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Research Article

# Stress, pitch accent, and beyond: Intonation in Maltese questions

Martine Grice [a,*], Alexandra Vella [b], Anna Bruggeman [a]

[a] IfL-Phonetik, University of Cologne, Herbert-Lewin-Str. 6, 50931 Köln, Germany
[b] Institute of Linguistics and Language Technology, University of Malta, Msida, MSD 2080, Malta

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ABSTRACT

Maltese question word interrogatives are shown to have an alternation in the association of postlexical tones with the question word. Tones associate with the left edge of the question word in direct questions, and with the lexically stressed syllable in indirect questions and when quoted. This alternation holds regardless of the metrical structure of the word. Maltese is thus the first language with lexical stress to be described as having a pragmatically conditioned alternation between fully-fledged pitch accents and pitch events without association to stress.



## 1. Introduction

In languages with lexical stress and post-lexical pitch accent, wh-words (or question words, henceforth qwords), typically carry a prenuclear or nuclear pitch accent (e.g. Haan, 2002 for Dutch; Prieto, 2004; Henriksen, 2014 for Spanish; Arvaniti & Ladd, 2009 for Greek). Although Maltese is considered to have both lexical stress and post-lexical pitch accents, intonation in qword questions has so far defied straightforward intonational analysis (Vella 2007, 2011). Prior experimental studies have found a characteristic pitch peak at the beginning of the qword rather than – as would be the case if there were a regular pitch accent – on the lexically stressed syllable. The analysis is further complicated by the fact that when the qword is sentence-initial, the peak co-occurs with the beginning of the phrase, making it difficult to determine whether the peak is associated to some aspect of the word itself or to the phrase.

In the present study, this confound was removed by considering the intonational properties of qwords that occur in other phrasal positions as well. This is made possible by the fact that in Maltese, the qword is not limited to occurring only in initial position in a sentence. This flexibility in word order allows for a more calibrated investigation of the location of pitch peaks. Specifically, in this study we analysed different qwords in interrogatives at three different phrasal positions (initial, peninitial and final), and compared these to qwords in two kinds of declaratives, one used as an indirect question (e.g. *. . .u staqsietni, mar jgħum ir-Ramla min.* '. . .and she asked me, who went swimming to Ramla.' see Table 2 for gloss) and the other involving a qword that is quoted (e.g. *Il-mistoqsija li għandna bżonn insaqsu hija: min.* 'The question we need to ask is: who.', see Table 2). In this latter case the qword is in narrow focus.

This paper intends to make two main contributions. First, it provides a further analysis of qword interrogative intonation in Maltese, building on earlier work (Vella 2007, 2011). In this context, the aim is to capture the realisational details of qword interrogative intonation and find a place for its analysis in what is currently known about the intonation of Maltese. The analysis of this tune has implications for a number of other structures in the language such as exclamatives, imperatives and vocatives, where pitch peaks also occur at some distance from the lexical stress (Vella 1995, 2009). See Section 5.1 for examples.

Second, this study contributes novel insights into intonational phonology by situating the findings in the wider discussion about the association of tones in the world's languages. In languages that have lexical stress, intonational pitch accents are reportedly restricted to stressed syllables e.g.

* Corresponding author. at: University of Cologne, IfL-Phonetik, Herbert-Lewin-Str. 6, 50931 Köln, Germany. Fax: +49 681 302 4684.
*E-mail address:* martine.grice@uni-koeln.de (M. Grice).

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0095-4470/

Gordon (2014). On the other hand, edge tones (boundary tones) are restricted to the edges of constituents (Jun, 2014). However, the possibility has been raised on a number of counts that this distinction is oversimplified.

- (1) Certain tones, referred to as *phrase accents,* have association properties that are typical of both pitch accents and edge tones. In addition to an association to the right edge of the phrase, they may have a secondary association to a lexically stressed syllable (Grice, Ladd, & Arvaniti, 2000) or to the right edge of a word (Beckman & Pierrehumbert, 1986; Pierrehumbert & Beckman, 1988).
- (2) *Languages without lexical stress* have been reported to associate tones to specific non-peripheral syllables (e.g. Jun & Fougeron, 2002; Ladd, 2008 on French; Maskikit-Essed & Gussenhoven, 2016 on Ambonese Malay; Bruggeman, Roettger, & Grice, 2017 on Tashlhiyt Berber). In these cases the tones can be some distance from the edge, making an edge tone analysis problematic.
- (3) In English, *pitch accents may be associated early in a word*, involving association to syllables other than the primary lexical stress (Shattuck-Hufnagel, Ostendorf, & Ross, 1994). However, this association is conditional on rhythmic constraints or achievement of optimal spacing of intonational tones. Similar phenomena have been reported for other languages, such as Polish (Hayes & Puppel, 1985) and Bedouin Hijazi Arabic (Al-Mozainy, Bley-Vroman & McCarthy 1995), although traditionally these early pitch accents are interpreted as a shift in the position of the stress (the "rhythm rule", Liberman & Prince, 1977), rather than, for instance, a difference in the association of the pitch accent to a secondary stress.
- (4) Finally, there are reports on *languages that have lexical stress but nonetheless associate intonational tones to unstressed syllables:* pitch accent in Kuot (an isolate spoken in Papua New Guinea) seems to categorically ignore stress (Lindström & Remijsen, 2005), while in Onondaga (Iroquian) the (non-)coincidence of pitch accent and stress depends on the word's position in the sentence (Gordon, 2014). However, such cases are rare and their analysis tends to involve a language-specific parameter setting, according to which association of these tones is determined. Moreover, the intonation systems of these languages are as yet poorly understood. Jun (2014:530) also points out the possibility of tones associating to either heads or edges in the same language, but this is complicated by the fact that Jun refers on the one hand to languages like French and Farsi (which are typically considered to lack *lexical* heads) and on the other hand to languages like Serbo-Croatian and Japanese (which have lexical pitch specifications in the form of a restricted *lexical pitch accent* inventory).

This paper investigates a language with lexical stress that is known to have regular pitch accents and phrase accents, but that also appears to have pitch events on unstressed syllables. From what has already been reported on the language, these latter tones are not phrase accents in the sense of (1), as they do not occur at the right edge of words or phrases. The presence of word stress rules out an analysis akin to (2). The tones in Maltese qwords might be similar to the early pitch accents described in (3), depending on the analysis of further aspects of the contour. Possibility (4) seems promising, especially since, while reports exist of other languages in which pitch accent might be independent of stress, the details of the intonation systems to which this may apply are still poorly understood. However, at this point there is no convincing evidence that a language may have lexical stress alternating with postlexical tones that associate to positions that are not close to the phrasal edge. In sum, our results aim to contribute towards the discussion of the role of stress in determining the association of tones and the discussion of tonal association in general.

The structure of this paper is as follows. The next section (2) serves as the general background, starting with some of the linguistic particulars of Maltese and its prosody (2.1), followed by an overview of qword interrogative formation in Maltese (2.2) and of what is currently known about qword interrogative intonation (2.3). Open questions about Maltese interrogative intonation, with reference to intonational phonology in general are raised in 2.4, together with hypotheses about possible findings and answers. Section 3 describes the experimental methods of the study reported on in this paper, and Section 4 the results. A discussion (Section 5) and conclusion (Section 6) round off the paper.

## 2. General background

### 2.1. Maltese

Maltese (Semitic, Arabic) is the national language of Malta and a co-official language with English, and as of 2016, with Maltese Sign Language. It is spoken by the overwhelming majority of the ca. 450 000 inhabitants of the Maltese Islands and by another 80 000 speakers elsewhere (Sciriha & Vassallo, 2006; Simons & Fennig, 2018). In Malta, Maltese is spoken alongside English, and the Maltese population exhibits varying degrees of Maltese/English bilingualism, with some people being trilingual, often also speaking Italian (Vella, 2012). Historically, Maltese derives from a variety of Arabic used in Muslim Sicily often referred to as Siculo-Arabic, which probably originated in Tunisia. Over the centuries the variety developed independently, drifting apart from its Maghrebian ancestor as it came to be increasingly and heavily influenced by Romance languages and later English, especially in terms of its lexicon and morphology (Mifsud, 1995; Borg & Azzopardi-Alexander, 1997; Brincat, 2011; Simons & Fennig, 2018). It has been claimed that phonologically, Maltese is typologically closer to Levantine dialects of Arabic (Wettinger, 1993; Alexander Borg, 1994). In terms of its intonation, there are reported similarities to Lebanese Arabic (Vella, 2003) as well as Sicilian varieties of Italian, especially Palermo (Grice, 1995; D'Imperio et al., to appear).

In Maltese, lexical stress is assigned on phonological grounds to the final, penultimate or antepenultimate syllable. It falls on the heavy (V: or VC) syllable closest to the right edge of the word, except in words having a closed final syllable, which can only be stressed if it is superheavy (V:C or VCC). In words in which there is no heavy syllable, lexical stress is penultimate by default (Vella, 2009).

Analyses of the intonation of Maltese declaratives and interrogatives have established the existence of two nuclear configurations comprising a pitch accent plus a boundary tone sequence, i.e. a falling H* + L Lp and a rising L* Hp respectively. The pitch accents associate with the lexical stress of the focus exponent – the head of [+focus] material in the last P(honological)-phrase within an I(ntonational)-phrase: boundary tones are labelled as p and i respectively, in line with notation adapted from Hayes & Lahiri (1991). In addition, Maltese has two post-focal tonal sequences comprising a phrase accent and a boundary tone, $L^{-}$ Hi and L + $H^{-}$ Hi. These

associate with the head of [−focus] material which follows the last [+ focus] P-phrase within the I-phrase: L⁻ Hi always follows the falling nuclear tonal sequence, thus H* + L L−Hi, and L + H⁻ Hi the rising one, thus L* Hp L + H⁻ Hi (Vella, 2003).

### 2.2. Question word interrogative structure in Maltese

Qwords in Maltese can be simple, such as *fejn* 'where', *għa-LIEX* 'why', *kemm* 'how much', *kif* 'how', *LIEma* 'which', *min* 'who', *xi*/*x'* 'what', or complex (Sutcliffe, 1936, see also Mifsud & Borg, 1997).[1] Complex forms usually comprise a preposition and one (or more) of the simple qwords. *Kemm*, for example, can occur in *minn KEMM* literally 'from how much', *saKEMM* 'until/up to when'. The compositeness or otherwise of complex qwords at the morphosyntactic level is not always clear (Fabri, 1993, Gatt p.c.) although distinct pairs such as *għalFEJN* 'why' and *għal FEJN* 'to where' suggest the existence of some sort of cline involving a greater or lesser degree of compositeness. It is also not completely clear whether forms of this sort have characteristics of a durational and possibly junctural nature which distinguish the more unitary forms from their less composite variants. Despite this uncertainty as to their composition, the complex qwords behave in all cases like phonological words for the purposes of stress placement, with stress being assigned following rules for the assignment of lexical stress in Maltese discussed above.

