Chapter two

Lexical tone in Magey Matbat

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2.1 Introduction

In this paper, I present a descriptive analysis of the comparatively rich tonal system of Magey Matbat, a language of the Raja Ampat islands, Papua Province. The original analysis was part of my PhD thesis (Remijsen 2001a). Since then, I have checked my analysis of the Magey Matbat tone system by means of further fieldwork research. Improvements to the original analysis have been incorporated in the current paper. The paper is structured as follows. After introducing the Magey Matbat language, I will present an impressionistic phonological analysis of its lexical tone system. Then an acoustic analysis is presented that corroborates the impressionistic analysis, and that provides detailed information on the phonetic realization of the lexical tone patterns. In the conclusion, the Magey Matbat tone system is compared with that of Ma^{l}ya, and I discuss the origin of lexical tone in Matbat and Ma^{l}ya, both Austronesian languages.

2.2 The Matbat language

2.2.1 Language situation

Magey Matbat has around 500 native speakers, spread over four small villages along the coast of the island of Misol (also spelled Misool). Misol lies halfway between New Guinea and the Moluccan island of Seram. The names of the four villages are Magey (or Mage), Kapacol, Aduwey, and Salafen. Their location is marked on the map in Figure 1. Several other languages are used on the island: Tomolol Matbat, Ma^{l}ya and Biga. Tomolol Matbat is closely related to Magey Matbat, and the two may or may not constitute dialects of a single language.[4] The term Matbat means

[4] In Remijsen (2001a) I followed the judgments of native speakers in classifying Tomolol Matbat and Magey Matbat as dialects of the same language. A recording of a wordlist with a native speaker of Tomolol Matbat, in a more recent fieldwork trip, convinced me that there

‘people of the land’, and distinguishes the Matbat from the Maˈya, or Matlow ‘people of the sea’, as they are called in Matbat villages. That is, on Misol, the term Matbat refers to an ethnic group, encompassing both the Magey Matbat and the Tomolol Matbat dialect or language communities. Hereafter I will use the term Matbat to refer to the Magey Matbat language or dialect.

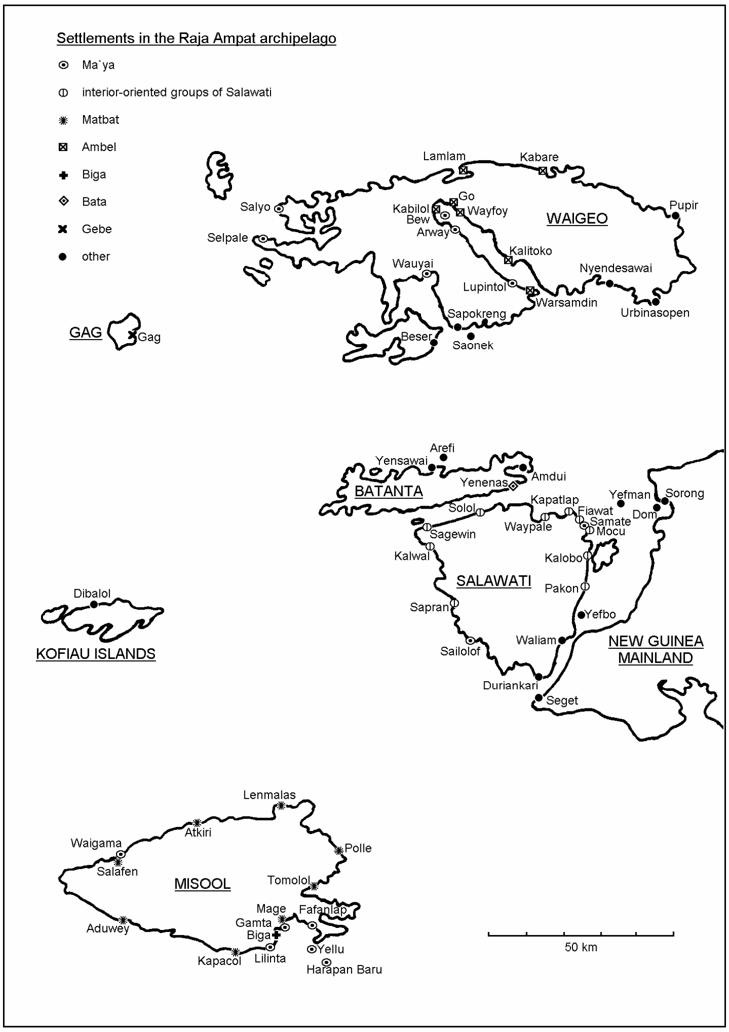

Figure 1: The Raja Ampat islands with the location of villages. From Remijsen (2001a).

are considerable differences between Tomolol Matbat and Magey Matbat at every level of the grammar. Anecdotally, the native speaker of Tomolol Matbat in question, who was married to a native speaker of Magey Matbat, and had settled at Magey, his wife’s village, reported that they had used Malay when they were recently married. This suggests that mutual intelligibility between Magey and Tomolol Matbat is rather limited.

Apart from Magey Matbat, Tomolol Matbat, Maˈya and Biga, there are the languages of various groups of migrants from outside the Raja Ampat archipelago, such as Butonese and Biak. The Matbat communicate with speakers of these languages in Malay. While school children learn the national standard of Malay – Bahasa Indonesia – at school, it is a regional dialect of Malay that is commonly used. Like all regional Malay dialects of Eastern Indonesia – such as Ambonese Malay (van Minde 1997) and Kupang Malay (Steinhauer 1983) – the variant used in the Raja Ampat islands has less derivational and inflectional morphology than the national standard, and is therefore easier to learn. In Matbat villages, this variant of Malay functions as a second language, used in all contacts with speakers of languages other than Maˈya. Conventionally, the Matbat accommodate the Maˈya by speaking the latter's language in contacts with them. The presence of migrants from outside the Raja Ampat islands in many Magey and Tomolol Matbat villages constitutes an obvious threat to the survival of the local language. Because the villages are so tiny, even a small number of non-Matbat settlers can have a considerable impact on the language balance. In Magey village, the Matbat speak their own language with other Matbat, and Malay with migrant members of the village community. I noticed that they also use Matbat in larger gatherings that included non-Matbat, switching to Malay only when the non-Matbat person is addressed directly.

