationship between the location of sub-basins[2] of the Bailong River in Diebu County and language variation in Thewo Tibetan, we can begin to answer the question of why Thewo Tibetan contains such rich variation, as well as further our understanding of how the Qinghai-Tibet Plateau's unique topography affects the spatial distribution of its languages and dialects. In addition, these results help us address a very practical problem: identifying language documentation needs. Some Tibetic languages which are located on the edge of the Tibetan Plateau are becoming moribund as their speakers are shifting to Chinese (Powell, 2016b). There is urgent need to document such languages before they become extinct. If there is a strong correlation between the spatial distribution of different dialects and the sub-basins wherein they are located, then Chamberlain's hypothesis might be leveraged to predict areas of heightened linguistic variation where language documentation would be particularly important.



Map 1. Diebu County's location within China

Thewo Tibetan itself is a Tibetic speech variety spoken within sub-basins located around the upper reaches of the Bailong River, a tributary of the Yangtze River. The majority of the Thewo speaking region falls within the borders of Diebu County, Gansu Province, China. Diebu County is located at the northeastern corner of the Qinghai-Tibet Plateau (See Map 1). Its topography is mountainous (see Map 2). Chinese linguists often classify Thewo as belonging to Choni Tibetan, a sub-dialect of Khams Tibetan (Zhang, 1996). Although Western linguists also often classify Thewo

[2] It is important to note here the exact relationship between a watershed and a sub-basin. A sub-basin is merely a basin which belongs to a larger basin, or watershed. Because no exact size is specified, the word sub-basin can refer to an area which drains into a small stream or an area which drains into a major tributary of an important river.

as a dialect of Choni Tibetan, in general they consider Choni (ISO 639-3 cda) to be a separate language distinct from the notion of Khams Tibetan (Ethnologue 2016, Tournadre, 2014). Thewo Tibetan has been reported to have a remarkable degree of internal variation, which has had a significant impact on levels of intelligibility found between different sub-varieties of Thewo Tibetan (Renzengwangmu, 2013).

Map 2. The topography of Diebu County

2 Data and methodology

As of yet there has been little research on Thewo Tibetan. Lin You-Jing (2014) wrote a phonological description of a Thewo variety on the Sichuan side of the Gansu-Sichuan border. Rengzengwangmu (2013) wrote a description of phonetic and phonological features of three varieties of Thewo Tibetan found in Diebu County. Powell (2016a) provides a socio-linguistic overview of language vitality and language use amongst the Thewo Tibetans. However, none of these papers provide the necessary data to conduct this study. Given this, I chose to travel to the area and gather lexical data for use in this study. I used a wordlist made up of 231 core lexical items (including several important language domains like body parts, numbers, animals, etc.), including a wide variety of phonological forms in Old Tibetan etymons. In total, I used 185 lexical sets for this study (Powell, 2022).

After selecting the wordlists to use for elicitation, the next step was to locate the sub-basins of the Bailong River located in Diebu County. Using local maps (Diebu County Annals, 1996) and Google Earth (earth.google.com), I mapped out Diebu's nineteen major sub-basins, several of which are uninhabited. In addition to mapping the Bailong's Diebu sub-basins, I also divided the areas draining directly into the Bailong river (rather than a tributary of the Bailong River) into three regions: the Upper Bailong Region, the Middle Bailong Region, and the Lower Bailong Region. These three areas are included as unique geographic units both in Table 1 and in Map 3.

Dangduo Sub Basin	**Upper Bailong**	**Gaorika Sub Basin**	**Lower Bailong**
Dangduo (A1)	Dalong (D1)	Gaorika (I/J2)	Qierguoda (L1)
Yiwa Sub Basin	Qiagao (D2)	**Rangga Long Sub Basin**	Luoda (L2)
Daiba (B1)	Nishen (D3)	Cuilong (J1)	**Zhaozang Sub Basin**
Gagu (B2)	**Anzi Sub Basin**	**Duoer Sub Basin**	Zhaozang Erdui (N1)
Zhizi (B3)	Cirika (F2)	Banzang (K6)	**Lazikou Sub Basin**
Waba Longwa Sub Basin	Yalieba (F1)	Adahei (K5)	Gongjian (M5)
Yeku (C1)	Taowuka (F3)	Daban (K4)	Sangzang (M6)
Yaan (C2)	**Middle Bailong**	Ranzi (K3)	Qiaa (M4)
Dala Sub Basin	Niao (G1)	Xirang (K2)	Dala (M3)
Zhawana (E4)	Qiawuka (G2)	Dayi (K1)	Wagu (M1)
Gaoji (E2)	**Jianni Longwa Sub Basin**		Chulong M2)
Nagai (E1)	Jianni (H1)		
Gewu (E3)	Bazang (H2)		

Table 1. The sub-basins and data points

Using Chamberlain's hypothesis as a geographical model, I selected 42 data-points in Diebu County. My basic goal was to select three data-points (depending on the number of villages) within each inhabited valley, or sub-basin, of the Bailong River in Diebu County. The first data point would be the village located deepest in the valley, the second data-point would be a village located midway down the valley, the third data-point would be a village located at the bottom of the valley close to the Bailong river, etc. Because of limited time and difficulty in finding language consultants in several villages, I only collected 37 wordlists from 37 different villages (see Table 1) in total. Out of these 37 wordlists, only four wordlists were collected off site. The other 33 wordlists were collected on site in the villages they represent. Most of my language helpers were farmers.[3] All of them had spent most of their life in their home village.

The next step was to choose a methodology by which to analyze the data. The traditional way to identify dialect boundaries with lexical data is to use isoglosses. However, given the inherent

[3] I am incredibly grateful to the many individuals who helped me record these wordlists and even opened their homes to me. The hospitality and generosity of the Thewo Tibetans has made a lasting impression upon me, and I hope to emulate their example in my own life.

challenges found in clustering isoglosses (Castro, 2014), I chose instead to use tools from the field of dialectometry. I chose to follow Kessler's (1996) work by measuring the distance between the phonetic strings of shared lexical items using edit distance.

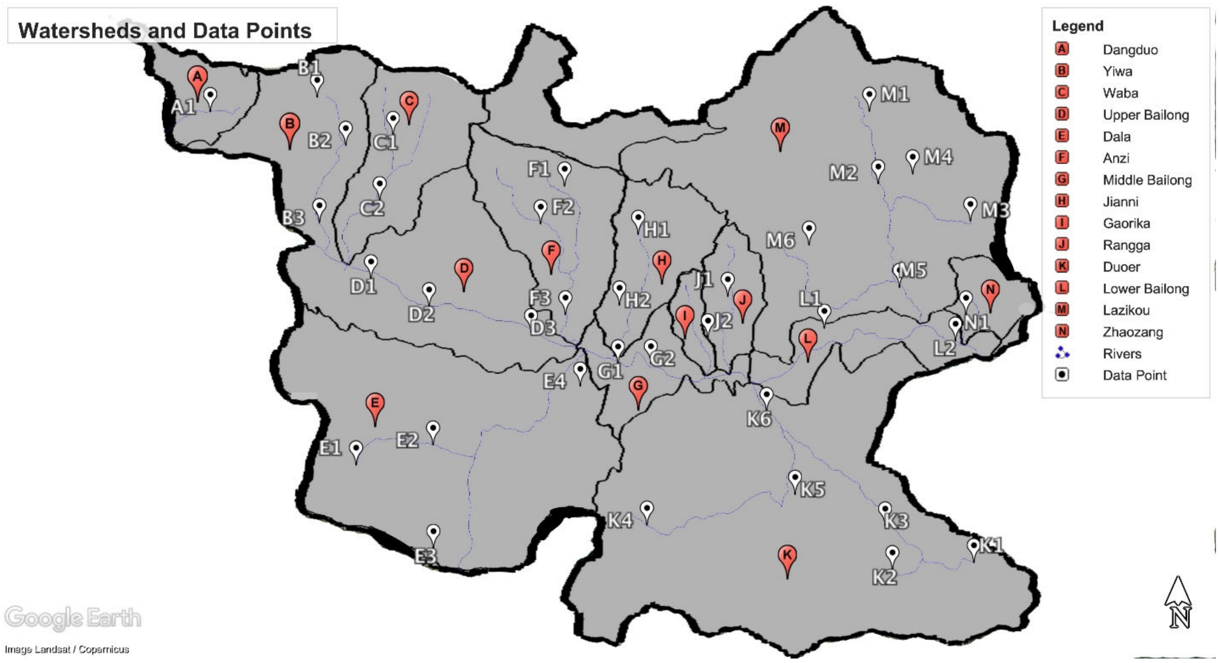
Edit distance uses deletions, insertions, and substitutions to change one string into another. Each of these three actions has a *cost* and this *cost* can be used to measure the distance between the two strings. For example, let us measure the phonetic distance between K5's (Adahei Village) [ju^{55}pa^{54}] and G2's (Qiawuka Village) [ɣu^{55}ka^{54}], both meaning 'owl.' In order to change [ju^{55}pa^{54}] into [ɣu^{55}ka^{54}], we need to first substitute the [ɣ] for [j] and then we need to substitute the [k] for the [p]. These two actions are given the total cost of two. This cost is then divided by the number of phonetic units in the longest string (in this case four). This gives a standardized numerical distance of 0.5 (see Table 2). Distance edit can be used quite effectively to create distance matrices which allow us to see the distances between multiple locations.