Descriptions of Maltese suggest that the qword is usually found sentence-initially (Sutcliffe, 1936). However, qwords may also occur in other positions (Borg & Azzopardi-Alexander, 1997), although with different degrees of acceptability and/or markedness. Borg and Azzopardi-Alexander (1997) suggest that there is greater freedom in constituent order possibilities in the case of so-called "echo questions". In an earlier study manipulating qword position (initial, medial and final in the phrase), Vella (2011) found that speakers use different acceptability criteria. In the trade off between "neutrality" and "acceptability", target sentences with a qword in initial position seemed to be the preferred renderings, followed by those with a qword in final position

### 2.3. Qword interrogative intonation in Maltese

The consensus in earlier work on the intonation of qword questions in Maltese by Vella (1995, 2007) and Magro (2004) is that Maltese qword questions, like their counterparts in many other languages, tend to end low or level, usually lacking a phrase-final rise. Two further tendencies have been observed as characterising the typical qword question tune in Maltese. The first is the tendency for relatively high F0, manifested by a higher F0 onset as compared to imperatives, tag-questions and vocatives (Magro, 2004; Vella, 2007) and relatively high maximum values: Vella (2007) provides some preliminary experimental results suggesting that the F0 peak in qword interrogatives (phrasal maximum consistently found on the qword) is higher than the absolute maximum in these other sentence modalities. The second observation that has been made is that the F0 peak occurring on the qword is aligned early in comparison to regular pitch accents (Borg & Azzopardi-Alexander, 1997, Magro, 2006; Vella, 2007). These analyses were inconclusive in that various matters related to the realisation of the F0 peak and the ensuing fall remain unresolved, particularly those relating to alignment. Moreover, it is unclear whether the intonational peak on the qword should be analysed as involving a pitch accent or whether an alternative analysis is needed for the relevant pitch event.

A follow-up study by Vella (2011) looked at qwords in different phrasal positions in interrogatives produced by two speakers. The study demonstrated a tendency for the pitch peak to occur in the vicinity of the qword regardless of its position (initial, medial or final). Interestingly, qwords with non-initial stressed syllables, such as *ma' MIN* 'with whom', seem to have earlier peaks in relation to the stress than monosyllabic qwords such as *MIN* 'who' or qwords with initial stressed syllables such as *MEta* 'when'. To capture the observation that qword interrogative intonation consists of a sharp fall from an F0 peak in the vicinity of the qword, followed by a low stretch of F0 which is sustained until the phrase end, a phonological analysis in terms of a sequence of H(igh) L(ow) L(ow) tonal targets was proposed by Vella (2011). She suggested that this H L L sequence involves an initial %H boundary tone, associated with the left phrase edge, followed by a L* pitch accent on the final accented syllable of the phrase and a final L% boundary tone, associated with the right edge of the phrase. However, this analysis cannot account for medial and final qwords.

### 2.4. Open questions and hypotheses

From the above observations it is clear that there is currently no conclusive analysis of qword interrogative intonation accounting for qwords in all positions in Maltese. Before addressing the unanswered questions, this section serves to consider the insights reviewed above in light of the wider discussion on qword interrogative intonation and general issues in intonational phonology.

In terms of crosslinguistic properties of qword questions, Maltese fits in with often reported pitch prominence on the qword (these languages include e.g. Greek, Spanish, Arabic, Hungarian, Tamil and Bininj-Gun-Wok; see contributions in Jun, 2005, 2014; Hirst & Di Cristo, 1998, and an overview in Bruggeman, 2018). While there is a crosslinguistic tendency for the main phrasal pitch prominence to be placed on the qword, several exceptions exist: qwords do not typically receive main phrasal pitch prominence in Germanic languages such as English and German (although Dutch appears to be less of an exception, cf. Haan, 2002; Chen, 2012). Qword pitch prominence is typically analysed as a pitch accent, based on two types of argument: (1) the qword is considered a (default) focused constituent (e.g. Kiss, 1995; Song, 2017) making the intonational event that co-occurs with it serve a prominence-cueing function, and (2) the pitch event is phonetically aligned with and interpreted as having a phonological association to a stressed syllable in these languages.

A more detailed study of qword interrogative intonation in Maltese can contribute to the debate about head versus edge

[1] In-text examples are provided in Maltese spelling, with capitals indicating stressed syllables. In the case of medial geminates, capitalisation of only one of the two orthographic elements reflects current understanding of syllabification in such cases (Galea, 2016). Where phonetic transcription is provided, conventions laid out in Borg and Azzopardi-Alexander (1997) are followed.

marking. Typically, intonational events on qwords are interpreted as pitch accents for functional reasons (argument (1) discussed above). However, although Maltese has lexical stress and regular fully-fledged pitch accents associating to stressed syllables in focused constituents, the pitch prominence in qwords is not obviously linked to the stressed syllable, and instead appears to occur close to the (left) word edge (preventing straightforward use of argument (2) above).

Starting from Vella (2011) analyses of the qword interrogative melody consisting of H L L, we shall focus our attention on the association properties – and thus the status in the intonation system – of the first two tones (H L), the final L being less controversially analysed as a phrase-final boundary tone, L%. The following three analyses are possible:

- Analysis 1: H and L both belong to a regular pitch accent. Since the peak is early and not clearly aligned with the stressed syllable, the obvious candidate would be an early falling pitch accent, i.e. H + L* associated with the stressed syllable.
- Analysis 2: The two tones are associated with the left-edge boundary, either associated with the intonation phrase, or some other constituent such as the word, i.e. %HL (where % simply means edge association and the lack of space between the two tones indicates that they belong together).
- Analysis 3: The third possibility is that the first two tones are independent, e.g. the H tone is associated with the left-edge (as in Analysis 2, with either the phrase or the word) and the other constitutes a monotonal regular L* pitch accent, i.e. %H L* (as in Vella, 2011).

All the above analyses are based on the assumption that Maltese has no lexically (or morphologically) specified tones (unlike, for instance, Swedish and Japanese) and that all tones are postlexical in nature. This is a reasonable assumption, based on our current understanding of the intonational system of Maltese (cf. Vella, 1995, 2009). To rule out any analysis that might consider the intonational properties to be lexically specified, this paper investigates the prosodic characteristics of the same qwords in direct questions and in other contexts. If qwords in a different context (for example, when not contributing to interrogative meaning) do not share the same intonational properties, this would corroborate the argument that the intonational characteristics of qwords are due to postlexical intonation and not inherent properties of qwords in general.

Specifically, the present study addresses the following questions:

1) What are the alignment details of the peak represented by the H tone in the contour observed for qword questions, and what does the alignment of the peak tell us about the phonological association of this tone?
2) What are the alignment details of the low turning point represented by the L tone in the contour characterizing qwords, and what does this mean for the phonological association of this tone?
3) What are the intonational properties of qwords that occur in non-interrogative contexts?

To facilitate the choice between competing analyses, several measurements beyond turning point alignment are taken into account. These include turning point scaling, and durational measurements of the initial and stressed syllables of the qword, the latter serving to explore the possibility that durational enhancement of parts of the qword differ as a function of structural prominence (lexical stress) and/or as a function of the vowel carrying intonational tones (the initial vowel in interrogatives).

## 3. Methods

### 3.1. Materials and data collection

Although a number of qwords in Maltese are di- and trisyllabic (Mifsud & Borg, 1997), those in frequent usage are often monosyllabic, many starting with a voiceless stop, e.g. /k/ (*kemm* 'how much' or *kif* 'how') or a fricative e.g. /f/ or /ʃ/ (*fejn* 'where' or *xi* often shortened to *x'* 'what'). The absence of voiced segmental material prior to the stressed vowel or syllable of the qword makes it difficult to establish the precise nature of the tonal events occurring at the start of the qword, especially if the qword is phrase initial.

In order to gain insights into the phonological analysis of tonal events, the materials used in the present experiment were constructed with sonorants. Target qwords were selected with a varying number of syllables before the beginning of the stressed syllable, namely morphologically simple *MIN* /miːn/ 'who' and three complex forms *ma' MIN* [mɐ 'miːn] 'with whom', *min MINnhom* [miːn 'mɪnːɔm] 'which one of them' and *ma' min MINnhom* [mɐ miːn 'mɪnːɔm] 'with which one of them', see Table 1 (note that the apostrophes in the examples are an integral part of Maltese orthography). The stressed syllable is realised with different vowel quality depending on whether the vowel is followed by a geminate (Galea, 2016): this is taken into account in the analysis.

Target qwords were embedded in different carrier sentences. The qword occurred in three phrasal positions within a direct interrogative: initial, peninitial and final. Qwords additionally occurred in two types of declaratives in final position: in indirect and quoted questions. The carrier sentences were identical for the different qwords, with the exception of the indirect and quoted question contexts. They are given in Table 2.

In both types of declaratives, the qword is in a structural position usually assigned by default to the nuclear pitch accent (Vella, 1995), i.e. final in the phrase. The declaratives were designed to allow for a direct comparison in final position of qwords in direct interrogatives with those in declaratives.

All carrier sentences were embedded in one of three scripted dialogues, which are given in Appendices A–C. The dialogues also contained distractor questions with two other qwords, *kemm* 'how much' and *minn kemm* 'from amongst how many' as well as polar questions.

The questions with the qword in initial position represent the most common form for qword questions, although they are attested in spontaneous speech in final as well as peninitial positions, the latter following the ubiquitous conjunction *mela*. In the context of the dialogues, developed by the second author, a native speaker of the language, the questions with the final qword are as felicitous as those with qwords in initial and peninitial position.