2.2.2 Previous studies

The only data on Magey Matbat and Tomolol Matbat are a small number of wordlists. The situation is the same for all other languages of the Raja Ampat islands apart from Maˈya (van der Leeden 1983, 1993, 1995, 1997; Remijsen 2001b, 2002). For Matbat, there is wordlist number 50 in Wallace (1869), which documents Magey Matbat, and three lists in the J. C. Anceaux collection (Smits & Voorhoeve 1992), all on the Tomolol variant. Wallace (1869) is the autobiographical account of the well-known biologist, who traveled through what is today Indonesia around the middle of the 19th century. He presents two wordlists of languages of Misol, which are introduced as follows:

> 49. Mysol (coast). – An island north of Ceram. Inhabitants Papuans with mixture of Moluccan Malays. Semi-civilized.
>
> 50. Mysol (interior).– Inhabitants true Papuans. Savages.
>
> [Wallace 1869 (2: 474)]

No names are given for either of the languages spoken in these two regions. In fact, wordlist 49 concerns Maˈya: most words in this list are identical to the ones in other wordlists of that language (van Peski 1914, van der Leeden 1983, 1993, Smits & Voorhoeve 1992). Evidence both of a linguistic and a non-linguistic nature suggests that wordlist 50 represents the Matbat language. As for the non-linguistic evidence, there is the note in Wallace (1869), cited above: the language is used in the interior, and the inhabitants are physically Papuan. The Matbat match both of these criteria. They lived in the interior of Misol until around 1970, when they moved to the coast.[5] In addition, the Matbat are close to the Papuan physical type (as presented e.g. in Wallace 1869), and more so than the Maˈya are. And if we can interpret ‘savages’ to mean that they were neither christians nor muslims, then this also points towards the Matbat, who adhered to their indigenous belief system until a few years before the move to the coast. As for the linguistic evidence, the lexical items of wordlist 50 largely correspond to the ones I collected of Magey Matbat.[6]

Table 1: A comparison of lexical data of Magey Matbat from wordlist no. 50 in Wallace (1869), and from my own data.[7]

English	List no. 50	My data
black	Bít	kabi^{12}t
dog	Yem	ye^{21}m
fire	Yap	ya^{3}p
to go	Bo	bo^{21}
hot	Pelah	pla^{12}
house	Dé	de^{3}
leaf	Idun	da^{21}n
moon	Náh	na^{41}
mother	Nin	ne^{3}n
oil	Menik	mni^{12}k
road	Má	ma^{41}
white	Boo	bu^{3}
wood	Ei	ha^{3}y
yellow	Flo	flu^{12}ŋ

2.2.3 Genealogic classification

On the basis of list no. 50 in Wallace (1869), Blust (1978) classified Magey Matbat as a member of the South Halmahera-West New Guinea (SHWNG) subgroup of Austronesian. Obviously, the limited amount of data available to Blust (1978) implies that this hypothesis can only be tentative. Upon closer scrutiny of the language system as a whole, it becomes clear that there are a number of typically Papuan characteristics, in particular its relatively complex tone system, noun class

[5] Self-report by villagers in Magey. It is line with similar developments on Salawati (Polansky 1957).
[6] Wordlist 50 was collected by Wallace’s assistant Charles Allen. A note in Wallace (1869) suggests that Allen collected the wordlist in the vicinity of Lilinta, in southeast Misol. This is the area of the settlements Magey and Kapacol.
[7] The numeric diacritics reflect lexical tones. They will be introduced in detail in the following section.

inflection, and inalienable possession. These characteristics do not reflect the Austronesian prototype (Foley 1998), but they are found in Papuan languages (Foley 1986, 1998). In addition, a considerable proportion of the Matbat lexical items are not of Austronesian origin. In view of all this evidence suggesting Papuan influence, I consider Matbat to be an Austronesian language that is deeply influenced by Papuan languages, although the hypothesis that the language would be non-Austronesian cannot be discarded at this stage.

2.3 Lexical tone in Matbat: phonological description

As suggested by the acute accents in Wallace (1869), Matbat is a tone language. I hypothesize that there are six lexically contrastive tonemes. These are the Extra High Fall, the High (level), the Low Rise, the Low (level), the Rise-Fall, and the Low Fall. The Matbat tones are transcribed using a numeric convention, in which the speaker's f_0-range is represented by the scale from 1 (low) to 4 (extra high). Within this range, level tones are represented by single digits, and contour tones by multiple digits. In this way, the Extra High Fall is transcribed /^{41}/, the High Level as /^{3}/, the Rise as /^{12}/, the Low Level as /^{1}/, the Rise-Fall as /^{121}/, and the Low Fall as /^{21}/.[8] The near-complete minimal set example in (1) illustrates the tonal contrast and provides phonological support for the distinction.

ba^{41} 'to hit'	ba^{3} 'grandfather'	(1)
ba^{12}p 'father'	ba^{1} 'to remain'	
ba^{121} 'stiff'	ba^{21} 'to flow'	

Additional two-, three- and four-member minimal sets are presented in Table 2, and in Table A1 of the Appendix. In general, there are many lexical contrasts solely distinguished by lexical tone.

[8] Tonemes are transcribed after the vowel of the syllable with which they are associated, but voiced codas are also associated with the tonemes cf. Figure 3. The transcription of segments is phonemic. Matbat transcriptions are in bold in the body of the text, and in regular type in tables.

Table 2: Monosyllabic minimal set examples illustrating the Matbat toneme inventory.

Extra High Fall	High (level)	Low Rise	Low (level)	Rise-Fall	Low Fall
		na^{12}n ‘animal’	na^{1}n ‘betel leaf’		na^{21}n ‘name’
mɔ^{41}n ‘areca nut’			mɔ^{1}n ‘heavy’		
t-ɛ^{41}l ‘1p.-go down’		tɛ^{12}l ‘cut’		tɛ^{121}l ‘fill’	tɛ^{21}l ‘testicle’
de^{41} ‘to throw’	de^{3} ‘house’			de^{121} ‘sick’	

Words with the Low Fall toneme on the final syllable often have an epenthetic final /o/ in phrase-final context. This is reminiscent of Ma$^{\mathrm{l}}$ya, where words that carry the Fall toneme always get an epenthetic final /o/. This similarity will be discussed at the end of the paper.

Monosyllabic words make up a considerable proportion of the Matbat lexicon, but disyllabic words are common as well. In my collection of over 800 lexical items, I have not encountered any monomorphemic words with more than three syllables. In di- and trisyllabic words, at least one syllable carries a toneme. The position of toneless syllables in polysyllabic words is not predictable. The distribution of toneless syllables is illustrated in (2).

kamɔ^{12}w	‘star’	wu^{3}yte	‘sea shore’	(2)
sapu^{41}lu^{12}y	‘round’	bi^{3}mbɔ^{121}mpu	‘butterfly’.	

These examples show that the Matbat tonemes are associated with individual syllables (‘syllable tone’) rather than with the word as a whole (‘word tone’). If Matbat had word tone, then the number of tonal patterns on polysyllabic words would be the same as on monosyllabic words. The words in (2) show that this is not the case. At the same time, the examples in (2) also show that many syllables are not specified for tone.

I tend to perceive prominence contrasts in relation to the lexical tones. For example, in polysyllabic words with only one lexical tone, the syllable with the toneme seems to stand out from among the neighboring toneless syllables. Also, in words with two tones, often one seems more prominent to me, e.g. the penultimate one in sapu^{41}lu^{12}y ‘round’.[9] However, there is no evidence for lexical stress as a phonological property. The majority of polysyllabic function words have the Low

[9] This is probably due to the fact that my native language, Dutch, is intonational, with high f_0 associated with stressed syllables when they carry a pitch-accent.