Location	**Phonetic Representation**	**Action**	**Cost**
K5	ju^{55}pa^{54}		
	ɣu^{55}pa^{54}	Substitution	1
G2	ɣu^{55}ka^{54}	Substitution	1
	Total Cost 2		
	Standardised distance = 2/4=0.5		

Table 2. Example of distance edit in use

Distance edit can be calculated on both phonetic strings and also phonemic strings. Because a phonetic string can be different from a phonemic string, using distance edit on a group of phonetic strings as opposed to phonemic strings can produce a different set of results. This can happen when the varieties being compared with distance edit have a different phonetic representation for what is described as the same phoneme. For example, if Speech Variety A has the sound [tɕ^{h}] and Speech Variety B has the sound [ʈʂ^{h}] but phonemically they are both written /tɕ^{h}/, then this difference will only be reflected by running distance edit on the phonetic string. Given that the purpose of this research paper is to explore the geographical distribution of synchronic language variation, both of these methods are reasonable options; however, using phonetic strings has the potential to show more variation, and thus provide more insight into how physical geography might or might not have shaped language variation. Again, the goal of this paper is not to identify dialect clusters, but rather to identify where the variation is found and to compare the geographical distribution of this variation with that of the sub-basins. However, the "insider-like" knowledge which a detailed phonological analysis would provide could help the researcher develop more consistent phonetic transcriptions (i.e. for sounds on a shared continuum, there would be greater knowledge of where the actual demarkation points reside) and could also help the researcher avoid using idiosyncratic data. Given that the data gathered for the present study was insufficient to conduct a thorough phonological analysis, my only choice was to use phonetic data and clarify the advantages and disadvantages of doing so. To maintain consistency in my transcriptions, I recorded the elicitation sessions whenever the speakers allowed and then compared recordings from different villages with my transcriptions, making changes so as to use the same symbol for the same sounds. To try to avoid any idiosyncratic data, I met with groups of speakers as often as possible rather than just one speaker. Although both these actions can help mitigate the afore mentioned problems, many issues likely remain for which I alone am to blame.

I used the web-based dialectometry tool Gabmap (gabmap.nl) to create distance matrices (see Appendix) and to analyze the data. Gapmap is not only very user-friendly but its calculations also build many helpful visualizations of the results. In addition, Gabmap also has built in coding to run clustering algorithms which produce dendrograms of language clusters. These features will be described in greater detail in Section 4. It should be noted here that this study is synchronic in nature. I am not attempting to map the historical correspondences of Thewo Tibetan to watersheds. Rather, I am trying to measure synchronic dialect differences and see whether or not these differences have a geographical distribution which matches the geographical distribution of the region's sub-basins.



Map 3. The sub basins and data points

3 Probable shortcomings in the data

To date I am aware of the following, probable shortcomings in the data: 1. out of the 185 lexical sets, not every set is made up entirely of cognates; 2. sometimes synonyms were elicited instead of the target word; and 3. there is likely at least some inconsistency with the transcriptions.

Regarding the first problem, given the limited number of lexical items collected for each data point, the criteria for determining cognates could not be based on a full diachronic analysis of the sound changes in the 37 speech varieties. Although cursory analysis of the data seemed to show that many of the items were likely cognates (i.e. the differences manifested confirmed with known sound changes from Old Tibetan to the modern Tibetic-languages), some lexical items do not reflect such sound changes and seem to reflect different etymologies. For example, in Luoda Village the word elicited for 'cloud' was [mu^{55}ru^{33}] yet in neighboring Zhaozangerdui Village the word [ɕi^{54}] was elicited for 'cloud.' While it would appear that [ɕi^{54}] comes from the Old Tibetan word sprin, meaning cloud, the origins of [mu^{55}ru^{33}] are less clear to me. It is possible that the first syllable of [mu^{55}ru^{33}] comes from the first syllable of the Old Tibetan word for fog, smug pa. Whatever the case may be, it is clear they share different etymologies.

This example relates to the second problem, namely potential misunderstandings during the elicitation which led to the wrong word being elicited. Could it be that in Luoda they also use the word [ɕi^{54}] for cloud and that miscommunication lead to the elicitation of the word for fog instead? Another possible example can be found in the words elicited for 'field' in Cierka Village and in Jiannicun Village, [ɕe^{54}] and [s^{h}a^{54}] respectively. It would seem likely that [s^{h}a^{54}] comes from the Old Tibetan word sa meaning 'soil, earth' and that [ɕe^{54}] comes from the second syllable of the Old Tibetan word sa zhing meaning 'field'. Given the extensive use of these two words, not only in the 37 speech varieties in question, but also in other Tibetic varieties, I believe that it is quite likely that I elicited a synonym in Jiannicun Village rather than the target word.

Regarding the third problem, probable inconsistencies in the transcriptions, every effort was made to avoid this. This included using groups of speakers whenever possible, rather than eliciting from only one speaker, as well as using recordings of the elicitation sessions to compare sounds to ensure consistent transcriptions. However, even with these preventative measures, it is possible and even likely that the transcriptions are not always consistent. For example, when comparing sounds on a shared continuum like [i] and [e], where exactly is their border (see Taowuka's [ɕi^{54}] meaning 'field' and Gewu's [ɕ^{h}e^{54}] also meaning 'field')? The closer to the demarcation point a sound is, the harder it is to consistently ascribe the same symbol. And without a detailed phonology based on a large corpus of data, and plentiful experience hearing the language, how does one know exactly where the boundary is between two similar sounds?

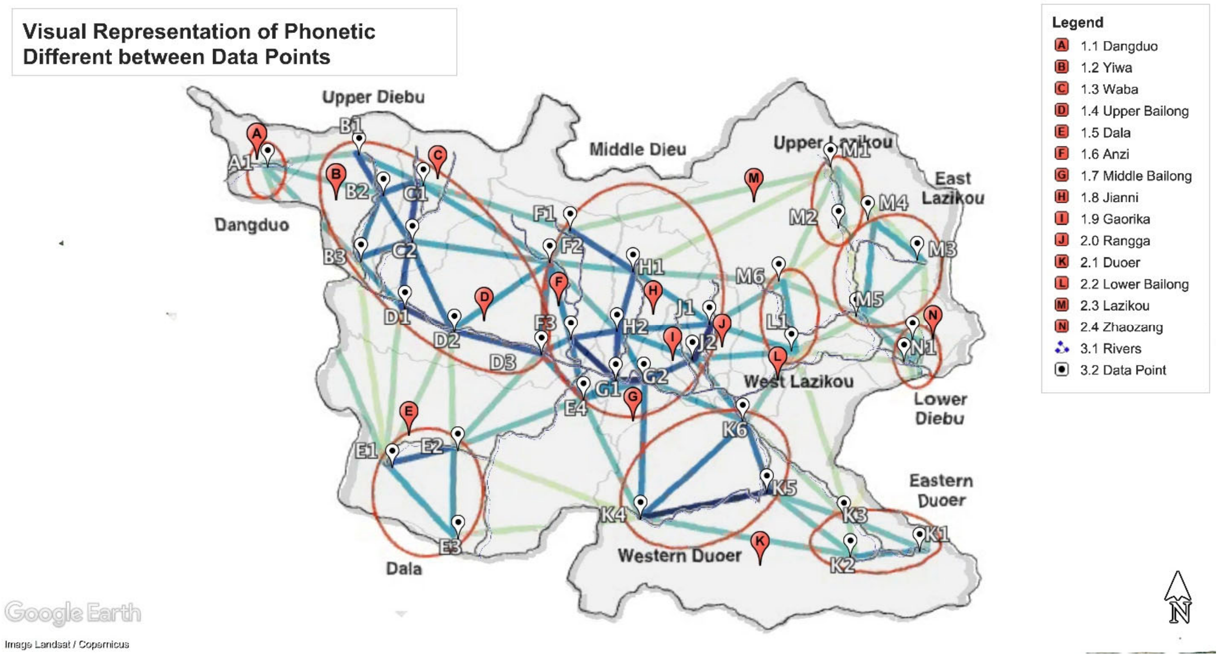
These three probable shortcomings have the potential to make the results of this study show a greater degree of difference than what actually exists. This is not a shortcoming in the methodology, indeed even using the traditional method of creating isoglosses would not solve this problem, rather it a problem with the data. As was mentioned above, I have made every effort to ensure consistency in the transcriptions, however, due to the scope of the work, I am unable to re-elicit the data. The initial collection took months and involved walking hundreds of miles. I would be quite happy for the opportunity to do it again. Alas time and financial constraints prevent this.