### 3.2. Participants & recordings

Ten participants took part in the study, five female and five male (F1-5 and M1-5 respectively) with no known or observable speech or hearing impairments. All speakers are bilingual Mal-

**Table 1**
Target question words and syllabification; stressed syllable in highlighted column.

| qword | gloss | Broad phonetic transcription and syllabification | | | |
|---|---|---|---|---|---|
| *MIN* | 'who' | | | 'mi:n | |
| *ma' MIN* | 'who with' | | mɐ | 'mi:n | |
| *min MINnhom* | 'which one of them' | | mi:n | 'mɪn: | ɔm |
| *ma' min MINnhom* | 'with which one of them' | mɐ | mi:n | 'mɪn: | ɔm |

**Table 2**
Target sentences for all five contexts, illustrated with qword min 'who' for the qword question and the quoted qword contexts, and with all four qwords in different contexts in the case of the indirect declarative.

| Direct interrogatives | Qword | Carrier sentence |
|---|---|---|
| Initial | | *Min mar j-għum ir-Ramla?*<br>who go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla<br>'Who went swimming to Ramla?' |
| Final | | *Mar j-għum ir-Ramla min?*<br>go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla who<br>'Who went swimming to Ramla?' |
| Peninitial | | *Mela min mar j-għum ir-Ramla?*<br>so who go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla<br>'So who went swimming to Ramla?' |
| Declaratives | | |
| Indirect question, final | *min* | *U staqs-iet-ni, mar j-għum ir-Ramla min.*<br>and ask.3SG.F.PFV-1SG go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla who<br>'And she asked me who went swimming to Ramla.' |
| | *ma' min* | *Għad-ni qed n-ipprova n-ifhem mar j-għum ir-Ramla ma' min.*<br>still-1SG PROG 1SG.IMPFV-try 1SG.IMPFV-understand go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla with who<br>'I'm still trying to understand with whom he went swimming to Ramla.' |
| | *min minnhom* | *N-ixtieq t-għid-li mar j-għum ir-Ramla min minn-hom.*<br>1SG.IMPFV-wish 2SG.IMPFV-tell-1SG go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla who from-3PL<br>'I would like you to tell me who amongst them went swimming to Ramla.' |
| | *ma' min minnhom* | *Għand-i bżonn in-kun n-af Mario mar j-għum ir-Ramla ma' min minnhom.*<br>at-1SG need 1SG.IMPFV-be 1SG.IMPFV-know Mario go.3SG.M.PFV 3SG.M.IPFV-swim DEF-Ramla who from-3PL 'I need to know with which one of them Mario went swimming to Ramla.' |
| Quoted qword, final | | *Iva. Mistoqsija (oħra) li għand-na bżonn in-saqs-u hija: min.* Yes.<br>Question (another.FEM) that at-1PL need 1.IPFV-ask-PL is.F who<br>'Yes. The question that we need to ask is who.' |

tese/English, but care was taken to select participants with Standard Maltese as their dominant language. None of the speakers reported connections, geographical or familial, to speakers of other dialects of Maltese. They were recorded in the studios of Campus FM, which forms part of Malta University Broadcasting.

Participants read the role of A in the scripted dialogues and the second author, a native speaker of Maltese, the role of B. Speakers were allowed time to familiarise themselves with the material and to practice reading their part of the dialogues aloud. They were instructed to read as "neutrally" as possible. Speakers read the set of materials a total of 4–7 times (the first six participants did seven repetitions, the remaining four did only four repetitions). The first reading was taken to be a practice run and the second, third and fourth readings were analysed, unless there were hesitations in which case later readings were used to replace any of the earlier discarded readings (N < 10).

### 3.3. Measurements

The total number of target utterances was 600 (4 qwords * 5 sentence types * 3 repetitions * 10 speakers). Acoustic analysis was carried out using Praat (Boersma & Weenink, 2016). All utterances were annotated manually for the location of target qword, and the initial vowel and stressed vowel within it. An example is shown in Fig. 1. Pitch contours estimated by the standard pitch algorithm were handcorrected and smoothed (15 Hertz bandwidth) (cf. Cangemi, 2015).

Fig. 2 shows representative example contours for the longest qword *ma' min minnhom* for one of the female speakers for each of the five carrier sentences (the full set of contours can be found in Appendix D). The three types of interrogatives, with the qword occurring in different positions, are shown on the left, and the two types of non-interrogatives (henceforth declaratives) are shown on the right.

Interrogatives are characterized, without exception, by the systematic presence of a clearly defined pitch peak that occurs at the start of the qword. This peak forms part of the main pitch event in the phrase. In contrast, declarative contours exhibit a pitch drop on the qword in the vicinity of the stressed syllable and potential pitch prominence elsewhere in the phrase. As these contours indicate that the intonational marking of qwords varies as a function of interrogativity, we consequently focused on slightly different prop-

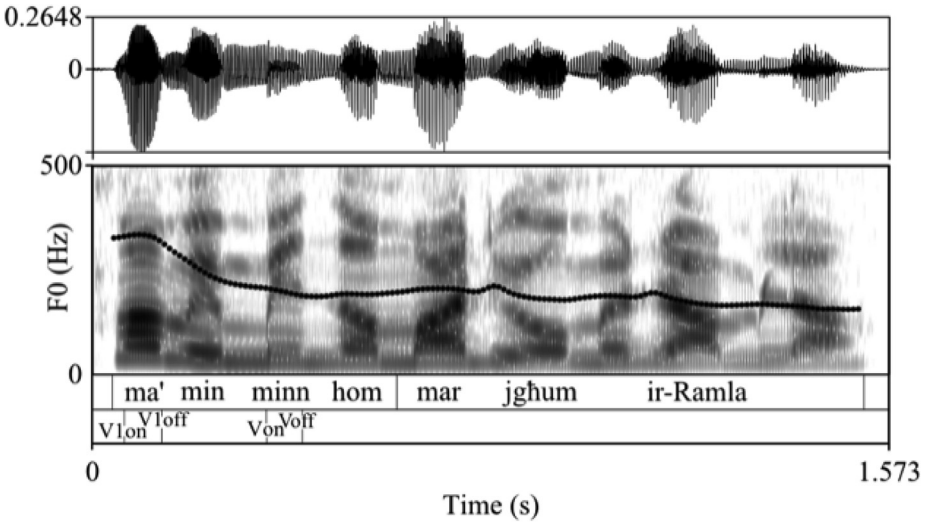


**Fig. 1.** Speech waveform, spectrogram and F0 contour for a question starting with *ma' min MINnhom* by speaker F2. On the first tier the beginning and end of the qword are marked. On the second tier, V1on and V1off reflect the onset and offset of the initial vowel [ɐ] in *ma'*, and Von and Voff the onset and offset of the stressed vowel [ɪ] in *minn*.

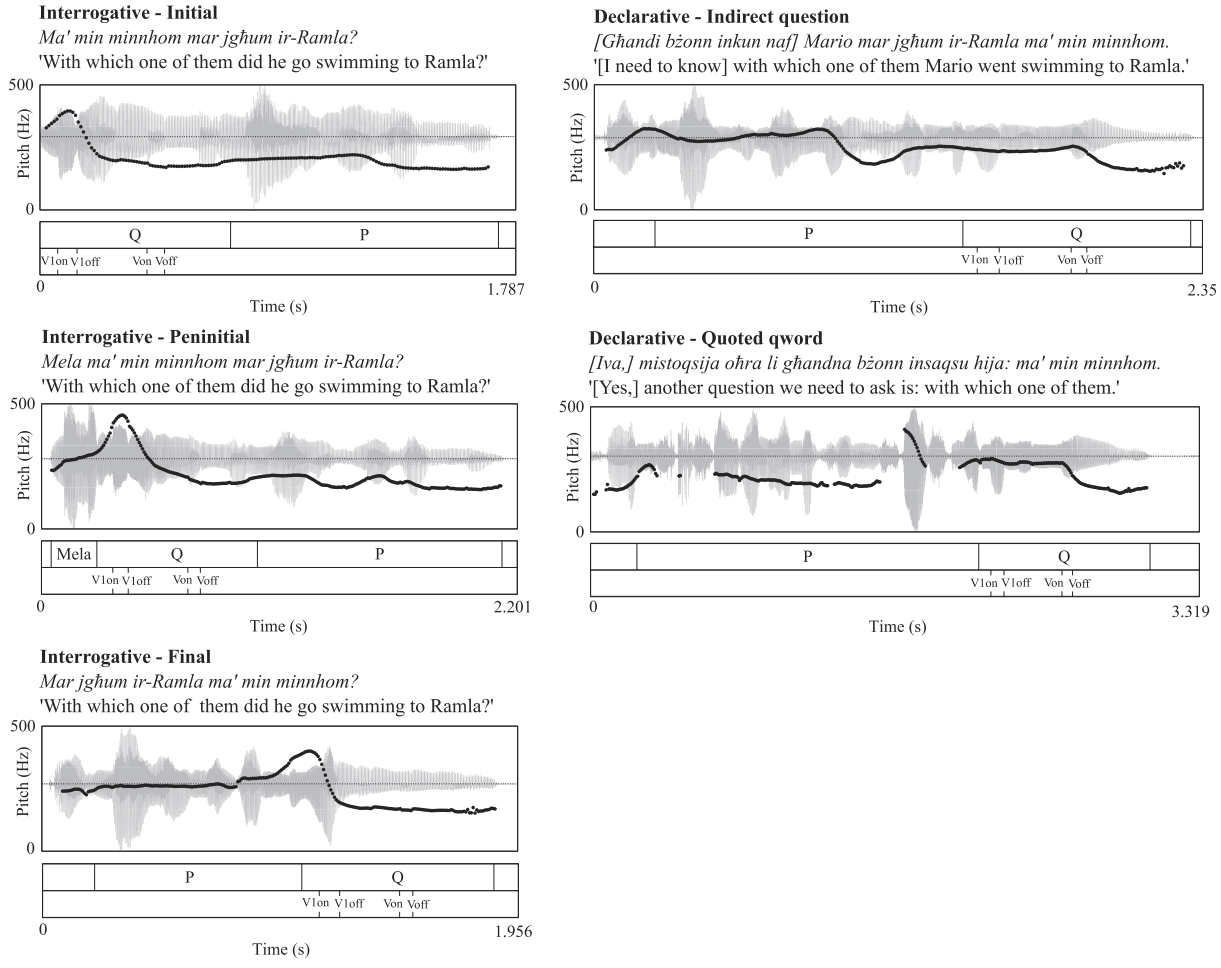


**Fig. 2.** Example f0 contours with qword *ma' min MINnhom* as produced by speaker F3. On the first annotation tier Q stands for qword and P for the remainder of the phrase containing the qword. On the second tier the initial and the stressed vowels are delimited.

erties in the quantitative analysis of the respective sentence types.

The following turning point (scaling and alignment) measures, depicted schematically in Fig. 3, were taken:

- **QH** – automatically detected maximum F0 on the qword, in interrogatives only;
- **TP1** – the start of the fall on the qword, in declarative utterances only;
- **TP2** – the end of the fall on the qword, in all utterances.

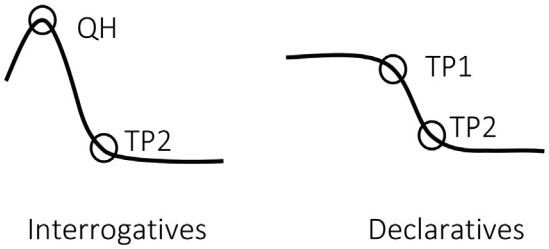


**Fig. 3.** Schematic representation of turning points in the f0 contour, QH and TP2 in interrogatives and TP1 and TP2 declarative phrases.