Fall toneme on one syllable – for example, ya^{21}ka 'I'; but there are plenty of exceptions, such as pɔ^{121}re 'not yet' and hafɔ^{12} 'they'.

2.4 Lexical tone in Matbat: acoustic analysis

2.4.1 Motivation and approach

The above phonological description of the Matbat tone system is based on impressionistic perception by the researcher. It can be corroborated quantitatively by means of an acoustic analysis of the hypothesized tonemes. For example, if mɔ^{41}n 'areca nut' is distinguished from mɔ^{1}n 'heavy' solely by its tone pattern, then the fundamental frequency (f_0) values should differ in a significant way, because f_0 is the acoustic correlate of perceived pitch or tone. This prediction can be tested by an analysis of variance (ANOVA). Also, if the analysis of the tone system hypothesized above is correct, then it should be possible to distinguish the tonemes from one another, again on the basis of their acoustic realization. Such a classification of the tonemes can be carried out by means of Linear Discriminant Analysis (LDA). And while the ANOVA merely indicates whether there is a certain degree of consistent variation between all tonemes, the LDA analysis will show whether this variation is large and consistent enough for the tonemes to be classified successfully.

Apart from corroborating the hypothesis that Matbat has the complex tone system outlined above, this acoustic analysis is also worthwhile because it gives a detailed account of the acoustic realization of the tones. In many languages, the realization of word-prosodic patterns varies in function of the position of a word in the utterance. For example, both intonational (e.g. English [Ladd 1996 and references there]) and tonal (e.g. Chengtu Chinese [Chang 1958 in Ladd 1996: 150], Laganyan Ma'ya [Remijsen 2001a, b]) languages have been reported to feature tonal configurations specific to certain phrasal boundaries. Also, in many languages, the final syllable of a word located at the end of an intonational phrase has a longer duration (Vaissière 1983, Maddieson 1997). This phenomenon may well be a linguistic universal. In order to determine whether the tones of Matbat are affected by such context-conditioned differences in the realization of word-prosodic patterns, the acoustic realization of tones is investigated in two sentence contexts – both in the middle and at the end of the sentence.

2.4.2 Data collection and data analysis

2.4.2.1 Speakers

I recorded 8 native speakers (4 male, 4 female) of the Matbat language. All speakers spoke the variant of the village of Magey (southeast Misol). Seven of them used Matbat in most of their daily interactions. The eighth was Absalom Jemput, a 20-year man who had moved from Magey to the city of Sorong two years earlier, and who assisted me with data collection. The informants were paid a fee.

2.4.2.2 Materials and procedure

The materials used in this analysis consist of 48 monosyllabic lexical items, including 9 three-way minimal sets. They are listed in the Appendix (Table A1). Some minimal sets were found while recording an extended Swadesh list. The majority, however, were found by Absalom Jemput. At a later stage, the words were checked with older native speakers. The lexical items were not segmentally balanced across the hypothesized tones, so that unwanted segmentally driven variation in fundamental frequency (f_0) may occur. It was attempted to include cases of each toneme both with and without a voiced coda.[10] The lexical items were distributed semi-randomly over three blocks, in such a way that members of a minimal set were in different blocks.

During the recording sessions, all interactions between the researcher and the informant took place in Malay. The procedure was the following. The native speaker was orally presented with an Indonesian lexical item, the Matbat translation of which he or she was to utter out loud. If need be, more information about the meaning or the usage of the word in Matbat was given. Rarely, a speaker was unable to translate the word on the basis of this information, or would offer a semantically related alternative. Then the researcher wrote the Matbat word on paper. If the speaker did not recognize the word, no further attempts were made to elicit it.

The response, a lexical item in Matbat, was recorded in three contexts – cf. example (3): (a) in isolation; (b) embedded sentence-finally in a carrier sentence; (c) embedded sentence-medially in a carrier sentence. Context (a) – in isolation – served merely as a check to determine whether the informant knew the requested word. With some informants context (a) was not recorded, and none of the context (a) data were analyzed. Context (b) and (c) were recorded twice. Because the context frames were the same throughout the recording session, the target words stood out as new information within the utterance they appeared in. The interaction with each informant lasted approximately one hour, interrupted by two short breaks between the blocks.

[10] The only gap in this respect is the Rise-Fall, for which I had not found any minimal contrast involving words with a voiced coda. Later on, in the course of the 2003 fieldwork research, I did find such a contrast (/tɛl/ in Table 2).

Researcher [in Malay]: (3)
Jalan road

Informant [in Matbat]:

(a)	ma^{41}				[citation form]
					road
(b)	hafɔ^{12}	fu^{21}	ma^{41}		[sentence-final in carrier sentence]
	3PL	say	road		They say road.
(c)	hafɔ^{12}	fu^{21}	ma^{41}	po^{21}w	[sentence-medial in carrier sentence]
	3PL	say	road	NEG	They do not say road.

The recordings were made using a Sony WM-D6C tape recorder (featuring user-controlled input level and a constant-speed mechanism) and a Shure SM10A directional close-talking microphone (head mounted with wind shield, ensuring a constant mike-to-mouth distance).

2.4.2.3 Data analysis and statistics

All sentences recorded in contexts (b) and (c) of example (3) were digitized, at a sampling frequency of 22,050 kHz. Sentences that were of a bad quality, in terms of background noise, voice quality or pronunciation (e.g. hesitations), were excluded from the analysis. The total number of sentences analyzed was 1,484 (2-4 realizations [1-2 sentence-medial + 1-2 sentence-final] * 48 lexical items * 8 speakers). F_0-tracks of these recorded sentences were produced by means of the accurate autocorrelation algorithm of Boersma (1993), which is implemented in Praat (Boersma & Weenink 1996). Where necessary, these f_0-tracks were hand-corrected for tracking errors. The target words were segmented manually on the basis of waveform and spectrogram representations of the recorded sentences. While duration was measured for the vowel only, the f_0-related measurements were made over the voiced part of the rhyme of the target word. This domain consists of the vowel plus any voiced coda. The following measurements were made:

- F_0 maximum, mean, and standard deviation. When voicing began slightly after vowel onset, the domain of measurement began at the first voiced ten-millisecond frame in the domain. The same procedure was applied, mutatis mutandis, when voicing ended before the end of the domain;
- The f_0 values at 10 milliseconds (ms) after the beginning of the vowel, and 10 ms before the end of the voiced part of the rhyme. By making these f_0 onset and offset measurements at 10 ms from the edges, the influence of segmental f_0 is somewhat reduced;
- Two time-related measures were made: vowel duration (in ms) and the alignment of the f_0 maximum. The alignment of the f_0 maximum is calculated as the division of the time span (in ms) between vowel onset and the f_0 maximum, by the time span (also in ms) of the voiced part of the rhyme, be it vowel or

vowel plus voiced coda. The resulting value is 0 when the maximum is located at vowel onset and 1 when it is located at the very end of the voiced domain.