4 Results

In the results below, I will use the terms 'isolate' and 'cluster'. These terms are not being used in the same way as they are used in historical linguistics. This is not a historical linguistics study. These are terms used in statistics. The method I am using clusters similar data together, and the word 'cluster/clustering' is the word used for this. Likewise, data which does not cluster can be thought of as an isolate—this does not mean it has no genetic affiliation, or that such an affiliation is unknown (the 'isolates' here are all Tibetic), rather it means that this particular speech variety is not similar to the other varieties and therefore forms a 'cluster' of one.

Gabmap produces maps which help visualize phonetic distances between data-points. In Map 4, the shaded lines represent the degree of phonetic distance between neighboring data-points.

The darker the line, the closer the two locations are phonetically. The lighter the line, the more distant two neighbors are phonetically. The shade of the line, or similarity between two points, is determined by the aggregate distance matrix produced by Gabmap. This matrix shows the average phonetic distance of all 185 cognate sets between every village (see Appendix 1 for matrix). Map 4 reveals one isolate, two large clusters with strong internal cohesion, two small clusters with strong internal cohesion, and five clusters with weak internal cohesion. The clusters, the data-points contained therein, and the sub-basins they are found in are as follows:



Map 4. A visual representation of phonetic difference between data points

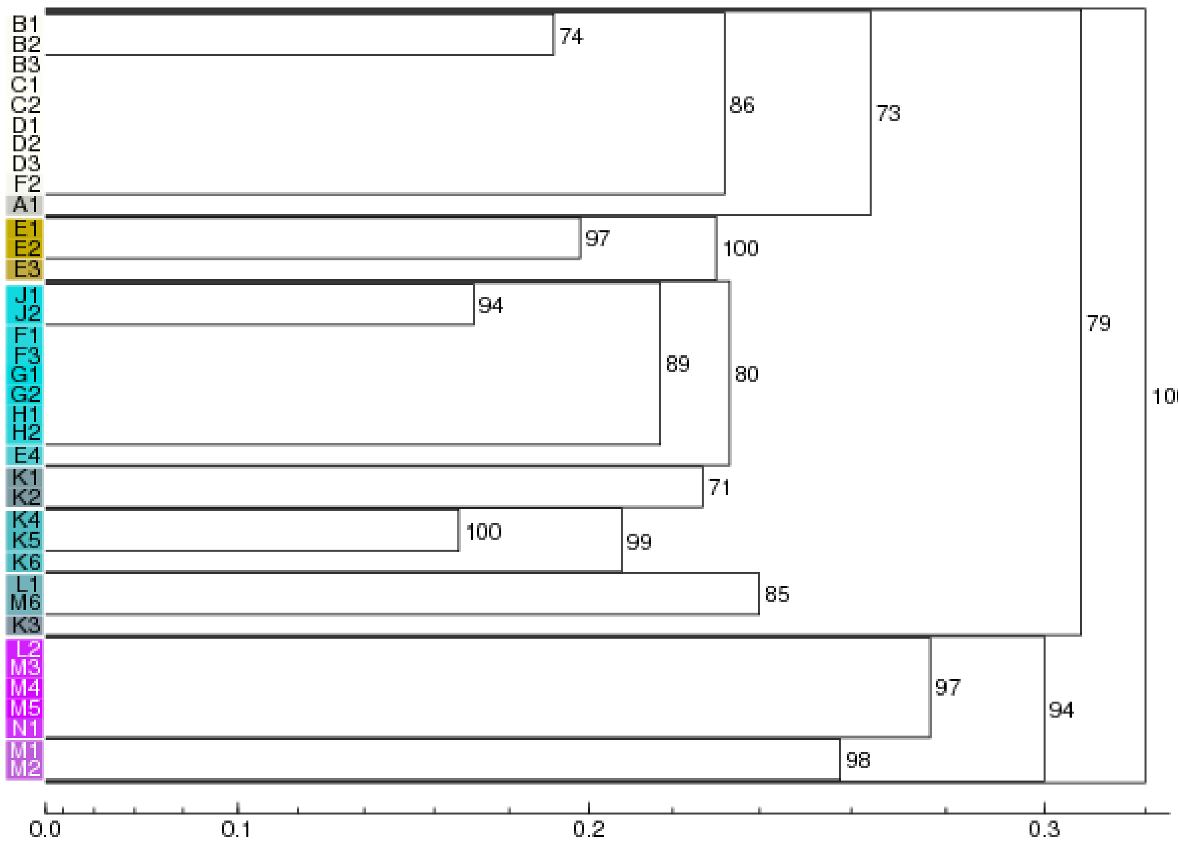
1. The Dangduo Isolate: The light teal lines between A1 and its neighboring data points suggests A1 is best clustered on its own.
2. The Upper Diebu Cluster: The data points located within the Yiwa (B) and Waba (C) sub-basins, as well as the Upper Bailong region (D), cluster together to form the first of the clusters with strong internal cohesion. This cluster includes B1, B2, B3, C1, C2, D1, D2, and D3.
3. The Middle Diebu Cluster: This cluster is made up of E4, F1, F2, F3, G1, G2, H1, H2, J1, and J2 and forms the second cluster with strong internal cohesion. This cluster includes the entirety of the Anzi (F), Middle Bailong (G), Jianni (H), Gaorika (I) and Rangga (J) sub-basins. It also includes E4 which is located on the lower reaches of the Dala River, geographically close to the other data points within the Middle Diebu Cluster.
4. The Dala Cluster: The speech varieties found in the interior of the Dala sub-basin (E) form the first of the small clusters with strong internal cohesion. This cluster includes E1, E2, and E3.

5. The Western Duoer Cluster: The speech varieties making up the western part of the Duoer sub-basin (K) can be grouped together to form the second small cluster with strong internal cohesion. This cluster includes the villages of K4, K5, and K6.
6. The Eastern Duoer Cluster: The speech varieties making up the Eastern part of the Duoer sub-basin (K) can be grouped together to form the first of the five clusters with weak internal cohesion. This cluster includes the villages of K1, K2, and K3.
7. The West Lazikou Cluster: The speech varieties spoken in M6, located on the Western edge of Lazikou (M), and the speech variety of the Lower Bailong Region's L1 can be grouped together to form the second cluster with weak internal cohesion.[4]
8. The Lower Diebu Cluster: L2 and N1 can be grouped together to form the third cluster with weak internal cohesion. This cluster includes the entirety of N (the Zhaozang sub-basin) and the lower portion of L (the Lower Bailong Region).
9. The East Lazikou Cluster: Within the Lazikou sub-basin, the M3, M4, and M5 can all be grouped together to form the fourth cluster with weak internal cohesion.
10. The Upper Lazikou Cluster: Located on the upper reaches of the Lazikou River, M1 and M2 can be grouped together to form the fifth cluster with weak internal cohesion.

These results only reflect the relationship between neighboring data points. Since dialects often form continuum with neighboring data points being more similar to each other than data-points separated by another data point, this map should adequately reflect the relationship between the data-points. At times, however, non-neighboring data-points are more similar than neighboring data-points. Therefore, I did a comparison of every individual data-point with every other individual data-point. To do this, I used Gabmap's fuzzy clustering tool.

Gabmap's fuzzy clustering tool provides a relatively stable option for clustering. Clustering algorithms, although very helpful for quantifying relationships between different data sets, tend to be unstable. To address this issue, Gabmap gives the option of concurrently running two different clustering algorithms (weighted average and group average) while adding statistical noise. This calculation is then run many times over and the aggregate results are displayed in a dendrogram. The results which emerge are thus more reliable than a normal clustering calculation allows for. I chose to use a noise level of 1 for this calculation. I also chose to only display clusters which appeared 70% of the time or more on the multiple reiterations of the calculation. The results displayed in the probabilistic dendrogram which this calculation produced (see Graph 1), are very similar to those of Map 4 (see following paragraph). At the largest level, the fuzzy clustering tool separated the data-points into two large clusters. The first of these clusters appeared 79% of the time on the multiple iterations of the calculation (this is the number which appears at the head of this cluster). The first cluster included all the data-points located within the A, B, C, D, E, F, G, H, I, J, and K sub-basins, as well as one data-point from L (L1). The second cluster included all of M, N, and also L2. Although this macro view is informative, i.e. we see that with the exception of L (the Lower Bailong Region), the clusters were split along watershed borders, it is still necessary to examine in closer detail the smaller clusters which emerge in the dendrogram. These clusters are as follows (See Graph 1):

[4] L1 was located high on a ridge above the Bailong River (this village has since been relocated to the banks of the Bailong River). It belonged directly to the Bailong River watershed rather than to a sub-basin thereof. However, the other side of the ridge belongs to sub-basin M.