Turning points were identified by one of two algorithms: the first locates the local minimum (TP1) or local maximum (TP2) in the second derivative of the pitch track, and the second takes the intersection of a two-line fitting method (cf. Welby, 2006; D'Imperio, 2000). Both methods used the same pre-specified time-window, which was determined based on examination of the contours. For direct interrogatives this was defined as the 300 ms. from QH, and for the declaratives the window spanned from 50 ms. before to 100 ms. after the onset of the stressed vowel. The method using the second derivative was taken as the default, but all TPs were examined on a case-by-case basis, and the two-line fitting method was chosen where the derivative yielded inappropriate results. When both methods failed to detect a sensible TP, the relevant point was excluded from further analysis (N = 16 for a total of 240 of TP1s, and N = 38 for a total of 600 TP2s).

The durational measurements consisted of:

- **duration of the stressed vowel**;
- **duration of the initial vowel** (for all qwords excluding *MIN,* in which there is only one vowel).

Based on the combined results of turning points and durational measurements, the following derivative measures were calculated to characterize the dynamic nature of the pitch event:

- **excursion size and duration of fall**: scaling of and distance between QH and TP2 in the case of peaks, and TP1 and TP2 in the case of high plateau regions;
- **rate of change**: F0 change throughout fall.

### 3.4. Statistical analysis

Statistical analysis was performed with linear mixed effect regression models (package lme4, Bates et al., 2015) in R (R Core Team, 2016). We used the lsmeans package (Lenth, 2016) to construct confidence intervals and to perform multiple comparisons in the case of post-hoc tests (Tukey method). Most models predicting our variables of interest had the same structure; when models diverge from the following specification this will be mentioned explicitly in the text.

Firstly, models include QWORD as a fixed effect rather than as a random effect. This choice followed from the observation that qwords differ in their stress pattern, length, and phonological vowels, especially the length and quality difference among vowels in the stressed syllable. As these factors are known to systematically affect intonational text-tune association, QWORD was treated as a fixed effect. Models further included a fixed effect of SENTENCE (Q-initial/Q-peninitial/Q-final, and/or D-indirect/D-quoted) and the interaction between QWORD and SENTENCE, as well as a random intercept for speaker. Any p-values we report are the result of model comparisons with $\chi^2$ likelihood ratio tests. Comparisons were made between a full model and a corresponding null model lacking the relevant interaction or fixed effect term.

Data and scripts are available at https://osf.io/trgjy/ on the OSF platform.

## 4. Results

Below we report the details of turning point alignment (4.1), followed by turning point scaling and dynamic measures (4.2) and finally the durational enhancement of vowels in different metrical positions within the word (4.3).

### 4.1. Turning point alignment

As motivated previously, different turning points are measured in the different sentence modalities: QH and TP2 in interrogatives, and TP1 and TP2 in declaratives, so that QH and TP1 both represent the beginning of a fall (see also Fig. 3). The following subsections deal with the alignment of each of these turning points separately.

#### 4.1.1. QH alignment: Interrogatives

Several regression models were run on peak position. The first set uses absolute peak distance measure, with one model predicting peak distance from the stressed vowel onset, and one predicting peak distance from the qword onset. Fig. 4 shows the estimated peak alignment and 95% CIs for both models run on these absolute distance values.

As expected, peak distance from qword onset is much more consistent across qwords than peak distance from the stressed vowel onset. Nevertheless, even for this most consistent segmental landmark peak alignment is still quite variable, with an estimated grand mean alignment of 70 ms. after the start of the qword, and individual mean estimates ranging from 18 ms. for *min* in phrase-final position to 89 ms. for *ma' min MINnhom* in peninitial position. The apparent differences are confirmed statistically: Models run on z-scores (to reduce non-normality of residuals present in the above models) showed an interaction between QWORD and SENTENCE ($\chi^2(6) = 30.952$, $p < 0.001$), suggesting that any positional effects on peak alignment are different for the different qwords. Post-hoc multiple comparisons reveal that most of the differences involve the monosyllabic qword *MIN*: In phrase-final position, it has earlier peaks than all other qwords (for all comparisons $t < -4.7$, $p < 0.001$), and in initial position, *MIN* appears to display earlier peaks than *min MINnhom* ($t = -2.5$, $p = 0.058$). The remaining difference also concerns phrase-initial position, with *ma' MIN* having earlier peaks than *min MINnhom* ($t < -3.1$, $p = 0.01$). A likely explanation for the phrase-final effect for *MIN* could be tonal repulsion, where a phrase-final low target (i.e. L%) on the same monosyllabic word can be expected to exert pressure on the peak to be realised earlier (Silverman & Pierrehumbert, 1990; Grice, 1995).

In sum, QH or peak alignment in interrogatives is independent of the stressed syllable, and instead this turning point

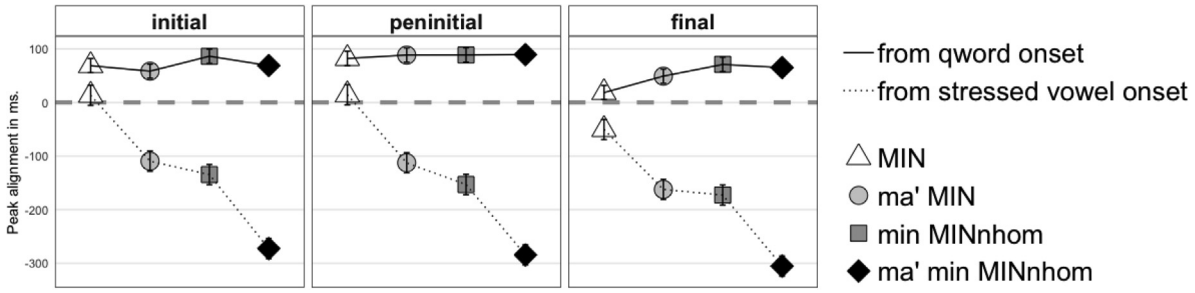


**Fig. 4.** Interrogatives: Estimated peak alignment from qword onset and from stressed vowel onset, with error bars depicting 95% CIs (based on model). Dashed line at $y = 0$ denotes the reference point for the two measures: qword onset in the case of the solid line, and onset of the stressed vowel in the case of the dotted line.

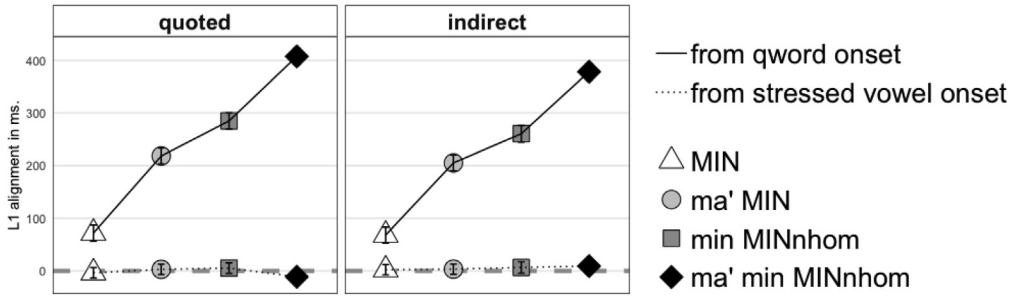


**Fig. 5.** Declaratives: Estimated TP1 alignment from qword onset and from stressed vowel onset, with error bars depicting 95% CIs (based on model). Dashed line at $y = 0$ denotes the reference point for the two measures: qword onset in the case of the solid line, and onset of the stressed vowel in the case of the dotted line.

systematically occurs immediately after the qword onset, with some word-specific effects at the phrase edges.

#### *4.1.2. TP1 alignment: Declaratives*

Declaratives exhibited an initial plateau on the qword followed by a sudden fall in the vicinity of the stressed syllable. TP1 was the turning point marking the start of this fall, and was found to be systematically aligned with the onset of the stressed vowel, rather than with the word onset. The output of two models predicting the distance between TP1 and the onset of the stressed vowel/the onset of the word is shown in Fig. 5. The pattern is the opposite to the above pattern for QH in interrogatives; TP1 is more systematically aligned with reference to the lexically stressed vowel than with reference to the word onset.

For the regression relative to stressed vowel onset, models run on z-scores showed no interaction between the two fixed effects SENTENCE and QWORD ($\chi^2(3) = 3.1$, $p = 0.38$). There was an individual effect of SENTENCE, in that quoted qwords have earlier TP1s than indirect questions: $\chi^2(1) = 5.6281$, $p = 0.02$. In absolute terms, the estimated difference is a negligeable 7 ms. There was also an individual effect of QWORD ($\chi^2(3) = 9.23$, $p = 0.03$). Post-hoc comparisons in the latter case revealed that this was due solely to *MIN* having earlier TP1s than *min MINnhom* ($t = -2.9$, $p = 0.02$).

In short, in declaratives, the onset of the fall is systematically located at the start of the stressed vowel.

#### *4.1.3. TP2 alignment: Interrogatives and declaratives*

TP2 is the turning point that is taken to mark the end of the fall in all utterances, interrogatives as well as declaratives. An initial exploration of the alignment of TP2 suggested that it is aligned differently between interrogatives and declaratives. Together with the fact that the preceding contour shows considerable differences, this motivated the decision to run models for TP2 on subsets of the data, with interrogatives and declaratives treated separately.

For both subsets, alignment of TP2 was considered with reference to several potentially relevant landmarks, i) absolute distance from the preceding turning point (QH in the case of interrogatives, and TP1 in the case of declaratives), ii) absolute distance from qword onset, iii) absolute distance from stressed vowel onset. Regression models predicting alignment for all these cases were run, with the same structure as previously: fixed effects of SENTENCE and QWORD and their interaction, and a random intercept for speaker. Fig. 6 shows the model estimates for the alignment of TP2 for both interrogatives and declaratives. Schematic representation of the respective alignment is shown in Fig. 7.

For the interrogatives, TP2 distance is rather consistent relative to QH as well as the qword onset, but not for the stressed vowel onset. Taking the qword onset as a reference point, estimated alignment for different qwords and positions ranged from 153 ms. (*MIN* in final position) to 237 ms. (*min MINnhom* in initial position). Since alignment of QH was stable relative to the qword onset, it comes as no surprise that alignment with respect to QH is also rather stable. Estimated alignment for different words ranges from 126 ms. at the lower end (for *MIN* in initial position) to 152 ms. at the higher end (for *ma' min MINnhom* in final position). Spanning a mere 26 ms, this latter range of mean alignment is small, especially since it accounts for different qwords that moreover occur in different phrasal positions.