- The slope of the f_0-track. Slope is computed by measuring mean f_0 (expressed in ERB) from the beginning of the vowel to its temporal mid-point (part1), and from the mid-point up to the end of the vowel (part2). The ERB value for part2 is subtracted from the ERB value for part1. The slope value is higher than 0 if f_0 falls throughout the syllable, and it is lower than 0 if f_0 rises through the syllable. It is close to 0 if f_0 is level, or if the domain measurement shows an equal-size mirrored change in f_0 in both parts of the vowel.

Data points were expressed in Hertz (Hz), as well as in terms of the psycho-acoustic ERB-scale. Whereas the Hertz value of an f_0 measurement is a direct reflection of the frequency of the component wave with the lowest frequency, the ERB-scale produces a derived measure, designed to take into account the characteristics of human perception. Human perception of frequency is logarithmic rather than linear. For example, the difference between 100 and 200 Hz is perceived as considerably greater than that between 1000 and 1100 Hz. By converting values on the physical (Hz) frequency scale to a psycho-acoustic scale, this characteristic of human perception can be taken into account, and the differences between values become more realistic in perceptual terms. The Equivalent Rectangular Bandwidth (ERB) (Hermes & van Gestel 1991) is such a psycho-acoustic frequency scale.[11] Only the ERB values were used in the statistical analyses (ANOVA and LDA).

Means and standard deviations were calculated as descriptive statistics. Repeated measures-style (RM) ANOVA's were carried out with fixed factors tone (Extra High Fall / High / Rise / Low / Rise-Fall / Fall) and sentence-context (medial / final), and a random factor speaker. As a criterion to determine significance, alpha was set at the value of 0.01 rather than at 0.05, because the number of tokens is large. The RM-ANOVAs will answer the question whether there is a significant difference in terms of the above-mentioned measures in function of the hypothesized tone contrast. Beyond that, however, the RM-ANOVA results do not allow us to determine how reliable these measures are at marking the distinctions between the various tonemes. Also, they do not provide an indication of the relative importance of these measures in the encoding of lexical tone. Both of these questions are highly relevant to this investigation.

The best way to answer these questions would be to investigate the relative importance of the above-mentioned measures in the perception of lexical tone by language users. An alternative approach is to use a statistical test to infer to what extent the acoustic measures distinguish between the various tonemes. In other words, such a statistical test reveals whether, and if so, to what extent, each of the measures could be of use to the language user in the perception of lexical tone. This can be done by means of Linear Discriminant Analysis (LDA). The LDA procedure generates a discriminant function, which is based on the linear combination of the

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[11] Hertz values can be converted to ERB values and vice versa by means of the following formulas (from Greenwood 1961):

$$[\text{ERB\_value}] = 16.7 \log_{10} (1 + [\text{Hz\_value}] / 165.4)$$

$$[\text{Hz\_value}] = 165.4 (10^{0.06 [\text{ERB\_value}]} - 1)$$

independent variables that provides the best discrimination between the groups. In this study, there are six groups, one for each toneme, and the independent variables on which the discriminant function is based are the above-mentioned acoustic measures. These measures are used as postdictors in the LDA, since their importance as tone correlates is evaluated in the same data set that was used to determine the weighing of these measures in the discriminant function. In other words, Linear Discriminant Analysis (LDA) was used to compare the degree of success with which the above acoustic measures can distinguish the six tonemes from one another. When combinations of acoustic parameters were evaluated, the stepwise approach was used, whereby a parameter is only added to the equation if its *F* probability value is sufficiently high to offer a significant contribution to the discrimination result (*F* to enter: > 3.84; *F* to remove: < 2.71). Both for the RM-ANOVA and the LDA analyses, all measures were standardized (z-transformed) per speaker to normalize for between-speaker variation in acoustic register and range.

2.4.3 Results and discussion

2.4.3 1 The effect of tone on f_0 and duration

Figure 2 shows averaged f_0-tracks of the 6 tonal patterns, normalized for differences in duration. The Extra High Fall stands out with its exceptional range: on average, f_0 falls 2 ERB (95 Hz) for this tone. The other tones are closer together in the tonal space, but each is clearly distinct from the others. Descriptive statistics are listed in Table A2 of the Appendix.

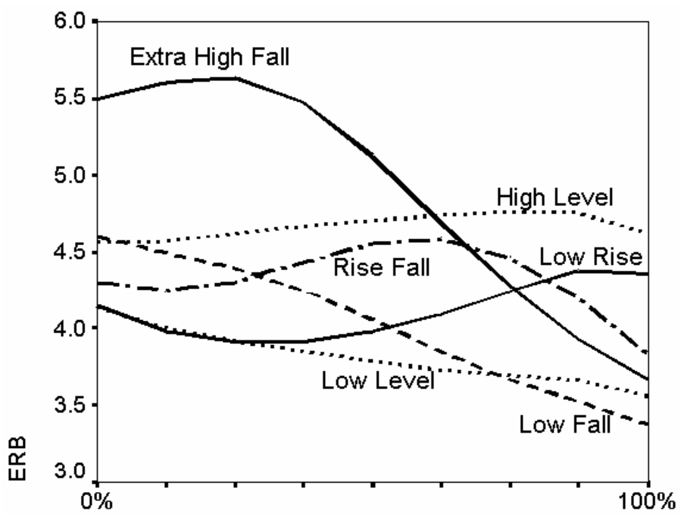

Figure 2: F_0-tracks of the 6 tones on the voiced part of the rhyme (vowel plus voiced coda, if any) of monosyllabic words (f0 in ERB as a function of normalized time).

The factor tone has a significant effect on all acoustic measures, in particular f_0 slope and f_0 at vowel onset (see Table 3). The significant effect of vowel duration as a function of tone is small in relation to the effects of the f_0-related measures. It could be attributed to various factors. On the one hand, contour tones, with two or more f_0 targets may intrinsically have longer durations than tones with fewer f_0 targets, as it takes more time to produce, for example, a rising+falling contour than a falling contour. In line with this prediction, the Rise-Fall, which has the most f_0 targets (low-high-low), also has the longest vowel duration (see Table A2 of the Appendix). Apart from this inherent durational difference between tones, there are two additional factors, which clearly influenced the variation in vowel duration between tonemes in the data set.

Table 3: Results of univariate RM-ANOVAs.

Criterion	Factor Tone (all $p < 0.01$)
Duration of vowel	F (5,35) = 45.8
F_0 mean	F (5,35) = 222.1
F_0 standard deviation	F (5,35) = 274.2
F_0 at vowel onset	F (5,35) = 452.2
F_0 end value	F (5,35) = 163.2
F_0 maximum	F (5,35) = 209.2
F_0 slope	F (5,35) = 516.9
Timing of maximum	F (5,35) = 325.4

First, words with the Low Fall often have an epenthetic /o/ added at the right word-edge when the word appears in sentence-final position. This causes the vowel on which the Low Fall is encoded to be penultimate rather than final. In the sentence-final condition, therefore, the measured part of the Low Fall is likely to be affected by final lengthening to a lesser extent than the other tonemes are.