Graph 1. Probabilistic dendrogram of Diebu's dialect clusters

11. The Upper Diebu Cluster (cream colored): This cluster appeared 73% of the time in the multiple calculations and contains (from top to bottom on the Dendogram) B1, B2, B3, C1, C2, D1, D2, D3, F2, and A1. This cluster contains a sub-cluster which includes all of the above data-points except A1. This sub-cluster contains a further division in which B1 and B2 are grouped together 74% of the time. The Upper Diebu Cluster includes the entirety of three sub-basins (A, B, C) and D (the Upper Bailong Region), as well as the data-point of F2 which is located in F (the Anzi Sub-basin).

12. The Dala Cluster (mustard colored): This cluster appeared 100% of the time and contains E1, E2, and E3 which are all located in the interior of E (the Dala Sub-basin). E1 and E2 are further grouped together as a sub-cluster in 97% of the calculations. The Dala Cluster is found entirely within one sub-basin (E), but doesn't include E4.

13. The Middle Diebu Cluster (light teal): The villages of J1, J2, F1, F3, G1, G2, H1, H2, and E4 were clustered together 80% of the time. This cluster is further divided into a sub-cluster which includes all of the above data-points except E4. This sub-cluster appears 89% of the time. Within this sub-cluster is a further division where J1 and J2 are grouped together 94% of the time. This cluster contains the entirety of two sub-basins (J and H), as well as the entirety of G (the Middle Bailong Region) and parts of the E (the Dala Sub-basin) and F (the Anzi Sub-basin).

14. The Eastern Duoer Cluster (blue-gray): K1 and K2 were grouped together 71% percent of the time. This cluster contains two data-points located deep within K (the Duoer Sub-basin).
15. The Western Duoer Cluster (dark teal): The villages of K4, K5, and K6 were grouped together 99% of the time during the multiple calculations. K4 and K5 were further grouped together as a sub-cluster and appeared during every reiteration of the calculation. This cluster is found entirely within K (the Duoer Sub-basin).
16. The Western Lazikou Cluster (blue-gray): L1 and M6 are grouped together 85% of the time. This cluster includes data-points from M (the Lazikou Sub-basin) and L (the Lower Bailong Region).
17. The Eastern Lazikou and Lower Diebu Cluster (purple): The villages of L2, M3, M4, M5, N1, were joined into a cluster which appeared 97% of the time. This cluster includes the entirety of the Zhaozang Sub-basin, a portion of the Lower Bailong Region, and a portion of the Lazikou Sub-basin.
18. The Upper Lazikou Cluster (light purple): M1 and M2 appeared grouped together 98% of the time. This cluster is located in the upper region of the M (Lazikou Sub-basin).

There are three primary differences between the results displayed in Map 4 and the results displayed in Graph 1. The first difference is that Gabmap's fuzzy clustering (Graph 1) grouped F2 (Cirika) with the Upper Diebu Cluster, rather than the Middle Diebu Cluster as in Map 4. Second, fuzzy clustering did not group K3 (Ranzi) with any particular cluster. This means that in Graph 1 the Eastern Duoer Cluster does not include K3. The third and final primary difference is that fuzzy clustering (Graph 1) joins Map 4's Upper Lazikou, East Lazikou, and Lower Diebu Clusters into one large cluster. However, Graph 1 does include a sub-cluster equivalent to Map 4's Upper Lazikou Cluster. Despite this, the speech varieties of M3, M4, M5, L2 and N1 remain clustered together in Graph 1 and separated into different sub-clusters in Map 4.

On the surface, the clusters found in Map 4 and Graph 1 seem to refute Chamberlain's hypothesis that speech varieties can be mapped to the basins they inhabit. Three factors seem to suggest this interpretation. First, the data-points of several individual sub-basins are split into different clusters, and these clusters are thus formed with more than one sub-basin. This can be found in: 1) Graph 1, where F2 is grouped with the Upper Diebu Cluster rather than the Middle Diebu Cluster; 2) Map 4 and Graph 1, where E4 is clustered with the Middle Diebu Cluster rather than the Dala Cluster; 3) Map 4 and Graph 1, where the Lower Bailong Region (L) is split into two clusters; Map 4 and Graph 1, where M6 is not clustered together with the other data-points of the Lazikou sub-basin (M). Second, there are several clusters which cover (almost) the entirety of multiple sub-basins. For example, the Upper Diebu Cluster found in both Map 4 and Graph 1 includes the data-points located within B, C, and D. Graph 1 goes a step further and includes A in this Upper Diebu Cluster. In addition, the Middle Diebu Cluster of Map 4 and Graph 1 contains all the data-points of F (except F2 in Graph 1), G, H, I and J, with the addition of data-point E4 within its borders. Third, K (the Duoer Sub-basin) and M (the Lazikou Sub-basin) each contain several clusters unique to their geographic area. The Duoer Sub-basin (K) contains the Eastern and Western Duoer Cluster. The Lazikou Sub-basin (M) is slightly more complicated. Both Map 4 and Graph 1 show that there is an Upper Lazikou Cluster made up of M1 and M2. In Map 4 and Graph 1 the constituents of the Eastern Lazikou Cluster are different. In Map 4 this Eastern Lazikou Cluster contains only M3, M4, and M5; however, in Graph 1 it also contains L2 and N1. These results clearly show that there is no one-to-one relationship between the spatial distribution of language variation and the geographic location of sub-basins, i.e. not every sub-basin forms an individual cluster.

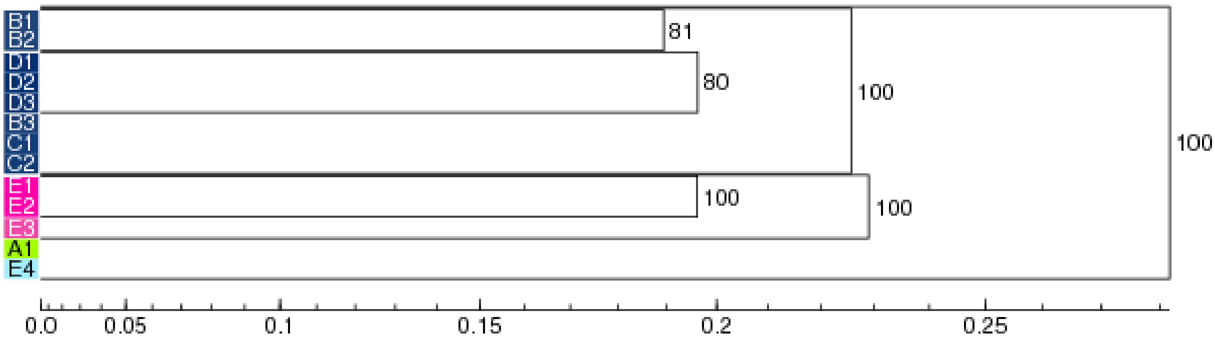
Despite this evidence against Chamberlain's hypothesis, there still emerges a clear correspondence between the borders of the different clusters and the borders of watersheds. Take for example the Upper Diebu Cluster and the Middle Diebu Cluster. Despite being quite large and encompassing more than one sub-basin, their geographic borders correspond to watershed borders. The seeming exceptions to this are E4 and F2. E4, although it belongs to E (the Dala Sub-basin), is located quite far from the other data-points in E and quite close to the data-points in F and G. Chamberlain, speaking on this very topic, states that the speech varieties of places located near the convergence of different rivers will likely have linguistic characteristics from each watershed (2015: 94). F2, however, is still a bit of an anomaly. There does exist an old road, or path, over the mountains which links F2 with D1. An elderly native from F2 related that years ago this road only took a few hours to traverse. Yet, it remains true that F2 is geographically (as the crow flies) much closer to F1 and F3. In addition to these facts, K (the Duoer sub-basin) and M (the Lazikou Sub-basin) contain several sub-basins of their own. These sub-basins are clustered together in Map 4 and Graph 1 to become their own independent clusters (Western and Eastern Duoer and Upper Lazikou). This fact strongly supports Chamberlain's hypothesis.

In order to explore the spatial relationship between language variation and sub-basins more thoroughly, especially the limited phonetic distance in the large clusters, I divided Diebu County into three different regions and ran Gabmap's fuzzy clustering calculation independently in each of these regions. I used the same criteria for these analyses as is used in Graph 1, i.e. I used a noise level of 1 and only allowed clusters which appeared more than 70 percent of the time to appear in the dendrogram. The three regions correspond to traditional divisions of the county into Upper, Middle, and Lower Diebu. Upper Diebu contains A, B, C, D, and E. Middle Diebu is made up of F, G, H, I, J, and K. Lower Diebu is made up of L, M, and N. The results are as follows.