For the declaratives, the qword onset is not a reliable predictor, whereas both TP1 and the onset of the stressed vowel are. Since TP2 was found to be aligned in the vicinity of the onset of the stressed vowel, the similarity between these two measures was expected. Estimated alignment across the two

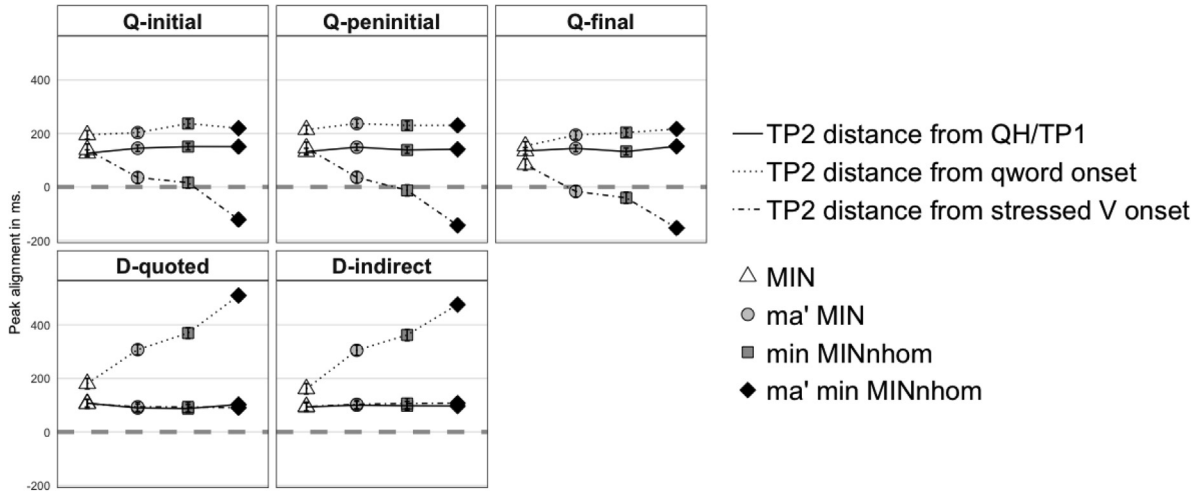


**Fig. 6.** Estimated TP2 alignment (points) with error bars depicting 95% CIs (based on model). Dashed line at $y = 0$ denotes the reference point for the three measures: relative to QH (peak) or TP1 (solid line), relative to qword onset (dotted line), and relative to the onset of the stressed vowel (dash-dotted line).

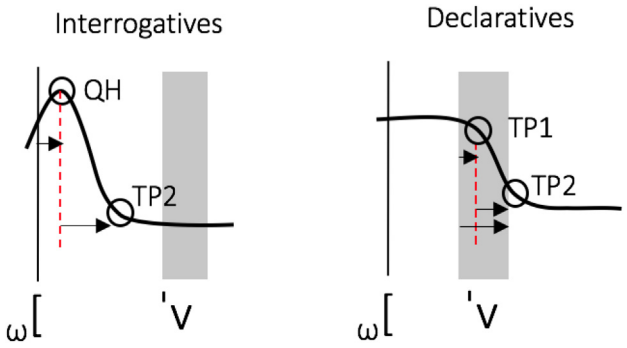


**Fig. 7.** Schematic representation of alignment in interrogatives and declaratives. Solid line denotes word onset (ω[) and grey shaded box represents stressed vowel Arrows are used to represent stable alignment, e.g. between the start of the word and QH, between QH and TP2 in interrogatives; between the start of the stressed syllable and TP1, as well as between the start of the stressed vowel (and TP1) and TP2, but not between the start of the word and TP1 in declaratives.

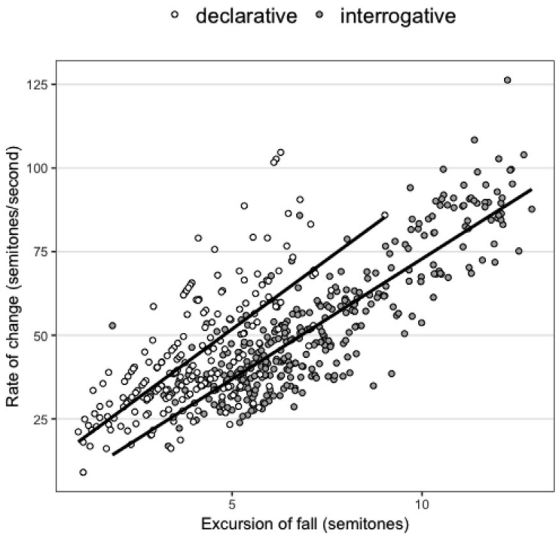


**Fig. 8.** Rate of change is correlated with excursion of the fall, across declaratives (white dots) and interrogatives (grey dots).

**Table 3**
RMSE values for the three types of models each predicting TP2 alignment with respect to a different segmental or prosodic landmark.

| L2 alignment predictor | Interrogatives | Declaratives |
|---|---|---|
| Absolute distance from preceding TP (QH/TP1) | 24.5 | 29.1 |
| Absolute distance from qword onset | 32.0 | 34.5 |
| Absolute distance from stressed vowel onset | 34.7 | 32.5 |

measures ranges from 88 ms. (*min MINnhom* in quoted context) to 108 ms (*MIN* in quoted context).

In order to see whether a distinction could be made between the two better predictors of alignment in each case, overall goodness of fit of each model in terms of Root Mean Square Error was examined. This measure reflects the average distance of a given datapoint from its model prediction, in the original measurement unit which in this case is ms. A summary is given in Table 3. In both cases, models predicting alignment relative to the prosodic landmark, i.e. the preceding peak (QH) or onset of the fall (TP1), fare somewhat better than the other two models.

#### *4.1.4. Interim summary: Tonal alignment*

The above discussions yielded the following insights about turning point alignment in qwords in interrogatives and declaratives.

i) The peak in interrogatives is aligned a fixed distance of ca. 70 ms. after the qword onset.
ii) The beginning of the fall in declaratives is aligned consistently at the onset of the stressed vowel.
iii) The reflex of the L tone (TP2) is aligned differently in interrogatives and declaratives; in interrogatives it is consistently aligned around 141 ms. after QH, and in declaratives it occurs some 97 ms. after the beginning of the fall.

These findings are shown schematically in Fig. 7.

**Table 4**
Turning point scaling and excursion size of fall, by speaker sex and by sentence type. Values are given in semitones (reference 100 Hz) and in Hertz.

| | QH in interrogatives ST (Hz) | TP2 in interrogatives ST (Hz) | TP1 in declaratives ST (Hz) | TP2 in declaratives ST (Hz) |
|---|---|---|---|---|
| Female speakers | 20.5 (330) | 12.4 (208) | 14.5 (232) | 10.5 (185) |
| Excursion (ST) | 8.1 | | 3.9 | |
| Male speakers | 8.0 (161) | 1.5 (110) | 2.6 (118) | −1.4 (93) |
| Excursion (ST) | 6.5 | | 4.0 | |
| Grand mean | 7.3 | | 4.0 | |

### 4.2. Turning point scaling and dynamic measures

It is clear from Fig. 1 that interrogatives have peak values that are much higher than the plateau values reached in declaratives. The average peak height in interrogatives is 245 Hz. (female speakers 330, male speakers 232) while the average maximum on the qword in declaratives, i.e. TP1, reaches only 175 Hz. (female 232, male 118). The average value for TP2 is less different across sentence modalities; 159 Hz. in interrogatives versus 139 Hz. in declaratives. The differing maximum f0 reached on the qword as a function of sentence type has a considerable effect on the excursion size of the fall. Measured in semitones, interrogative falls (on average 7.3 ST) have a range 1.8 times the size of the fall in declaratives (on average 4 ST). These differences are summarised by speaker sex and sentence type in Table 4 below.

Clearly, the scaling of the intonational events in interrogatives and declaratives is considerably different. This difference can at least in part be explained in terms of a positional effect, in that qwords in declaratives occur in phrase-final position while qwords in interrogatives occur in initial and peninitial sentence position as well as in final position. Declarative qwords can however be compared directly with those interrogative qwords that occur in phrase-final position. On a partial dataset containing only phrase-final qwords, a model regressing excursion size (in semitones) on MODALITY (interrogative/declarative) with a random intercept for speaker and a random slope for qword-specific effects of modality reveals that scaling differences do in fact persist between the two sentence modalities when controlling for position ($\chi^2(1) = 17.6$, $p < 0.001$) with interrogatives retaining greater falls ($\beta = 3.4$, $t = 16.8$).

Finally, differences between the pitch events in interrogatives versus declaratives might be exhibited in the steepness of the fall expressed as the rate of change per second. Note that under the standard assumptions about intonational events as analysed within autosegmental metrical phonology, it is usually expected that the slope of an intonational event is likely to be characterised by variability, while the turning points that define an intonational event exhibit relative stability (Arvaniti, Ladd, & Mennen, 1998). Given that the turning points in this study were found to align in a constant manner, the rate of change might be expected to vary along with excursion size.

Fig. 8 shows rate of change of the excursion of the fall for all utterances. Excursion of the fall is quite variable, ranging from about 1 to 13 semitones, and rate of change is strongly correlated with it (conditional $R^2 = 0.72$ across the full dataset, regressing rate of change on MODALITY and EXCURSION SIZE, and their interaction, with random intercepts for speakers and qwords). There is an interaction between the two fixed effects ($\chi^2(1) = 16.28$, $p < 0.001$); with greater excursion size, rate of change increases for both sentence modalities ($\beta = 6.3$, $t = 13.4$), but it changes more drastically in declaratives ($\beta = 3.3$, $t = 1.3$) than in interrogatives ($\beta = 1.3$, $t = 4.1$).

Fall duration measured as the distance between TP1 and TP2 in declaratives was under 100 ms, and between QH and TP2 in interrogatives about 140 ms. The relatively short duration of the fall in declaratives could explain why rate of change is impacted more by increasing excursion size. In any case, these results indicate that the general correlation is one where greater falls are associated with steeper slopes. This finding is compatible with an interpretation that considers the alignment of the turning points, rather than the slope, to be a systematic characteristic of the intonational events under consideration.

### 4.3. Durational enhancement

This section investigates whether there is any durational enhancement of stressed vowels as a function of whether these are marked by pitch movement (in the declarative sentences) or not (as in the interrogative sentences). It also investigates whether there is any durational enhancement of word-initial vowels as a function of pitch movement (present in the interrogatives, absent in the declaratives).

#### 4.3.1. Stressed vowel duration

Fig. 9 shows mean duration as estimated by the model for the absolute duration of the stressed vowel, in ms, and normalised duration with vowel duration expressed as a percentage of qword duration.