Second, some tonemes are represented in the data set predominantly by closed syllables, while others are represented predominantly by open syllables. The duration of a given vowel that is checked by a coda consonant is – ceteris paribus – shorter than that of the same vowel in an open syllable (Klatt 1976, Maddieson 1985). This phenomenon is evident from the tone data under investigation. On average, the vowels of open syllables have a duration of 213 ms, but the duration of the vowels in closed syllables is only 170 ms. The difference in vowel duration between tones can therefore be attributed to some extent to the variation in closed/open syllable-words for each tone. For example, the tone with the longest average vowel duration, the Rise-Fall (212 ms), is represented in the data set by open-syllable words only. The tone with the shortest average duration, the Low Fall (195 ms), is represented by five closed-syllable words and only one open-syllable word.[12] The effect of syllable structure exacerbates the effects of the two earlier-mentioned causes for variation in vowel duration in function of tone. The Rise-Fall already was singled out by the complexity of its tonal targets, and likewise, words with the Low Fall underwent final lengthening to a lesser extent than other tonemes, because of the epenthetic /-o/ in that context. When the above ANOVA with factor tone and vowel duration as the dependent variable is repeated with open syllables only, the effect is reduced considerably [F (5,35) = 29.37, $p < 0.01$].

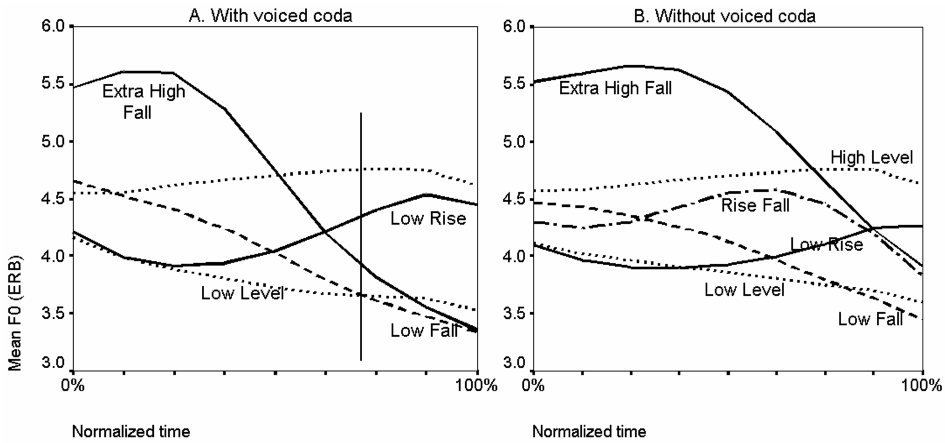

Figure 3: F_0-tracks of the 6 tones on monosyllabic words with voiced coda (A), and without voiced coda (B). F0-tracks are represented on a normalized time axis, and plotted against an ERB scale. The vertical line in 3A marks the average location of the coda onset. Note that the Rise-Fall is not included in A as it was not represented in the data set by closed-syllable words.

The domain with which the Matbat tonemes are associated appears to be the voiced part of the rhyme, irrespective of its constituent structure. A comparison of the tones with (Figure 3A) and without (Figure 3B) voiced coda reveals that there is no conspicuous difference in tonal realization between these two syllable types. All tones are marked with greater f_0-excursions on syllables featuring a voiced coda (Figure 3A): the Low Rise goes higher, the tones ending in a low target go lower. These differences can be explained as follows. When the syllable features a voiced coda, there is more segmental material to mark the f_0-pattern of the tone on. In other words, the tonal realization of syllables without a voiced coda can be interpreted as a mild case of truncation of the prototypical realization of the tonemes.

[12] Phonemically, /ya^{21}w/ 'seed' has a VC rhyme. In the acoustic analysis, the sequence /aw/ has been treated as a diphthong vowel, so as to avoid the problem of segmenting this sequence.

It was mentioned above that the factor tone has a significant effect on all acoustic measures, including vowel duration. In particular for vowel duration, where the size of the effect was small, this significant result could be due to the large size of the data set. It is therefore worthwhile analyzing the effect of tone by means of a more critical analytic method, such as Linear Discriminant Analysis (LDA). In this investigation, LDA is used to determine the success with which the six tones can be distinguished from one another in the data set, on the basis of one or more of the acoustic measures. The LDA results for successful discrimination of tones are presented in Table 4.

Of all single postdictors, the measure f_0 slope yields the best result: 67.7 percent of the cases can be correctly classified for their tone on the basis of this measure alone. The other f_0-related measures give substantial correct classification scores as well. Relative to a 16.6 chance level baseline, these results constitute unmistakable evidence that the f_0-related measures are crucial to the tone distinction. Vowel duration, on the other hand, hardly raises the correct classification above the chance-level baseline. This shows that the significant effect of tone on vowel duration in the RM-ANOVA should not be considered as an indication that vowel duration is an acoustic correlate of the lexical tone contrast under investigation. Instead, it is an artifact, probably due to the fact that the data set was not balanced for syllable structure, and the epenthetic final /o/ on words with the Low-Fall toneme.

Table 4: LDA results – correct classification of tones on the basis of a number of postdictors (both single and combined). To be interpreted relative to a 16.6 percent chance-level baseline.

Acoustic measure(s)	Correct classification
Duration of vowel	22.9
F_0 mean	52.6
F_0 standard deviation	51.2
F_0 at vowel onset	54.5
F_0 end value	43.2
F_0 maximum	60.1
F_0 slope	67.7
Timing of maximum	54.2
Best result with two postdictors:	
f_0 slope & f_0 mean	85.6
with three-postdictors:	
f_0 at vowel onset & f_0 slope & f_0 mean	88.7

By including several f_0-related measures simultaneously in the LDA, the discrimination result can be increased to between 85 and 90 percent correct classification. With three acoustic measures as postdictors, the best correct classification result stands at 88.7 percent. The confusion matrix of this LDA (see Table 5) reveals that it is specifically the Rise-Fall toneme that is incorrectly classified, most often as a Low Rise or as a High. None of the measures sets it apart from the other tones: inspection of the descriptive statistics (Table A2 in Appendix) reveals that for most measures, it is the average value of the Rise-Fall that lies closest to the mean over all tones. Also, the Rise-Fall appears to vary considerably as a function of utterance context (see Figs. 4A, B).

Table 5: Confusion matrix for LDA with three postdictors: f_0 at vowel onset, f_0 slope, and f_0 mean. Classification results are expressed as percentages, and absolute numbers are included between parentheses in totals column.