4.1 Upper Diebu

When applied to the Upper Diebu sub-basins, fuzzy clustering reveals two isolates and two clusters as displayed in Graph 2. Neither A1 nor E4 is grouped together with another cluster and thus these two data-points form the two isolates. The first cluster appears 100% of the time and is formed with the speech varieties found in B (the Yiwa Sub-basin), C (the Waba Longwa Sub-basin), and D (the Upper Bailong Region). These areas include B1, B2, B3, C1, C2, D1, D2, and D3. This cluster is further sub-clustered into two groups. B1 and B2, which both belong to B (the Yiwa Sub-basin) are clustered together in 81% of the multiple calculations. The Upper Bailong data sites of D1, D2, and D3 are clustered together 80% of the time into a second sub-cluster. The speech varieties of C1 and C2, which both belong to C (the Waba Longwa Sub-basin), and B3 which belongs to the lower reaches of B (the Yiwa Sub-basin) are not sub-clustered together.

The second cluster includes the data sites of E1, E2, and E3, all of which belong to the interior of E (the Dala Dub-basin). This cluster appears 100% of the time. E1 and E2, which both belong to the same tributary of the Dala River, are grouped together 100% of the time into this cluster's one sub-grouping.



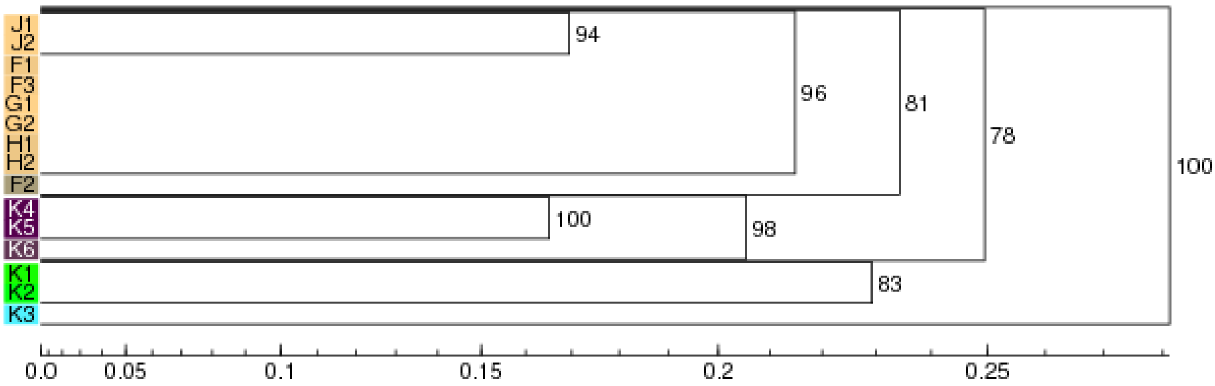
Graph 2. Probabilistic dendrogram of upper Diebu speech varieties

4.2 Middle Diebu

Fuzzy clustering, when applied to the Middle Diebu Region, as shown in Graph 3, produces two main clusters and one isolate. The first of the clusters appears 78% of the time and has two major sub-clusters. The first major sub-cluster is made up of the F, G, H, I, and J sub-basins. This major sub-cluster appears 81% of the time and itself contains one sub-cluster. This sub-cluster is made up of J1, J2, F1, F3, G1, G2, H1, and H2 and appears 96% of the time. It is interesting to note that F3 is not linked with this sub-cluster but rather remains directly under the first of the two major sub-clusters. Interestingly enough, J1 and J2 are formed into yet another sub-cluster which appears 94% of the time. J2 (Gaorika) itself is located on the top of a hill; half of it belongs to I (the Gaorika Sub-basin) and the other half belongs to J (the Rangga Longwa Sub-basin). It is located about a two hour walk from J1 (Cuilong) and hence the similarity between these two speech varieties is easy to understand.

The second major sub-cluster is made up of K4, K5, and K6 and appears 98% of the time. This cluster is synonymous with the Western Duoer Cluster of Map 4 and Graph 1. It contains the sub-cluster of K4 and K5, which both belong to the same tributary of the Duoer River. This sub-cluster appears 100% of the time.

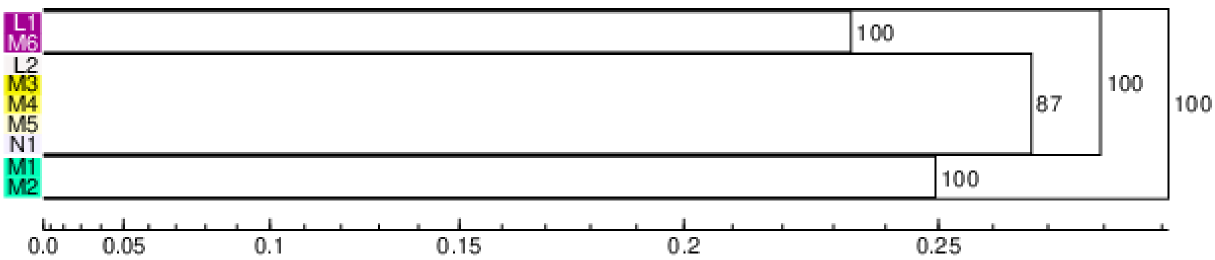
The second cluster appears 83% of the time and is made up of K1 and K2 which both belong to tributaries of the Duoer River. These speech varieties are clustered together in Map 4 to form two of the three villages of the Eastern Duoer Cluster. In Graph 1 they also form the Eastern Duoer cluster. K3 is the isolate, and despite it being somewhat similar to the Eastern Duoer cluster as can be seen in Map 4, it remains unclustered in this calculation. The reasons for this remain unknown.



Graph 3. Probabilistic dendrogram of middle Diebu speech varieties

4.3 Lower Diebu

As displayed in Graph 4, fuzzy clustering creates two clusters in the Lower Diebu Region. The first of these clusters appears 100% of the time and is formed by L1, M6, L2, M3, M4, M5, and N1. This cluster is divided into two sub-clusters, the first of which is made up of L1 and M6 and appears 100% of the time. This cluster corresponds to the Western Lazikou Cluster found in Map 4 and Graph 1. The fact that this cluster contains data points from two different sub-basins is not entirely surprising. Although they technically belong to different sub-basins/regions, L1 is located very close to the top of a ridge. The other side of that ridge belongs to M's (Lazikou's) Sangba Sub-basin where M6 is located. The second sub-cluster is made up of L2, M3, M4, M5, and N1. This sub-cluster appears 87% of the time. The second cluster is made up of M1 and M2, which are both grouped together in Map 4 and Graph 1 to form the Upper Lazikou Cluster. This cluster appears 100% of the time.



Graph 4. Probabilistic dendrogram of lower Diebu speech varieties

5 Discussion

In this section I will discuss how the results answer this paper's research question: is there a spatial correspondency between the geographical distribution of Diebu County's sub-basins and the geographic distribution of Thewo's dialectal variation? This section will be organized by sub-basins, starting from the upper reaches of the Bailong River and flowing downstream to the end (A-N).

The speech variety found in A (the Dangduo Sub-basin), as is seen in Map 4 and Graph 1 and 2, is clearly unique from the other data points. The large degree of phonetic variance between A1 and the neighboring data points supports Chamberlain's hypothesis and indicates a spatial correspondence between the location of language variation and sub-basins.

In B (the Yiwa Sub-basin), we see a strong phonetic similarity between all three data-points, especially between B1 and B2 (as is shown in Graph 2). At the same time, these data-points are phonetically very similar to the data-points of C (the Waba Longwa Sub-basin). In fact, as can be seen in the aggregate distance matrix (see Appendix), after B1, B2 is phonetically most similar to C1, not B3. The four data-points phonetically most similar to B3, ranked according to similarity are C1, C2, B2, and D2. Although B3 belongs to B (the Yiwa Sub-basin), it is located near the mouth of the Yiwa River. In his paper, Chamberlain (2015: 94) argues that data-points located near the convergence of different waterways will likely share the characteristics of the corresponding watersheds. The linguistic situation of B3 supports this hypothesis. It is similar to both the data-points within its own sub-basin as well as the data-points located within C (the Waba Longwa sub-basin) and D (the Upper Diebu Region). However, I would have expected B3 to be phonetically closer to D1 than D2 given that D1 is geographically quite close to B3. The complexity of these phonetic distances is somewhat reflected in Graph 2 where B3, C1, and C2 are not sub-clustered. Overall, the linguistic situation in B suggests that the sub-basin might have impacted language variation, although this spatial similarity is not nearly as clear as that found within A (the Dangduo Sub-basin).