Clearly visible in the top panels is that absolute vowel duration is subject to an interaction between SENTENCE and QWORD ($\chi^2(12) = 125.14$, $p < 0.001$), with the shorter but not the longer qwords exhibiting some durational differences as a function of sentence type. Post-hoc pairwise comparisons confirm that the only significant differences are found between *MIN* and *ma' MIN* in initial and peninitial position on the one hand versus these same words in final sentence positions ($t < -6.0$, $p < 0.001$ for all comparisons). This effect reflects sentence position (initial/peninitial versus final) rather than sentence modality (interrogative versus declarative). In terms of absolute duration across all qwords and position, the vowels that are different from the rest are found in phrase-final qwords, where these vowels are moreover also in absolute phrase-final position (in contrast to stressed vowels in longer qwords in phrase-final position). It seems likely therefore that the durational enhancement of stressed vowels in *MIN* and *ma' MIN* reflects phrase-final lengthening effects rather than an effect of stress per se, which would be expected to hold across the board.

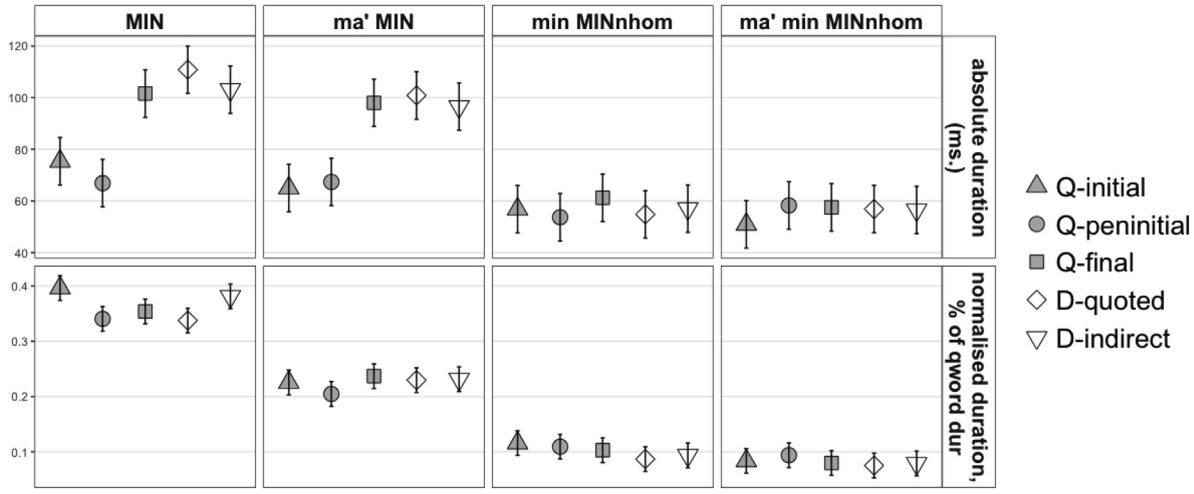


**Fig. 9.** Estimated stressed vowel duration, absolute (top panels) and as a proportion of qword duration (bottom panels).

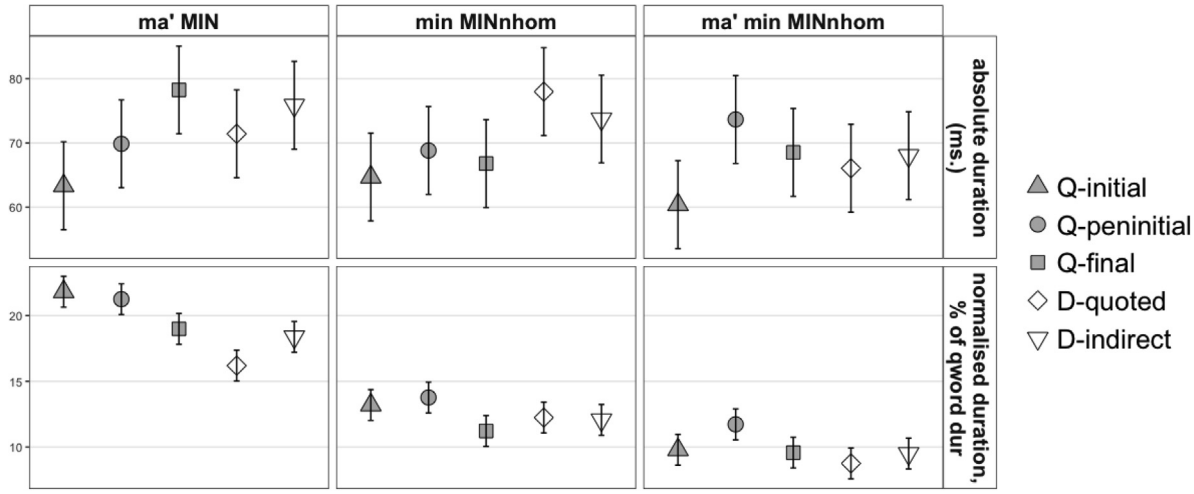


**Fig. 10.** Estimated initial vowel duration as a proportion of qword duration.

Absolute duration was compared with vowel duration expressed as a percentage of qword duration.[2] At least upon visual inspection normalised vowel duration even in the shorter qwords is more stable. As for absolute duration however there was an interaction between SENTENCE and QWORD ($\chi^2(12) = 35.64$, $p < 0.001$). Post-hoc comparisons show that this interaction is due to only a few cases, all to do with *MIN*: Q-initial *MIN* is longer than in all other positions excepting D-indirect ($t > 3.3$, $p < 0.001$). *MIN* is shorter in Q-peninitial than in D-indirect sentences ($t = -3.48$, $p < 0.01$), and shorter in D-quoted than in D-indirect ($t = -3.24$, $p < 0.05$). These differences do not appear to be meaningful in the sense of cutting across position and/or sentence modality, but more interestingly the absence of the same kind of durational differences (a positional one) as above lends further support for an interpretation of the latter as involving final lengthening. The lack of a difference in normalised vowel duration in final position indicates that the qword as a whole is subject to lengthening, and that the stressed vowel within it is not disproportionately lengthened. Pitch event-induced lengthening seems to be absent altogether: such an effect would be expected to occur for the qwords in declaratives, which have a pitch event clearly aligned with the stressed syllable.

In short, there is no lengthening effect present here whereby stressed vowels that carry pitch movement (i.e. in declaratives) are expanded, in contrast to stressed vowels that do not (i.e. in interrogatives). This means that there is no durational evidence to support an interpretation in terms of accentual lengthening of stressed vowels in the case of declaratives. Instead, stressed vowel duration appears to be rather constant, and generally unaffected by rising/falling intonational events occurring on the word.

#### *4.3.2. Qword initial vowel duration*

As discussed previously, in direct interrogatives the qword-initial vowel tends to carry the main phrasal pitch peak, while in declaratives, no specific intonational event co-occurs with it. If the presence of a pitch event causes durational enhancement,

[2] In the case of target words ending in [m] which were also followed by a word starting with [m] (as in the Q-initial context, e.g.: *min minnhom mar j-għum ir-Ramla?)* the word boundary was placed in the middle of the [m] segment.

the expected result would be that interrogatives exhibit longer initial vowel duration than declaratives.

Fig. 10 shows the absolute and normalised duration of the qword-initial vowel for the three polysyllabic qwords (due to the identity of the stressed and initial vowel we leave *MIN* aside for the purposes of this discussion). Because the initial vowel differs in quality ([ɐ] in *ma' MIN* and *ma' min MINnhom* and [iː] in *min MINnhom*), we discuss the patterns per qword rather than by position.

On both measures there was an interaction between SENTENCE and QWORD (absolute: $\chi^2(8) = 23.774$, $p < 0.01$, normalised: $\chi^2(8) = 33.256$, $p < 0.001$). Looking at absolute duration, there is no clear split in vowel duration as a function of sentence modality in the expected direction. In general, qwords in interrogatives do not appear to have longer initial vowels. An exception to this is *min MINnhom* which has vowels in initial and final qwords in direct interrogatives that are up to 13 ms. shorter than in D-indirect condition ($t < -3.1$, $p < 0.05$), but not significantly shorter than in D-quoted condition.

Turning to normalised duration, post-hoc multiple comparisons reveal several significant differences at $\alpha = 0.05$:

- All but two pairwise comparisons for *ma' MIN* were significant ($t > 2.9$, $p < 0.05$). The exceptions were vowels in Q-initial versus Q-peninitial conditions and Q-final versus D-indirect conditions.
- The main difference for min *MINnhom* was between peninitial and final qwords in interrogatives, with Q-peninitial having longer vowels ($t = 3.5$, $p < 0.01$). Durational differences between initial and final qwords in interrogatives approached significance ($t = 2.7$, $p = 0.053$).
- *ma min MINnhom* has shorter vowels in Q-peninitial position than in all other conditions ($t > 2.9$, $p < 0.05$).

These differences together do not paint a consistent picture in terms of a split in duration as a function of sentence type (interrogative/declarative), nor even one in terms of phrasal position (e.g. final versus other positions).

In sum, the present results provide no evidence for a substantial durational difference separating those qword-initial vowels that carry a peak (in direct interrogatives) from qword-initial vowels that do not (in declaratives with a phrase-final qword). There appears to be no durational enhancement as a function of the presence of pitch movement, similar to the above findings on the durational properties of stressed vowels, which did not appear to expand durationally when marked by a pitch drop.

## 5. Discussion

### 5.1. Interpretation of results: intonational categories in Maltese

Trivially, the differences observed between qwords in interrogatives and declaratives corroborates our analysis of the H and L tones as being postlexical, allowing us to concentrate on the analysis of these tones as intonational.

The results reported on in the previous section confirm earlier observations about qword prosodic properties, in the sense that all ten speakers mark interrogative qwords by a salient high pitch near the left word edge. This holds for qwords in interrogatives in all positions in the phrase (initial, peninitial and final). It was additionally shown that qwords in declaratives are characterised by different intonational properties. Specifically, these qwords exhibit a fall in the vicinity of the stressed syllable, typically preceded by a high plateau region with no clearly identifiable peak. In the following, a phonological analysis will be proposed for both intonational events.

For interrogatives, we previously stated three possible postlexical analyses of the H L tonal sequence proposed to hold for the qword tonal contour in Vella (2011). These were 1) an H + L* pitch accent, 2) a tonal complex with left edge assocation %HL, 3) a sequence of a boundary tone %H and an L* pitch accent. The details of the turning points in interrogatives suggest that the H and L tones have no association with the stressed syllable: neither the peak (QH) nor the low turning point (TP2) was aligned with reference to the stressed syllable. This rules out an analysis in terms of a pitch accent associating with a stressed syllable (Analysis 1 in Section 2.4). Moreover, the low turning point was aligned relative to the preceding peak, suggesting that the two turning points form the phonetic reflex of a tonal complex (ruling out Analysis 3 in Section 2.4). The remaining option, Analysis 2, with the tonal event analysed as a tonal complex with edge association, was suggested based on phrase-initial qwords. The present experiment however showed that non-phrase-initial qwords are marked by the same intonational event, precluding an analysis in terms of a left IP-edge tonal complex. If the tonal event is associated with an edge, this edge must be the word edge (in the present case of qwords, a prosodic or phonological word edge). We therefore suggest a variant of Analysis 2, in terms of a complex edge tone HL, which instead of associating to a phrasal edge (i.e. %HL), associates to a word-edge (i.e. ω[HL).