Classified as → Actual ↓	Ex. High Fall	High Level	Low Rise	Low Level	Rise Fall	Low Fall	Total
Ex. High Fall	97.2	1.4	.0	.0	.0	1.4	100 (285)
High Level	.0	90.3	2.2	.0	7.5	.0	100 (279)
Low Rise	.0	3.6	93.3	2.4	.6	.0	100 (329)
Low Level	.0	.0	.0	97.9	.4	1.8	100 (282)
Rise-Fall	.0	32.3	21.8	7.3	33.9	4.8	100 (124)
Low Fall	1.6	4.9	.0	5.4	.0	88.1	100 (185)

2.4.3.2 The effect of utterance context on f_0 and duration

Many languages feature utterance-final lengthening, a phenomenon whereby the last rhyme of a word has a relatively long duration in utterance-final position (Vaissière 1983, Maddieson 1985, Cambier-Langeveld 2000). Final lengthening also occurs in Matbat: while average vowel duration in sentence-final position stands at 233 ms, it is only 145 ms sentence-medially. This effect of utterance context on vowel duration is significant [F (1,7) = 198.0, p < 0.01].

Utterance context also affects f_0, but the effect is limited. Visual comparison of the tonal realizations in utterance-final (Figure 4A) and utterance-medial (Figure 4B) position shows that the tonal targets are essentially the same. That is, there is no boundary tone following the lexical tone in phrase-final position.

All of the falling tones (Extra High Fall, Rise-Fall, Low Fall) end lower in the utterance-final context. This effect is significant in separate RM-ANOVAs based on items with the Extra High Fall, the Rise-Fall and the Low Fall, with independent factor sentence context and the dependent f_0 end value [Extra High Fall: $F(1,7) = 62.2$, $p < 0.01$; Rise-Fall: $F(1,7) = 25.8$, $p < 0.01$; Low Fall: $F(1,7) = 48.6$; $p < 0.01$]. But it is only the falling tones that have lower end targets. When the same analysis is carried out with those items that have the Low toneme, sentence context has no significant effect on the f_0 end value [F (1,7) = 5.55, n.s.].

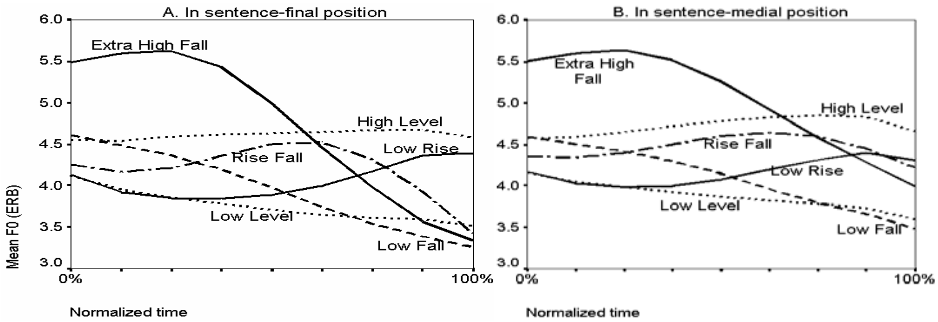

Figure 4: F_0-tracks of the 6 tones on the voiced part of the rhyme of monosyllabic words. Target words in sentence-final (A), and in sentence-medial (B) position. The tracks are represented on a normalized time axis, and plotted against an ERB scale.

Instead of interpreting the lowering of falling tones in utterance-final context as a matter of interaction of word-prosodic tone with a phrase-level boundary tone, I interpret it along the same lines as the similar phenomenon found for words with a voiced coda. The lexical tones are realized more fully on utterance-final syllables, because final lengthening provides additional material on which to realize the f_0 pattern. The contour tones reach more extreme values: the falling tones go lower, and the rising tone goes higher. The level tones, however, are not affected in any systematic way. In this way, utterance-final lengthening has different consequences for tonal realization of the contour tones as compared to the level tones.

2.5 Conclusion and discussion

2.5.1 Matbat is a tone language with six tonemes

According to the analysis presented here, Matbat features a lexical tone system with six tonemes. The minimal set data provide strong evidence for the phonemic nature of the tonal contrast. An acoustic analysis supported this analysis, and provided detailed information on the realization of the six tonemes. This analysis showed that the realization of the tonemes is not greatly affected by the presence of a prosodic boundary, nor by the composition of the syllable with which a toneme is associated. A Linear Discriminant Analysis showed that the phonetic differences between the tonemes are consistently realized. The only exception is the Rise-Fall. I attribute the low correct classification result of tokens of this toneme in the LDA to the fact that it shares characteristics with so many other tonemes.

On the assumption that this analysis is correct, Matbat is the second South Halmahera-West New Guinea (SHWNG) language of the Raja Ampat archipelago to feature lexical tone, next to Maˈya. In the following section, I will compare the

Matbat tone system with that of Maˈya, the other SHWNG language of the Raja Ampat archipelago that has lexical tone.

2.5.2 Comparison with the Maˈya tone system

The genetically related language Maˈya has three lexical tones – High, Low Rise, and Fall (Remijsen 2001a, b, 2002), in addition to lexically distinctive stress. Maˈya is spoken on the three biggest islands of the Raja Ampat archipelago: Waigeo, Salawati, and Misol – the island where Matbat is spoken (cf. Figure 1). Of the six tonemes of Matbat, three correspond to a toneme in Maˈya. That is, the Matbat High Level /3/, Low Fall /21/, and Low Rise /12/ tonemes resemble the three tonemes of Maˈya, that have very similar phonetic realizations. The transcription of the Matbat tonemes and their Maˈya counterparts in terms of a numeric notation is the same. Table 6 shows some examples of Maˈya minimal sets for tone.

Table 6: Minimal sets for lexical tone in Maˈya (Salawati dialect).

High	Low Rise	Fall
na^{3}	na^{12}	na^{21}
‘sugar palm’	‘sky’	‘belly’
ga^{3}	ga^{12}	ga^{21}
‘wood’	‘place’	‘cracked’
ba^{3}n	ba^{12}n	ba^{21}n
‘(car) tyre’	‘k.o. tree’	‘to seek shelter’

In Matbat, words with the Low Fall on the final syllable have an optional epenthetic final /o/ in phrase-final context. Something very similar is the case for the phonetically similar Fall toneme in Maˈya. Here the epenthetic final /o/ is invariably present in utterance-final position. The Matbat Low Fall and the Maˈya Fall are acoustically identical, so it is likely that one of them has influenced the other. It is more probable that Maˈya influenced Matbat rather than the way around, since Matbat is only used on Misol, and could not have exerted an influence on the Waigeo and Salawati variants of Maˈya, which also feature the epenthetic final /o/.