The language situation found within C (the Waba Longwa Sub-basin) also supports Chamberlain's hypothesis. Although the speech varieties of C1 and C2 are similar to their neighboring speech varieties in different sub-basins, they remain closest to each other and to D1. D1 is located a short walk from the mouth of the Waba Longwa River. D1's phonetic similarity to B's data-points, to C's data-points, and to the other speech varieties found in the Upper Bailong Region support Chamberlain's hypothesis that dialects located near the convergence of two or more watersheds will share features from each watershed. Although the C speech varieties are very similar to their neighbors, they form a unique linguistic area with a high degree of cohesion, thus supporting the use of Chamberlain's hypothesis at the sub-basin level.

The three data points located in D (the Upper Bailong Region) display a stronger cohesion to each other rather than to other data-points. This can be seen in both Map 4 and in Graph 2. In Graph 2 these three data points are clustered together into the same sub-cluster. As such, the linguistic situation in D (the Upper Bailong Region) shows the potential of applying Chamberlain's hypothesis even at the sub-basin level.

In E (The Dala Sub-basin), we see some of the strongest evidence for a correlation between the spatial distribution of dialectal differences and sub-basins. The three data-points E1, E2, and E3 are clustered together in Map 4, Graph 1, and Graph 2. In addition, as clearly seen in Map 4, Graph 1, and Graph 2, E1 and E2 form a sub-cluster within this cluster. E1 and E2 belong to the same minor tributary of the Dala River. E4 shows closer phonetic similarity with its neighbors to the outside, namely D and G (the Upper and Middle Bailong Regions respectively) and F (the Anzi Sub-basin). Because of E4's close proximity to these places and the great distance between it and the other Dala Sub-basin data-points, this situation does not seem disprove Chamberlain's hypothesis. However, it does highlight the important role geographical distance plays in dialectal variation. On the whole, the linguistic situation of E lends strong support for Chamberlain's hypothesis being used to help explain the spatial distribution of language variation in Diebu County.

The situation found within sub-basin F also supports Chamberlain's hypothesis. Map 4 seems to suggest that F1 is closest to H1 rather than another F data-point. This is in part due to how Map 4 was produced. Map 4 compared each data-point with their immediate neighbors. One of F1's immediate neighbors is H1, i.e. they are geographically quite close to each other (F3 was not an immediate neighbor). The aggregate distance matrix, however, shows that F1 is closet to F3 (a phonetic distance of 0.160) rather than H1 (a distance of 0.174). It is quite clear from this aggregate distance matrix (found in the Appendix), that the variety which is phonetically closest to F1 is F3. The similarity between F1 and H1 might relate to the existence of an old road which ran between them. Chamberlain argues that the presence of roads between locations will create exceptions to his hypothesis. F2, which is phonetically closet to F3 (0.189), has a similar situation. An old road runs between F2 and D1. F2 itself is phonetically more similar to D1 (0.194) than F1 (0.216). More research would likely reveal a clearer picture of why F2 is more similar to D1 than F1. F3, located near the opening of the Anzi River, is most similar to G1 (0.146), F1 (0.160), and H2 (0.174). Overall, Chamberlain's hypothesis does not seem to fully explain the linguistic diversity in and around F, yet, it does seem to offer some helpful starting points for further research.

The linguistic situation of H also supports Chamberlain's hypothesis. Although H1 is phonetically closest to F1 (0.174), the second closest phonetic similarity is to H2 (0.179). The presence of the afore mentioned old road is likely to explain H1's similarity to F1. H2 is also more similar to H1 and G1 (located at the mouth of the H sub-basin—i.e. G1 could also be analyzed as belonging to the H basin) than to any other data-points. These characteristics do not in any way refute Chamberlain's hypothesis and thus H is a good example of how Chamberlain's hypothesis is useful to explain the spatial spread of Thewo's language variation.

Map 4 clearly shows that J1 and J2 are phonetically more similar to each other than to any other data-points. Graph 1 and Graph 3 also support this with the two data-points in question being grouped together into the same sub-cluster. In reality, J2 is located on top of a mountain which divides sub-basins I and J. Half of the village is in I and half of the village is in J. J2 is also only a two hour walk away from J1. Here again we see a correlation between the spatial distribution of dialectal variation and sub-basins.

The K sub-basin, and its sub-basins, also reflect a correlation between the spatial distribution of linguistic variation and sub-basins. The data-points to the west in K (K4, K5, and K6) are joined together in Map 4 and in Graph 1 and 3 into the same cluster. Graph 1 and 3 always sub-divide K4 and K5 into the same sub-cluster. These two villages both belong to the same tributary of the Duoer River. This tributary enters the Duoer River just upriver of K6. This situation strongly corresponds to Chamberlain's theory. The situation in the eastern area of K is slightly different. Although Map 2 groups K1, K2, and K3 into the same cluster, it is clear that K3 is somewhat unique. Graph 1 and 3 do not even cluster Ranzi with any other grouping and simply leave it as an isolate. The reason for this is unknown and is worthy of more research. Even K1 and K2 are not as similar as we would expect. However, the reason for this might be socio-religious. K1 and K2 belong to different, competing Buddhist sects.

In L, L1 remains phonetically closest to J2, with J1 and M6 placing second and third respectively. In Graph 1, M6 and L1 form an independent sub-cluster and in Graph 4 they are sub-clustered together to form a distinct sub-cluster. This should not be entirely surprising. Despite L1 and L2 both being located in the same region, they remain geographically distant from each other, and the banks of the Bailong river are fairly steep for most of this distance. In addition, historically speaking, L1 was located high above the Bailong River and not far from the ridge line separating L1 from M6. The similarity L1 and M6 have to J1 and J2 might be explained by the presence of an old road which linked M6 with J1 and J2. Although it does not appear that the phonetic distance between L1 and L2 necessarily contradicts Chamberlain's hypothesis, without more data to the contrary, it would be hard to argue that the linguistic situation found in L offers strong support for this hypothesis.

Sub-basin M is the largest sub-basin in Diebu and here again we find evidence of a spatial relationship between the distribution of dialectal variation and sub-basins. In Map 4, Graph 1, and Graph 4, M1 and M2 are grouped together in their own distinct sub-cluster. This cluster is located in the upper reaches of the Lazikou River. M3 and M4 both belong to another sub-basin of M and are grouped together in Map 2. In Graph 1 and 4 these two locations are joined together with M5, L2, and N1. However, it seems clear from the aggregate distance matrix that M3 and M4 along with the M5 could be grouped together in their own independent cluster. Overall, the spatial distribution of language variation here closely matches the spatial distribution of the sub-basins.

Regarding sub-basin N, in Map 4, L2 and N1 are combined together to form the Lower Diebu Cluster. Although I grouped L2 together with L1 into L (the Lower Bailong Region), it is in fact located at the mouth of the Zhaozang River, the river running through sub-basin N. The similarity between L2 and N1 is therefore quite understandable given their close proximity to each other. Although in Graph 1 and 4 these two locations do not even form a sub-group, the aggregate distance matrix clarifies that N1 is closest to L2 and then M5. This similarity suggests that there exists a spatial relationship between sub-basins and the distribution of language variation.

6 Conclusion

Chamberlain's model (2015) appears to have relevance for explaining the geographical spread of language variation in Thewo Tibetan, although clearly there are other, more complex factors at play. In most of the sub-basins explored, there was evidence of a spatial correspondence between the geographical distribution of linguistic variation and sub-basins. This correspondency was even found in sub-basins of the E and K sub-basins. More research is necessary to demonstrate whether or not Diebu County's situation is reflective of sub-basins around the entire Qinghai-Tibet Plateau; however, it is clear that Chamberlain's hypothesis cannot be refuted by this case study. These results not only further our understanding of Thewo Tibetan's internal language variation's geographical distribution, but also furthers our understanding of how physical geography has shaped the linguistic landscape of the Qinghai-Tibet Plateau. This case study also suggests that this hypothesis can be leveraged to predict areas of heightened language variation where language documentation needs might exist. Sub-basins where no linguistic research has yet been conducted potentially have unique varieties worthy of documentation and description.