For the tonal event on qwords in declaratives we had no specific prior hypothesis. In contrast to qwords in interrogatives, qwords in declaratives exhibited no clear peak but instead an F0 fall on the stressed syllable as is also the case in most varieties of Italian such as Neapolitan (D'Imperio, 2002). The first turning point TP1, marking the onset of the fall, occurred at the onset of the stressed vowel. The second turning point TP2, marking the end of the fall is aligned with reference to TP1, and occurs near the end of the stressed vowel. The consistent alignment with the stressed syllable makes this tonal event a likely candidate to be analysed as a pitch accent. Since the present event involves a pitch fall, and in light of the consistent alignment of TP1, the present tonal event appears to be an instance of the H* + L pitch accent, as proposed in Vella (1995), although typical H* + L pitch accents in the language have so far tended to have a step-up to the peak, a property that is missing in the present data.

Turning point scaling results highlight a further difference between the two tonal events that occur on qwords, namely that the peak in interrogatives is much higher than the peak in the non-interrogatives. Since the intonational events are analysed as phonologically distinct in their association properties, there is no need to posit a further encoding of this scaling difference; additional height of the peak may be one of a number of cues for edge association in the language or may be related to a general property of interrogatives at a more global level.

Durational results pertaining to the initial and stressed vowels were not found to support any arguments about the phonological status of the pitch events under discussion. The possibility that vowels are enhanced as a function of pitch

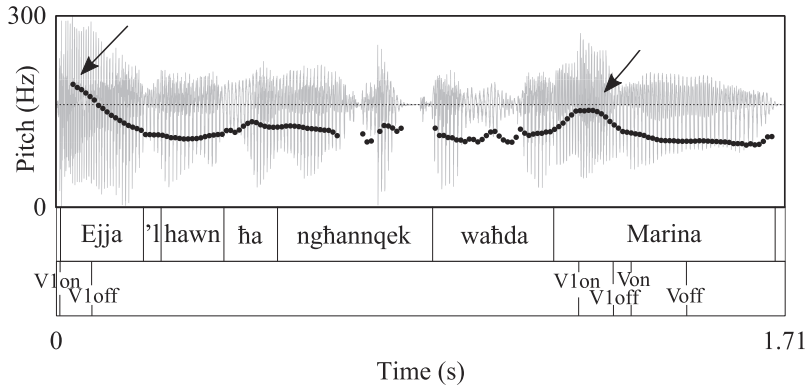


**Fig. 11.** Imperative with initial peak, followed by vocative with an initial peak (indicated by means of arrows). *Ejja 'l hawn ħa ngħannek waħda, Marina*. 'Come here let me give you a hug, Marina.'

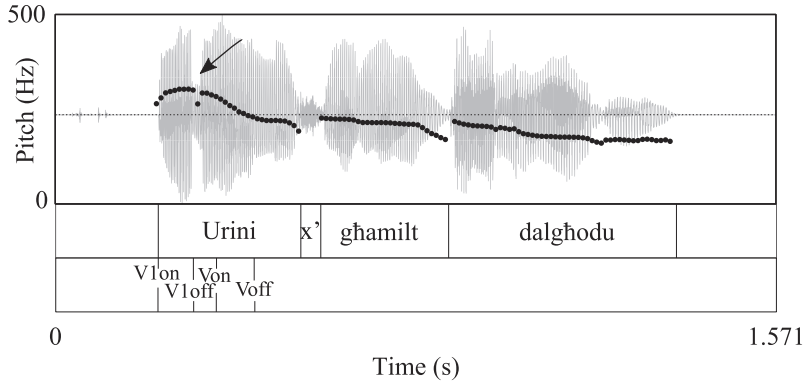


**Fig. 12.** Imperative with initial peak (indicated by means of arrows). *Urini x'għamilt dalgħodu*. 'Show me what you did this morning.'

prominence was neither confirmed for qword-initial vowels (which were not longer in interrogatives than in declaratives) nor for stressed vowels (which were not longer in declaratives compared to interrogatives). In many languages, pitch events associating with positions of structural prominence, i.e. stressed syllables, are found to cause lengthening effects in the form of accentual lengthening relative to the same syllables that lack this pitch prominence (cf. Cambier-Langeveld, 2000). In this sense, the pitch accent in the declaratives could have been expected to yield stressed vowels that are longer than their counterparts in interrogatives, which lacked a pitch movement on the stressed syllable. It is possible that Maltese simply does not exhibit as much accentual lengthening as English, but further work will be needed to explore this possibility.

In conclusion, the details of turning point scaling and alignment provide ample evidence to support an analysis in terms of the existence of both edge and head association at the level of the word in Maltese qwords. This analysis is worth considering for other cases which appear to have similar word-initial peaks. Figs. 11 and 12 show examples of such contours.

Fig. 11 shows an imperative (*Ejja 'l hawn* 'Come here') with an initial peak, and a subsequent vocative with an initial peak on the first syllable of *Marina* (despite the lexical stress being on the penultimate syllable).

Fig. 12 shows another imperative contour, where lexical stress is penultimate, on *ri* but nonetheless the peak is on the initial syllable *ur*.

Clearly more cases will need to be taken into account, taking care to separate the target word from the phrase edge, before a definitive analysis of intonation in these modalities can be found.

### 5.2. Implications for prosodic typology

The data discussed in this paper, and the proposed analyses, have certain implications for our general assumptions about tonal primitives as used in AM analyses of intonation. Two types of structures are generally taken to be basic building blocks, pitch accents and boundary tones. These are defined according to two criteria: i) their function within the system, i.e. whether they are prominence-cueing (i.e. serving as a cue to prominence, (Ladd, 2008:54) or edge-marking (i.e. serving to divide the utterance into chunks), and ii) their association properties, i.e. whether they associate with heads (the lexically stressed syllable of the focussed word or focus exponent, for example) or edges (beginnings or ends) of constituents respectively.

This twofold definition is to some extent problematic for the present data. Specifically, Maltese has regular pitch accents that associate with lexically stressed syllables in some (and in fact most) contexts. As was shown for question words, however, the same word may have a complex pitch accent associating with its lexical stress *or* a word edge-associated tonal complex, depending on the sentence modality. An analysis of this word edge-associated tonal complex as marking the edge of a larger prosodic constituent (ip/IP) is ruled out by the fact that question words appear to have the same tonal structure across different positions in the phrase. Moreover, stipulating

the presence of an ip/IP-boundary due to the presence of word-edge marking would be circular, and is not warranted perceptually. The language thus appears to make use of both the word edge and the word head for the association of tones.

While it can be argued that at least the declarative qwords are characterised by a prominence cueing event (by virtue of the tones seeking out the lexically stressed syllable), the same reasoning would rule out a prominence-cueing interpretation of the edge-aligned tonal complex in interrogative qwords. These arguments belong to the aforementioned association criteria. Yet in terms of the functional criteria, there is no independent evidence that the edge-associated pitch event serves a demarcative function. In fact, qword pitch prominence in most languages is considered a prime example of prominence marking by virtue of the semantic load of qwords, and the similarities between qwords and foci (see 2.4). It is of course possible to classify the tonal event at the qword edge as delimitative (i.e. contributing towards dividing up the utterance into chunks), based purely on its alignment and by extension, interpreted association. This would however run counter to much of the work that has been done over the last few decades and that has shown that phonetic criteria in the form of turning point alignment alone do not suffice in the phonological analysis of intonational events (e.g. (Arvaniti, Ladd, & Mennen, 2000; Barnes, Brugos, Shattuck-Hufnagel, & Veilleux, 2012; Barnes, Veilleux, Brugos, & Shattuck-Hufnagel, 2012; D'Imperio, 2000; Niebuhr, 2003)). The conundrum presented by the present data seems to call for a separation of form and function in the categorisation of intonational tones: the alignment and association of an intonational event should not be the sole determinant of its function as either demarcative or prominence-cueing.

The present data raise a second issue relating to the role of lexical stress in the intonational system of Maltese, and in intonation systems more generally. In Maltese, lexically stressed syllables are clearly not the only attractors of (potentially prominence-cueing) pitch events. This amounts to saying that prominence-cueing intonational events do not necessarily seek association to a stressed syllable. Typically, however, languages that have stress do not seem to use this option, as virtually all the literature on the topic has found that intonational events co-occur with stressed syllables, although with limited exceptions, as discussed in Section 1.

Little research has enquired directly as to whether, and if so how, prominence-cueing may be achieved without reference to stressed syllables. For example, for languages that lack stress altogether, it is unclear how pitch events are to be interpreted. Ambonese Malay is argued to lack any kind of intonational prominence, and the language's intonation is analysed as consisting of sequences of boundary tones (Maskikit-Essed & Gussenhoven, 2016). This is similar to analyses of Korean (Jun, 2005), Greenlandic (Arnhold, 2014) and Mongolian (Karlsson, 2014). French, by contrast, is argued to have intonational prominence (sometimes explicitly called 'pitch accent') targeting a fixed phrase-final position (as opposed to a fixed lexical position, in which case the language would have lexical stress (Michelas, Portes, & Champagne-Lavau, 2016; Post, 2000; Welby, 2006). There is also accumulating evidence that the intonational systems of Tashlhiyt Berber and Moroccan Arabic exhibit functionally prominence-cueing intonational events in the absence of lexical stress, which under standard autosegmental metrical assumptions would not be possible (Grice, Ridouane, & Roettger, 2015; Hellmuth et al., 2015; Roettger, Bruggeman, & Grice, 2015; Roettger, 2017; Bruggeman et al., 2017; Bruggeman, 2018).

To return to Maltese, the present data on the intonational properties of qwords highlight the difficulties with a strict form-function correspondence of the building blocks of autosegmental metrical intonation analysis. Maltese exhibits word-edge intonational events in the presence of lexical stress elsewhere in the word, which has so far been unattested. A tentative explanation for the hybrid character of Maltese prosody might be sought in the historical language contact that has resulted in present-day Maltese. For instance, the early peak contour in declaratives with fronting reported for Palermo Italian, e.g. *Domani glielo porta* 'Tomorrow he will bring it to her' (Grice, 1995:148, 167) is striking in its similarity to the phenomenon reported on here. However, there is no clear indication that word-edge tonal complexes are also found in past- or present-day contact varieties of Maltese.