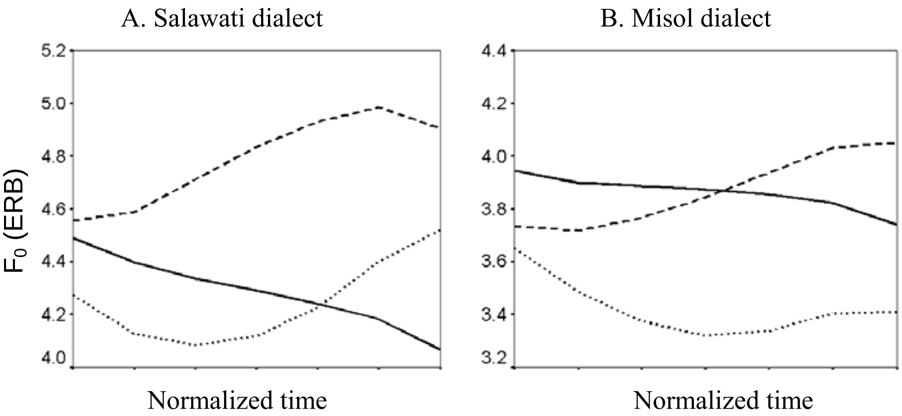

Figure 5: F_0 tracks of the three Maˡya tonemes as realized on the vowel of monosyllabic words in sentence-final position in a carrier sentence. The tracks are represented on a normalized time axis plotted along an ERB-scale. Fall tonemes (full line); High tonemes (interrupted line); Low Rise toneme (dotted line). Separate figures for the Salawati (A) and Misol (B) dialects. From Remijsen (2001b: 484).

Figure 5 shows the tonal space of Maˡya, for each of two dialects, those of the islands Salawati and Misol (see Figure 1). Misol is the island where Matbat is spoken alongside Maˡya. The f_0 tracks of these Maˡya dialects have been analyzed by means of a methodology that is very similar to that used in the analysis of Matbat tone. Just as was done for Matbat, (pseudo-)minimal sets were collected in a carrier utterance from eight native speakers.

While the three Maˡya tonemes each have a phonetically similar counterpart in the Matbat tone system, there are some important differences between the word prosodies of the two languages. Most obviously, Matbat has three additional tonemes. Also, while the Maˡya tonemes are restricted to the final syllable of the word, the association of tones with syllables in Matbat is unpredictable, as illustrated by the examples in (2). In other words, the Maˡya tonal contrast is tighter constrained in a syntagmatic sense. If we consider the variation of tonal systems as a continuum between the lexical pitch-accent type and the prototypical tone system (cf. McCawley 1978), then Matbat is closer to the prototypical lexical tone type than Maˡya is. Finally, unlike Matbat, Maˡya has a lexical stress contrast independent of lexical tone (Remijsen 2001b), in addition to the lexical tone contrast.

2.5.3 The origin of tone in Matbat and Maˡya

Lexical tone is uncommon among Austronesian languages. Out of 1,262 (Grimes 1996) Austronesian languages, no more than 16 (1.3 percent) have been reported to feature lexical tone. Apart from Matbat and Maˈya, the following 14 Austronesian languages have been reported to feature lexical tone:

- The Chamic languages Eastern Cham (Edmondson & Gregerson 1993) and Utsat (Maddieson & Pang 1993)
- Mor, a language from Cendrawasih Bay (Laycock 1978)
- Kara, Barok and Patpatar, all in New Ireland (Hajek 1995)
- The North Huon Gulf languages Yabem and Bukawa (Ross 1993)
- Five languages of New Caledonia (Rivierre 1993)
- Awad Bing (Cahill 2003)

While most of these languages have a two-tone contrast, three-tone systems have been reported for Eastern Cham and for Cémuhî, one of the New Caledonia languages.[13] A conspicuous exception, however, is Utsat, which has five lexically contrastive tonemes. Utsat is used by a small community of only two villages on Hainan island, surrounded by a population speaking a Chinese tone language (Maddieson & Pang 1993). The comparative anomaly of the Utsat tone system makes sense when we take into account the influence of language contact. Language contact may also have been a factor in the origin of lexical tone in Eastern Cham, Mor, Kara, Barok, and Patpatar. The tone languages of the North Huon Gulf and of New Caledonia, on the other hand, have been interpreted as instantiations of spontaneous tonogenesis (Rivierre 1993, Ross 1993, respectively).

I hypothesize that the six-toneme system of Matbat is the result of language contact with a non-Austronesian tone language. Different from the Chinese speech community surrounding Utsat, however, this non-Austronesian language no longer exists.[14] Various types of tonal phenomena, including complex lexical tone systems, have been reported for the non-Austronesian (Papuan) languages of nearby New Guinea (Donohue 1997 and references there). However, no Papuan tone language is currently spoken on Misol, or anywhere else in the Raja Ampat archipelago. The closest non-Austronesian language is Moi, which is used on the New Guinea mainland and on the eastern coast of Salawati island – Moi has not been reported to feature lexical tone (Menick 1995). In the absence of evidence of an existing non-Austronesian language with a similarly complex tone system in the area, I hypothesize that the Papuan tone language involved in the contact situation was used on Misol before the arrival of Proto-SHWNG on Misol, probably around 1500 BC (Bellwood 1998:961). Matbat, then, evolved out of this contact situation. Below I will present additional arguments in favor of this hypothesis.

There is strong evidence that the prosodic characteristics of a substrate language may significantly contribute to a language that develops from a contact situation, even when the influence of this substrate language elsewhere in the language system

[13] Inspection of the data on Awad Bing in Cahill (2003) suggests that this language may have a word-prosodic contrast similar to the word-accent systems of e.g. Serbo-Croatian and Swedish. There is one prominent syllable in the word, which can have either a high or a falling tone. In the examples in Cahill (2003), the prominent syllable is consistently marked by duration and intensity, which are well known correlates of lexical stress.
[14] Unless Matbat itself would be reclassified as a non-Austronesian language.

and in the vocabulary is fairly limited. In this way, Papiamentu, a creole language of the Caribbean with a predominantly Spanish and/or Portuguese vocabulary, has retained a tonal contrast from its West African heritage (Römer 1991). Similarly, the Scots dialect of the Shetland islands (north of Scotland) has complementary quantity, a phenomenon that is characteristic for its Norse substrate: in stressed closed monosyllabic words, long vowels are followed by a short consonant and short vowels by a long consonant (van Leyden 2002).

Moreover, evidence of a Papuan influence is not limited to the Matbat tone system. It is also apparent from the vocabulary, and from the grammar. My own data on the Matbat lexicon suggest that a considerable proportion of the lexicon of Matbat has not been derived from an Austronesian ancestor. Although all SHWNG languages in the Raja Ampat archipelago have non-Austronesian lexical items, the phenomenon is the most prominent in Matbat and Ambel, another SHWNG language of the Raja Ampat islands. Like its tonal contrast, the considerable proportion of non-Austronesian items in the Matbat lexicon can be accounted for readily by attributing it to the non-Austronesian substrate language. In addition Matbat has inflection for inalienable possession on body parts and kinship terms, and inflection for noun classes on numerals. Both of these characteristics do not reflect the Austronesian prototype (Foley 1998), but they are not uncommon in Papuan languages (Foley 1986, 1998). It is worthwhile to note that the tonal contrast is tied up with these typically Papuan phenomena in the Matbat morphosyntax. In summary, the contact situation that would have given rise to the tone system is independently required to account for the presence of other non-Austronesian influences in the Matbat language.