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Appendix

Table 1 (Appendix)

	M1	M2	M4	M3	M6	M5	L2	N1	K3	K2	K1	K4
M1	0	0.233379	0.274551	0.282755	0.282963	0.290238	0.295997	0.28984	0.328582	0.310501	0.293196	0.279337
M2	0.233379	0	0.252819	0.271235	0.262751	0.259914	0.264523	0.259246	0.31631	0.294135	0.27277	0.260437
M4	0.274551	0.252819	0	0.210332	0.262729	0.213736	0.234902	0.260382	0.312689	0.293492	0.270697	0.260482
M3	0.282755	0.271235	0.210332	0	0.26864	0.240452	0.254653	0.271243	0.322991	0.311536	0.281265	0.272106
M6	0.282963	0.262751	0.262729	0.26864	0	0.251185	0.261989	0.259187	0.268889	0.256997	0.230804	0.228136
M5	0.290238	0.259914	0.213736	0.240452	0.251185	0	0.225968	0.236473	0.298852	0.282489	0.256359	0.243456
L2	0.295997	0.264523	0.234902	0.254653	0.261989	0.225968	0	0.232798	0.314562	0.291242	0.262891	0.274297
N1	0.28984	0.259246	0.260382	0.271243	0.259187	0.236473	0.232798	0	0.297508	0.285241	0.250763	0.251586
K3	0.328582	0.31631	0.312689	0.322991	0.268889	0.298852	0.314562	0.297508	0	0.255168	0.232106	0.226796
K2	0.310501	0.294135	0.293492	0.311536	0.256997	0.282489	0.291242	0.285241	0.255168	0	0.203675	0.230954
K1	0.293196	0.27277	0.270697	0.281265	0.230804	0.256359	0.262891	0.250763	0.232106	0.203675	0	0.199398
K4	0.279337	0.260437	0.260482	0.272106	0.228136	0.243456	0.274297	0.251586	0.226796	0.230954	0.199398	0
K5	0.292129	0.276946	0.270405	0.291939	0.230472	0.264021	0.28276	0.268287	0.234457	0.235488	0.210431	0.137518
G2	0.299018	0.268108	0.275927	0.284906	0.224823	0.269199	0.274602	0.261146	0.254266	0.250966	0.225169	0.190834
K6	0.29103	0.281977	0.286329	0.304789	0.24853	0.274781	0.302418	0.27824	0.257787	0.261223	0.231171	0.184771
J2	0.282466	0.264211	0.264289	0.280657	0.218953	0.246932	0.270091	0.258555	0.250498	0.238029	0.22341	0.18645
J1	0.278442	0.248535	0.260887	0.276036	0.224699	0.249709	0.282091	0.262087	0.266107	0.252175	0.239216	0.194061
L1	0.28525	0.251759	0.262686	0.267986	0.212969	0.255111	0.266284	0.255022	0.273218	0.263032	0.23257	0.221622
G1	0.282373	0.267125	0.266004	0.27799	0.22695	0.245369	0.277102	0.249523	0.250955	0.245341	0.216978	0.176725
H2	0.288929	0.27841	0.271084	0.287505	0.251389	0.265193	0.297508	0.274088	0.276728	0.269484	0.253197	0.211462
H1	0.276491	0.270333	0.276822	0.285535	0.239945	0.260474	0.279112	0.2617	0.277514	0.255813	0.233306	0.217921
F2	0.3035	0.290477	0.297153	0.297724	0.23551	0.274866	0.293628	0.279098	0.289755	0.291122	0.268658	0.233083

Table 1 (Appendix)

	M1	M2	M4	M3	M6	M5	L2	N1	K3	K2	K1	K4
F1	0.283151	0.255664	0.271791	0.283137	0.231512	0.250514	0.266301	0.25183	0.273978	0.255089	0.233852	0.219056
F3	0.278857	0.269451	0.277923	0.288193	0.23129	0.25565	0.274232	0.264684	0.271192	0.251317	0.234989	0.203538
E3	0.330996	0.314799	0.319279	0.33571	0.284811	0.302471	0.316216	0.315813	0.31554	0.302703	0.288552	0.271944
E2	0.317022	0.308677	0.324123	0.32554	0.285456	0.309244	0.31108	0.3196	0.323404	0.304539	0.298295	0.276514
E1	0.319488	0.303249	0.329985	0.332447	0.284658	0.303766	0.32309	0.316342	0.323422	0.304124	0.292494	0.277127
E4	0.294796	0.277106	0.296951	0.298943	0.254285	0.273762	0.300394	0.279534	0.285432	0.26134	0.251915	0.229952
D3	0.296941	0.282751	0.302567	0.29574	0.257345	0.274727	0.299168	0.286857	0.290822	0.283793	0.265891	0.238287
D2	0.325294	0.308505	0.310336	0.3022	0.2737	0.281183	0.31474	0.295078	0.30242	0.306495	0.287266	0.264954
D1	0.312473	0.2923	0.291298	0.305625	0.265924	0.27579	0.303141	0.281028	0.302388	0.290466	0.272801	0.245834
C2	0.31739	0.305726	0.292986	0.307167	0.260985	0.273848	0.300725	0.281163	0.287018	0.287711	0.273871	0.245675
C1	0.321865	0.3154	0.307695	0.314047	0.264228	0.275555	0.310353	0.285835	0.304004	0.28339	0.27531	0.262452
B3	0.327136	0.311794	0.3129	0.313335	0.257085	0.292492	0.303462	0.29198	0.316482	0.294538	0.289672	0.270808
B2	0.313915	0.290334	0.298887	0.299248	0.265064	0.269701	0.300181	0.27907	0.306943	0.296715	0.277311	0.261281
B1	0.320225	0.293116	0.298946	0.306359	0.284944	0.283378	0.310441	0.286003	0.317649	0.304141	0.280962	0.270858
A1	0.314009	0.296419	0.307154	0.314005	0.283128	0.291025	0.309034	0.288121	0.297102	0.293722	0.28982	0.272292

Table 2 (Appendix)

	K5	G2	K6	J2	J1	L1	G1	H2	J1	F2	F1	F3
M1	0.292129	0.299018	0.29103	0.282466	0.278442	0.28525	0.282373	0.288929	0.276491	0.3035	0.283151	0.278857
M2	0.276946	0.268108	0.281977	0.264211	0.248535	0.251759	0.267125	0.27841	0.270333	0.290477	0.255664	0.269451
M4	0.270405	0.275927	0.286329	0.264289	0.260887	0.262686	0.266004	0.271084	0.276822	0.297153	0.271791	0.277923
M3	0.291939	0.284906	0.304789	0.280657	0.276036	0.267986	0.27799	0.287505	0.285535	0.297724	0.283137	0.288193
M6	0.230472	0.224823	0.24853	0.218953	0.224699	0.212969	0.22695	0.251389	0.239945	0.23551	0.231512	0.23129
M5	0.264021	0.269199	0.274781	0.246932	0.249709	0.255111	0.245369	0.265193	0.260474	0.274866	0.250514	0.25565

Table 2 (Appendix)

	K5	G2	K6	J2	J1	L1	G1	H2	J1	F2	F1	F3
L2	0.28276	0.274602	0.302418	0.270091	0.282091	0.266284	0.277102	0.297508	0.279112	0.293628	0.266301	0.274232
N1	0.268287	0.261146	0.27824	0.258555	0.262087	0.255022	0.249523	0.274088	0.2617	0.279098	0.25183	0.264684
K3	0.234457	0.254266	0.257787	0.250498	0.266107	0.273218	0.250955	0.276728	0.277514	0.289755	0.273978	0.271192
K2	0.235488	0.250966	0.261223	0.238029	0.252175	0.263032	0.245341	0.269484	0.255813	0.291122	0.255089	0.251317
K1	0.210431	0.225169	0.231171	0.22341	0.239216	0.23257	0.216978	0.253197	0.233306	0.268658	0.233852	0.234989
K4	0.137518	0.190834	0.184771	0.18645	0.194061	0.221622	0.176725	0.211462	0.217921	0.233083	0.219056	0.203538
K5	0	0.204772	0.183131	0.189914	0.204321	0.238146	0.192387	0.219549	0.230709	0.254784	0.236617	0.222718
G2	0.204772	0	0.210503	0.177775	0.188886	0.232541	0.147602	0.199639	0.20831	0.198852	0.207025	0.182364
K6	0.183131	0.210503	0	0.205539	0.20692	0.24531	0.194047	0.228105	0.230829	0.257146	0.245357	0.231985
J2	0.189914	0.177775	0.205539	0	0.147961	0.214542	0.159754	0.200751	0.194834	0.230028	0.191896	0.176946
J1	0.204321	0.188886	0.20692	0.147961	0	0.217454	0.167831	0.190667	0.202163	0.221819	0.205405	0.187489
L1	0.238146	0.232541	0.24531	0.214542	0.217454	0	0.227514	0.246788	0.244075	0.253947	0.238431	0.238659
G1	0.192387	0.147602	0.194047	0.159754	0.167831	0.227514	0	0.16149	0.18042	0.200819	0.177807	0.145694
H2	0.219549	0.199639	0.228105	0.200751	0.190667	0.246788	0.16149	0	0.178632	0.228122	0.19659	0.173557
H1	0.230709	0.20831	0.230829	0.194834	0.202163	0.244075	0.18042	0.178632	0	0.229393	0.174121	0.190205
F2	0.254784	0.198852	0.257146	0.230028	0.221819	0.253947	0.200819	0.228122	0.229393	0	0.216489	0.189461
F1	0.236617	0.207025	0.245357	0.191896	0.205405	0.238431	0.177807	0.19659	0.174121	0.216489	0	0.160235
F3	0.222718	0.182364	0.231985	0.176946	0.187489	0.238659	0.145694	0.173557	0.190205	0.189461	0.160235	0
E3	0.283035	0.263356	0.293683	0.272104	0.26824	0.307358	0.257643	0.279695	0.28086	0.263767	0.276537	0.250192
E2	0.279461	0.262381	0.290238	0.271717	0.26772	0.293165	0.252549	0.274189	0.264438	0.263813	0.26844	0.246798
E1	0.285804	0.266457	0.286375	0.278834	0.265739	0.302311	0.253453	0.275339	0.277074	0.274511	0.273022	0.250208
E4	0.239735	0.203825	0.239422	0.2177	0.208224	0.253737	0.194008	0.213241	0.221309	0.225436	0.215884	0.188869
D3	0.250845	0.223462	0.263811	0.230136	0.234046	0.264194	0.199536	0.229321	0.224791	0.196781	0.215979	0.199662