## 6. Conclusion

The present paper has investigated the intonational properties of question word interrogatives in Maltese across phrasal positions and across sentence modalities (interrogatives/declaratives). Interrogatives are marked by a high peak on the qword occurring consistently at its left edge. Declaratives, by contrast, were marked by a pitch fall that was completed over the stressed syllable of the qword. We argue that the intonational prominence found at the left word edge of Maltese qwords in interrogatives is a word-edge tonal complex ωHL. In contrast, qwords in declaratives were analysed as bearing a H* + L pitch accent, found in other sentence modalities in the language.

These results provide evidence that Maltese has, on the one hand, intonational events which are readily classified as regular pitch accents, due to their association with a lexically stressed syllable, and, on the other hand, intonational events that occur at a word edge. The existence of both of these tonal events in a single language, on the same, identical phonological constituent, only occurring as a function of sentence modality, makes Maltese prosody typologically rare. Most languages seem to make use of only one of these prosodic categories, that is, of either pitch accents that associate to lexical heads (most commonly), or of postlexical intonational events that associate to *phrasal* domain edges (as in Malay, Korean and Greenlandic – languages that lack lexical stress altogether).

Our current understanding of prosodic typological variation among the languages of the world does not readily accommodate the results reported here for Maltese. This suggests that we need to be more flexible in terms of the prosodic-typological properties languages may exhibit.

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**Appendix A**

Two other versions of this dialogue were used in order to elicit all four qwords in all three different contexts.

| Interrogatives (initial/final) + Declaratives (indirect question) | | | |
|---|---|---|---|
| Target | Speaker | Maltese | Translation |
| | B | Hawn xbin, ilek ma tarahom lill-oħrajn? | Hi, is it a long time since you saw the others? |
| | A | Iva, ili ftit. Ħlief lil dak il-miġnun. Mar jgħum ir-Ramla. | Yes, it's been a while. Except for that mad one. He went swimming to Ramla. |
| Q-initial *MIN* | B | ***Min* mar jgħum ir-Ramla?** | **Who went swimming to Ramla?** |
| | A | Mario. Imma naf li mhux waħdu mar. | Mario. But I know he didn't go alone. |
| Q-final *ma' MIN* | B | **Mar jgħum ir-Ramla *ma' min*?** | **With whom did he go swimming?** |
| | A | Naħseb li mal-aħwa Borg. | I think he went with the Borg siblings. |
| Q-final *min MINnhom* | B | L-aħwa Borg? Imma dawk xi ħamsa qegħdin fil-familja. **Mar jgħum ir-Ramla *min minnhom*?** | The Borg siblings? But there are five of them in the family. **Which one of them went swimming to Ramla?** |
| | A | Celine naf li marret Marsalforn ma' xi nies oħra, imma kien hemm ukoll grupp li mar ma' Melina. | I know that Celine went to Marsalforn with some others, but there was a group who went with Melina. |
| Q-initial *ma' min MINnhom* | B | Issa ħawwadtni ta' vera. Tgħid! ***Ma' min minnhom* mar jgħum ir-Ramla?** | Now you've really confused me. I wonder! **With which one of them did he go swimming to Ramla?** |
| D-indirect *ma' MIN* | | **Għadni qed nipprova nifhem mar jgħum ir-Ramla *ma' min*.** | **I'm still trying to understand with whom he went swimming to Ramla.** |
| | A | Isma' meta niġu lura mir-Ramla trid nixtrilek biljett tal-EuroMillions? | Listen, when we come back from Ramla, would you like me to buy you a EuroMillions ticket? |
| | B | Irridu nagħżlu numru minn kemm? | We have to choose a number from amongst how many? |
| | A | Minn tnejn sa għaxra. U ħaġ'oħra, naf li m'għandhiex x'taqsam, imma tgħid, il-bibien nagħmluhom tal-aluminju? | From two to ten. And another thing, I know it's not relevant, but what do you say, shall we get doors made out of aluminium? |
| | B | Skont! Kemm hu ogħli l-aluminju? | It depends! How expensive is aluminium? |

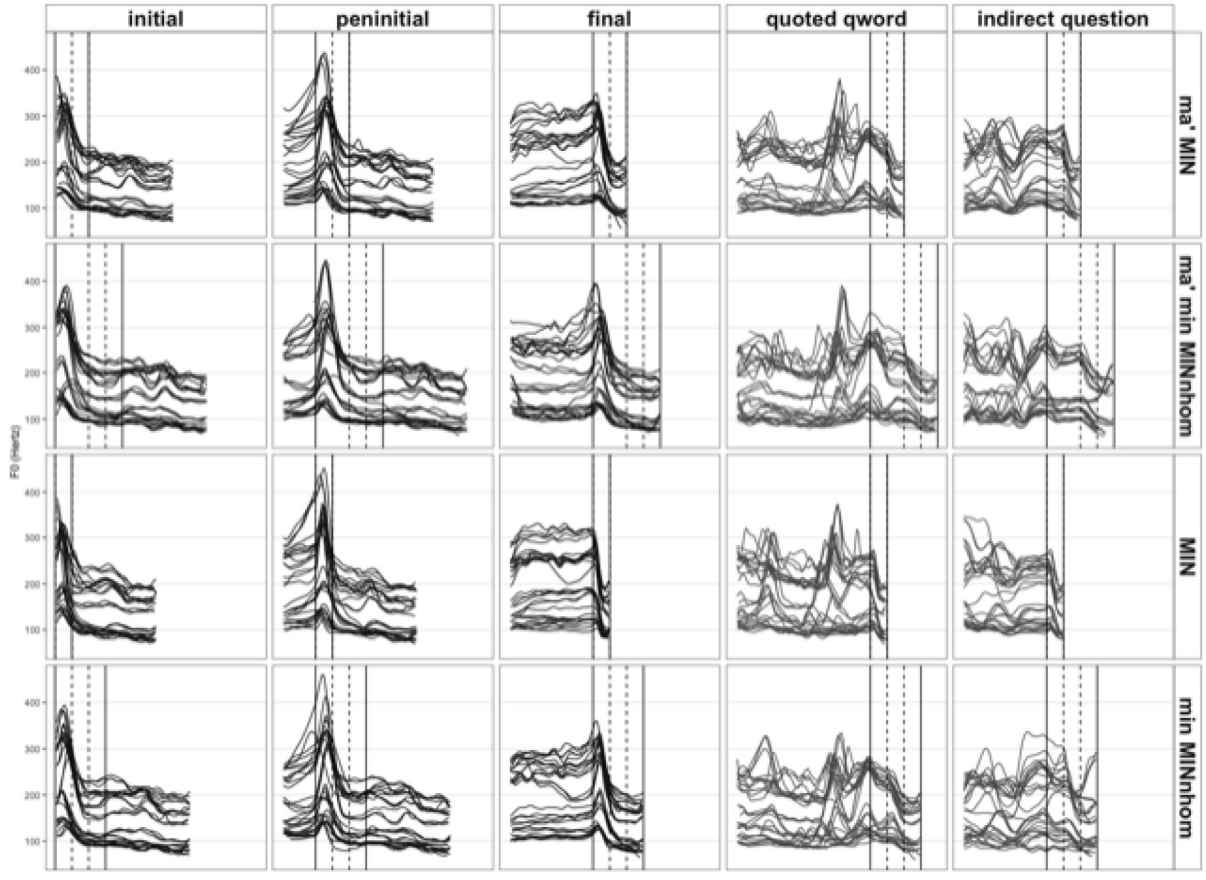
**Appendix B. Scripted dialogue with target sentences containing all four question words in interrogatives in phrase-peninitial position.**

| Interrogatives (peninitial) | | | |
|---|---|---|---|
| Target | Speaker | Maltese | Translation |
| | B | Hawn xbin, ilek ma tarahom lill-oħrajn? | Hi, is it a long time since you saw the others? |
| | A | Iva, ili ftit. Kien hemm xi ħadd li mar jgħum ir-Ramla, imma l-bqija marru jgħumu Marsalforn. | Yes, it's been a while. One of them went swimming at Ramla, but the rest went to Marsalforn. |
| Q-peninitial *MIN* | B | **Mela *min* mar jgħum ir-Ramla?** | **So who went swimming to Ramla?** |
| | A | Mario. Ma naħsibx li mar waħdu imma Sarah żgur li ma marritx miegħu. | Mario. I don't think he went alone, but I am sure Sarah didn't go with him. |
| Q-peninitial *ma' MIN* | B | **Mela *ma'* min mar jgħum r-Ramla?** | **So with whom did he go swimming to Ramla?** |
| | A | Naħseb li mar ma' Jason. L-oħrajn kienu għadhom ma ddeċidewx x'riedu jagħmlu għax xi ħadd minnhom kellu jogħqod man-nanna. Mingħalija ftehmu fl-aħħar... | I think he went with Jason. The others hadn't yet decided what they wanted to do because one of them needed to stay with his grandmother. I believe they reached agreement in the end... |
| Q-peninitial *min MINnhom* | B | **Mela *min minnhom* mar jgħum ir-Ramla?** | **So which of them went swimming to Ramla?** |
| | A | Melina naħseb għax kien hemm xi wħud li xtaqu jmorru ma' Celine u dik Marsalforn marret. | I think Melina did because some of them wanted to go with Celine but she went to Marsalforn. |
| Q-peninitial *ma' min MINnhom* | B | **Mela *ma' min minnhom* mar jgħum ir-Ramla?** | **So with which one of them did he go swimming to Ramla?** |

**Appendix C. Scripted dialogue with target sentences containing all four question words in declaratives, quoted condition.**

| Declaratives (quoted question word) | | | |
|---|---|---|---|
| Target | Speaker | Maltese | Translation |
| D-quoted *MIN* | B | **Il- mistoqsija li għandna bżonn insaqsu hija *min*.** | **The question we need to ask is 'who'.** |
| | A | U kemm għandek bżonn tkun taf ukoll? | And do you also need to know how much? |
| D-quoted *ma' MIN* | B | **Le, il-mistoqsija li għandna bżonn insaqsu hija *ma' min*.** | **No, the question we need to ask is 'with whom'.** |
| | A | X'jiġifieri, u meta ma tridx tkun taf? | What do you mean? And don't you need to know when? |
| D-quoted *min MINnhom* | B | Le, lanqas meta, m'għandna bżonn inkunu nafu. **Il-mistoqsija li għandna bżonn insaqsu hija *min minnhom*.** | No, I don't need to know when either. **The question we need to ask is 'which one of them'.** |
| | A | U hemm xi mistoqsija oħra? | And is there any other question? |
| D-quoted *ma' min MINnhom* | B | **Iva, mistoqsija oħra li għandna bżonn insaqsu hija *ma' min minnhom*.** | **Yes, another question we need to ask is 'with which one of them'.** |

**Appendix D**




**Appendix D.** Full set of f0 contours by sentence type. Contours are time-normalised based on 10 extraction points per syllable in the phrase.

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