There is also a negative argument, against the alternative hypothesis, that tone in Matbat is the result of spontaneous tonogenesis. When a language develops tonal contrasts through internal development, it is possible to relate the resulting tonal contrast to segmental contrasts in the ancestor language, such as a voicing contrast in stops (Hombert 1978, Ross 1993). I have found no such regular correspondences for Matbat.

It was observed above that all three Maˈya tones are acoustically similar to Matbat tones: both languages have a high level toneme, a low rise, and a low fall. Given this close similarity, I extend the substrate hypothesis so as to account for lexical tone in Maˈya as well. That is, I hypothesize that the non-Austronesian tone language that contributed lexical tone to the contact situation out of which Matbat developed, or another non-Austronesian language closely related to it, was the source of the Maˈya tonal contrast. For Matbat, the substrate hypothesis is the only plausible scenario for tonogenesis. For tonogenesis in Maˈya, on the other hand, there is a realistic alternative.

There is evidence that the Maˈya villages of the Raja Ampat archipelago played an important part in the slave trade between west New Guinea and the Moluccas, and that there frequently were slaves in *raja* villages such as Samate (see Remijsen 2001a). This history of slavery offers a potential explanation for the origin of lexical tone in Maˈya – just as it does for Papiamentu. It is therefore possible that Maˈya developed lexical tone through contact with the Papuan tone languages of slaves. However, this alternative hypothesis has important weaknesses. First, the tone system of Maˈya is very similar across the Misol, Salawati and Laganyan dialects (Remijsen 2001a, b). This similarity suggests that the Maˈya lexical tone system developed before the dialect split, which predates the historical record and is part of Maˈya mythology. If tonogenesis would have taken place through language contact induced by the slave trade after the dialect split, then the Misol dialect would have different tones from the Salawati dialect, because both groups were hunting/buying slaves in different areas of New Guinea (see Remijsen 2001a). Admittedly, it is possible that the slave trade predates the migration of the Maˈya. Second, only two of the Papuan languages of the Bird's Head, the area of origin of most slaves, are tonal. Abun has a three-way tone contrast with a low functional load (C. Berry 1998, K. Berry p.c.), and Mpur has a four-tone contrast with a high functional load (Odé 2002). Both are located in the northern part of the Bird's Head, well out of reach of the Maˈya slave-hunters from Misol. As mentioned earlier, the Papuan language closest to the Raja Ampat islands, Moi, is not a tone language (Menick 1995). Finally, if the case of Matbat allows us to safely assume that a tone language was used on Misol before the arrival of the Austronesians, then this increases the likelihood of the same or a related tone language being used elsewhere in the Raja Ampat archipelago.

The most likely explanation for tonogenesis in Maˈya, therefore, is that the non-Austronesian substrate language or languages that was / were used on the Raja Ampat islands before the arrival of the Austronesians featured lexical tone contrasts. When speakers of this language came in contact with and assimilated Austronesian Proto-SHWNG, they retained the tone contrast of the substrate language. Parsimoniously, the same hypothesis accounts for tonogenesis in Matbat.

2.5.4 Further research

Very little is known about Raja Ampat languages other than Maˈya. Our knowledge on these languages is limited to wordlists, and even those most basic data are not available for Bata. I believe that Matbat and Ambel are the most worthwhile objects of language documentation. These are the two languages that show the least similarity with Maˈya. Maˈya is relatively well-documented, if we include those materials by van der Leeden that have not yet been published (van der Leeden ms. 1, ms. 2). Efforts are underway to publish these materials, and to provide a grammar sketch of Magey Matbat.

A thorough investigation of the morphosyntactic systems of Matbat and Ambel would probably be rewarded with the discovery of more typically Papuan phenomena. Such research would complement the investigations of Reesink (1998) on the Papuan languages of the Bird's Head, which is adjacent to the Raja Ampat archipelago. Whereas Reesink highlighted the typically Austronesian features of Papuan languages, such studies on Ambel and Matbat would document the Austronesian side of this *Sprachbund*.

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Appendices

Table A1: Words used in the acoustic analysis of Matbat tones.

Extra High Fall	High Level	Low Rise	Low Level	Rise-Fall	Low Fall
fa^{41} ‘chalk’				fa^{121} ‘bad’	
la^{41}m ‘to brag’	la^{3}n ‘song’		la^{1}m ‘needle’		
	ma^{3}t ‘people’	ma^{12}t ‘dead’	ma^{1}t ‘guava’		
		sa^{12}m ‘separate’			sa^{21}m ‘possible’
ma^{41} ‘road’		ma^{12} ‘cooked’			
na^{41} ‘moon’		na^{12} ‘sweet’	na^{1} ‘rain’	la^{121} ‘sun’	
		na^{12}n ‘animal’	na^{1}n ‘betel leaf’		na^{21}n ‘name’
	s-a^{3} ‘1S-climb’	sa^{12} ‘salty water’			
mɔ^{41}n ‘areca nut’			mɔ^{1}n ‘heavy’		
	to^{3}l ‘three’	t-o^{12}l ‘1P-stand’			to^{21}l ‘egg’
de^{41} ‘to throw’	de^{3} ‘house’			de^{121} ‘sick’	
n-e^{41}n ‘3P-sleep’	ne^{3}n ‘mother’		ne^{1}n ‘to carry’		
t-ɛ^{41}l ‘1P-descend’		te^{12}l ‘to chop’	te^{1}l ‘push off’		
	hu^{3}ŋ ‘to enter’	hu^{12}ŋ ‘to search’			hu^{21}ŋ ‘to use’
	nu^{3} ‘village’	nu^{12} ‘to kiss’	nu^{1} ‘coconut’		
tu^{41} ‘grass’		tu^{12} ‘to peel’		tu^{121} ‘thunder’	
			ni^{1}p ‘to fly’		ni^{21}p ‘to press’
	ya^{3}w ‘banana’				ya^{21}w ‘seed’

Appendices

Table A2: Descriptive statistics for Matbat tones. Average values for each measure: f_0 mean, f_0 standard deviation, f_0 at vowel onset, f_0 maximum, time of f_0 maximum, f_0 slope, and vowel duration.

		F_0 Mean	F_0 SD	Vowel onset f_0	Max. f_0	Time max. f_0	F_0 Slope	Vowel dur.
Ex. High Fall	Hz	184	33.8	212	222	.19	1.298	170
	ERB	4.93	1.09	5.53	5.71			
High Level	Hz	171	5.0	165	179	.72	.977	197
	ERB	4.68	.156	4.55	4.85			
Low Rise	Hz	145	8.9	145	163	.80	.936	206
	ERB	4.10	.289	4.08	4.49			
Low Level	Hz	133	7.0	146	148	.02	1.064	190
	ERB	3.81	.223	4.09	4.14			
Rise-Fall	Hz	157	12.1	153	172	.57	1.00	212
	ERB	4.35	.394	4.28	4.69			
Low Fall	Hz	143	17.6	167	169	.03	1.19	195
	ERB	4.04	.578	4.56	4.61			
All tones	Hz	156	13.9	165	176	.41	1.07	189
	ERB	4.33	.450	4.53	4.76			