Table 2 (Appendix)

	K5	G2	K6	J2	J1	L1	G1	H2	J1	F2	F1	F3
D2	0.279159	0.242531	0.286162	0.252357	0.252723	0.276101	0.224521	0.244767	0.256907	0.202165	0.231704	0.207634
D1	0.257509	0.233841	0.267923	0.242292	0.240882	0.269854	0.21873	0.237149	0.249989	0.194182	0.235575	0.201823
C2	0.256883	0.239879	0.267515	0.236986	0.249595	0.259661	0.217198	0.230042	0.242901	0.214023	0.231719	0.214801
C1	0.269221	0.250883	0.281555	0.249839	0.254049	0.269832	0.232088	0.249083	0.249727	0.213622	0.233582	0.221173
B3	0.282509	0.243633	0.284486	0.266306	0.268676	0.283568	0.245074	0.257713	0.255161	0.203207	0.239611	0.229329
B2	0.269941	0.249892	0.2788	0.254241	0.259892	0.266172	0.234561	0.24101	0.248387	0.201161	0.232479	0.216663
B1	0.279098	0.264153	0.282436	0.263293	0.261777	0.285722	0.248586	0.250465	0.25779	0.230226	0.251288	0.243945
A1	0.278858	0.258978	0.283572	0.264333	0.259945	0.281224	0.24432	0.256184	0.263699	0.246209	0.247618	0.252005

Table 3 (Appendix)

	E3	E2	E1	E4	D3	D2	D1	C2	C1	B3	B2	B1	A1
M1	0.330996	0.317022	0.319488	0.294796	0.296941	0.325294	0.312473	0.31739	0.321865	0.327136	0.313915	0.320225	0.314009
M2	0.314799	0.308677	0.303249	0.277106	0.282751	0.308505	0.2923	0.305726	0.3154	0.311794	0.290334	0.293116	0.296419
M4	0.319279	0.324123	0.329985	0.296951	0.302567	0.310336	0.291298	0.292986	0.307695	0.3129	0.298887	0.298946	0.307154
M3	0.33571	0.32554	0.332447	0.298943	0.29574	0.3022	0.305625	0.307167	0.314047	0.313335	0.299248	0.306359	0.314005
M6	0.284811	0.285456	0.284658	0.254285	0.257345	0.2737	0.265924	0.260985	0.264228	0.257085	0.265064	0.284944	0.283128
M5	0.302471	0.309244	0.303766	0.273762	0.274727	0.281183	0.27579	0.273848	0.275555	0.292492	0.269701	0.283378	0.291025
L2	0.316216	0.31108	0.32309	0.300394	0.299168	0.31474	0.303141	0.300725	0.310353	0.303462	0.300181	0.310441	0.309034
N1	0.315813	0.3196	0.316342	0.279534	0.286857	0.295078	0.281028	0.281163	0.285835	0.29198	0.27907	0.286003	0.288121
K3	0.31554	0.323404	0.323422	0.285432	0.290822	0.30242	0.302388	0.287018	0.304004	0.316482	0.306943	0.317649	0.297102
K2	0.302703	0.304539	0.304124	0.26134	0.283793	0.306495	0.290466	0.287711	0.28339	0.294538	0.296715	0.304141	0.293722
K1	0.288552	0.298295	0.292494	0.251915	0.265891	0.287266	0.272801	0.273871	0.27531	0.289672	0.277311	0.280962	0.28982
K4	0.271944	0.276514	0.277127	0.229952	0.238287	0.264954	0.245834	0.245675	0.262452	0.270808	0.261281	0.270858	0.272292

Table 3 (Appendix)

	E3	E2	E1	E4	D3	D2	D1	C2	C1	B3	B2	B1	A1
K5	0.283035	0.279461	0.285804	0.239735	0.250845	0.279159	0.257509	0.256883	0.269221	0.282509	0.269941	0.279098	0.278858
G2	0.263356	0.262381	0.266457	0.203825	0.223462	0.242531	0.233841	0.239879	0.250883	0.243633	0.249892	0.264153	0.258978
K6	0.293683	0.290238	0.286375	0.239422	0.263811	0.286162	0.267923	0.267515	0.281555	0.284486	0.2788	0.282436	0.283572
J2	0.272104	0.271717	0.278834	0.2177	0.230136	0.252357	0.242292	0.236986	0.249839	0.266306	0.254241	0.263293	0.264333
J1	0.26824	0.26772	0.265739	0.208224	0.234046	0.252723	0.240882	0.249595	0.254049	0.268676	0.259892	0.261777	0.259945
L1	0.307358	0.293165	0.302311	0.253737	0.264194	0.276101	0.269854	0.259661	0.269832	0.283568	0.266172	0.285722	0.281224
G1	0.257643	0.252549	0.253453	0.194008	0.199536	0.224521	0.21873	0.217198	0.232088	0.245074	0.234561	0.248586	0.24432
H2	0.279695	0.274189	0.275339	0.213241	0.229321	0.244767	0.237149	0.230042	0.249083	0.257713	0.24101	0.250465	0.256184
H1	0.28086	0.264438	0.277074	0.221309	0.224791	0.256907	0.249989	0.242901	0.249727	0.255161	0.248387	0.25779	0.263699
F2	0.263767	0.263813	0.274511	0.225436	0.196781	0.202165	0.194182	0.214023	0.213622	0.203207	0.201161	0.230226	0.246209
F1	0.276537	0.26844	0.273022	0.215884	0.215979	0.231704	0.235575	0.231719	0.233582	0.239611	0.232479	0.251288	0.247618
F3	0.250192	0.246798	0.250208	0.188869	0.199662	0.207634	0.201823	0.214801	0.221173	0.229329	0.216663	0.243945	0.252005
E3	0	0.203536	0.211126	0.253359	0.261391	0.264444	0.264514	0.269404	0.264187	0.256896	0.266651	0.270535	0.2665
E2	0.203536	0	0.17564	0.236738	0.241726	0.264058	0.26753	0.260958	0.273365	0.264413	0.268348	0.258931	0.259207
E1	0.211126	0.17564	0	0.230904	0.245288	0.260532	0.260854	0.265286	0.282222	0.27435	0.276137	0.274477	0.254416
E4	0.253359	0.236738	0.230904	0	0.198229	0.236686	0.230744	0.247647	0.241808	0.24921	0.244609	0.238158	0.253934
D3	0.261391	0.241726	0.245288	0.198229	0	0.167434	0.177492	0.191643	0.204679	0.207973	0.194804	0.210785	0.236508
D2	0.264444	0.264058	0.260532	0.236686	0.167434	0	0.16454	0.182255	0.203584	0.195027	0.191461	0.208621	0.229174
D1	0.264514	0.26753	0.260854	0.230744	0.177492	0.16454	0	0.170359	0.205036	0.202757	0.187981	0.210691	0.239525
C2	0.269404	0.260958	0.265286	0.247647	0.191643	0.182255	0.170359	0	0.163881	0.184343	0.185465	0.201212	0.233766
C1	0.264187	0.273365	0.282222	0.241808	0.204679	0.203584	0.205036	0.163881	0	0.172997	0.185199	0.208373	0.238331
B3	0.256896	0.264413	0.27435	0.24921	0.207973	0.195027	0.202757	0.184343	0.172997	0	0.19012	0.21567	0.23759
B2	0.266651	0.268348	0.276137	0.244609	0.194804	0.191461	0.187981	0.185465	0.185199	0.19012	0	0.170862	0.231347

Table 3 (Appendix)

	E3	E2	E1	E4	D3	D2	D1	C2	C1	B3	B2	B1	A1
B1	0.270535	0.258931	0.274477	0.238158	0.210785	0.208621	0.210691	0.201212	0.208373	0.21567	0.170862	0	0.239852
A1	0.2665	0.259207	0.254416	0.253934	0.236508	0.229174	0.239525	0.233766	0.238331	0.23759	0.231347	0.239852	0