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PITCH RANGE IN L1/L2 ENGLISH. AN ANALYSIS OF F0 USING LTD AND LINGUISTIC MEASURES

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ABSTRACT

This study presents preliminary results on the differences of pitch range in selected utterances produced by American English native speakers and Italian learners of English. The hypothesis being tested is that Italian learners of English transfer their L1 pitch range variation into their L2: The English sentences produced by the Italians are expected to have overall higher pitch levels and narrower pitch span than those produced by the Americans. A cross-linguistic study was conducted to compare pitch level and span in 5 sentences in English and Italian as produced by 8 American English speakers from California and 8 Italian speakers from North Eastern Italy. LTD and linguistic measures were calculated to analyze differences in pitch range across the groups. The results show that Italians use high pitch levels when speaking Italian and lower levels when speaking English. Their pitch spans are overall wider in Italian and narrower in English. Linguistic measures were found to be more effective than LTD measures in capturing differences in pitch range across languages.

Keywords: pitch range, F0, intonation, English L2, Italian L1.

1. INTRODUCTION

It is often suggested that Italian-accented English sounds like a sing-song and is more rhythmic than English [7]. Intonation, rhythm and stress patterns are responsible for such an effect, and probably also pitch range plays a role in the perception of the Italian lilt.

The aim of this study is to compare pitch range in selected utterances produced by American English native speakers and Italian learners of English, to analyze and understand cross-linguistic differences in pitch level and span.

2. PITCH LEVEL AND SPAN

Recent studies have been aimed at investigating the characteristics and perceptual effects of pitch level and span, as well as their differences across languages. While pitch *level* is a sort of reference line calculated over the rises and falls within each contour, pitch *span* is a measure of the distance between the highest and lowest F0 value in the contour [6, 9, 10]. Generally, pitch level and pitch span are correlated and covary to a large extent: the higher the pitch level, the higher the pitch span.

Chen et al. [4] claim that languages differ in their use and interpretation of pitch range because the perception of pitch is both universal and language-specific. In this way, pitch level and span may represent a language-specific meaning component, which is affected by the principle of the 'Frequency Code' formulated by Ohala [13]. According to this principle, high pitch is associated with smallness, politeness and lack of threat while low pitch is associated with largeness, assertiveness and threatening intent [9, 13]. Thus, differences in pitch range across genders are not due to mere anatomical differences between men and women, they are also a matter of social behaviour and gender roles [14].

2.1. Pitch range in English L2

How do Italians use pitch range when speaking English? How can pitch range affect the way they are perceived? Recent studies on Italian prosody in English [1, 2] suggest that there may be substantial differences in the intonation patterns used by Italian non-native speakers and English native speakers. Little is known about the Italian and English differences in pitch range.

L2 learners have been reported as speaking with a narrower pitch range and less pitch variation than L1 speakers. Mennen et al. [11, 12] compared the production of pitch range by Southern Standard British English speakers (SSBE) and Northern Standard German speakers (NSG), and proposed a new methodological approach to quantify pitch range across languages. The study showed that the SSBE speakers have higher and more varied pitch range than the NSG speakers. This is probably the reason why British high-pitched voices (especially female) may be perceived as "over-excited" or even "aggressive" by German listeners. On the contrary, German low-pitched voices may sound

"bored" or "unfriendly" to British listeners [12].

A study comparing British and Dutch [4] showed that, at identical pitch ranges, British English is perceived as more confident and friendlier than Dutch. The Dutch speakers of the experiment used a small standard pitch range. This may be due to the fact that Dutch speakers are less concerned than British speakers to use pitch range variation extensively to signal universal meanings.

3. RESEARCH QUESTIONS

In line with previous research [11, 12], one might think that no matter the language, L2 speech is characterised by a narrower pitch range than L1 speech. Thus, also English sentences produced by Italians may have an overall lower and narrower pitch range than those produced by Americans.

The present experiment is aimed to test two hypotheses. The first is that English sentences produced by Italians have a narrower pitch span than those produced by Americans. The second hypothesis is that Italian learners of English are influenced by their L1, and thus they transfer the L1 pitch range variation into their L2. If the second hypothesis is confirmed, the pitch range shown by Italians in their L1 speech will be similar to the pitch range shown by Italians in their English L2 sentences. Thus, regardless the language being spoken (L1 vs. L2), Italians are expected to use the same pitch patterns in English and Italian.

4. SUBJECTS AND MATERIALS

This study compares native and non-native productions of 5 sentences selected from a short passage from 'The Little Prince' by Antoine de Saint-Exupéry. The text was read aloud by 8 American (Am) (4 male vs. 4 female) speakers from California and 8 Italian (It) (4 male vs. 4 female) speakers from the North East of Italy. All Am participants were speakers of American English, they came from California and studied at UCLA. All It speakers were either spending a period abroad in Los Angeles or were students graduating at UCLA. The age of the participants ranged from 20 to 28 years (mean age: 24 years). None of the speakers reported any speech, hearing or communication disorder at the time of the recording. There was no screening for formal training in music or singing, nor for a history of smoking.

The materials were collected at the Linguistic Department of the University of California, Los Angeles. All the audio files were recorded at a sample frequency of 44.1 KHz and digitally acquired in a sound-attenuated booth in the Phonetic Laboratory.

5. PROCEDURE

In the experiment, the subjects were asked to read aloud short sentences and some dialogic passages in a natural way. The Am subjects read the materials in English; the It subjects read them in English and Italian. As a result, data were extracted from three different groups: (1) Americans speaking English (Am), (2) Italians (It-En) speaking English, and (3) Italians speaking Italian (It-It). The corpus created consisted of 120 utterances (8 speakers x 5 sentences x 3 language groups).

After recording the short texts, selected sentences were compared with Praat [3]. The data were analyzed following the method proposed by Mennen et al. [12], thus, pitch values were analyzed and compared across groups by calculating long-term distributional (LTD) and linguistic measures.

5.1. Linguistic measures

To calculate linguistic measures, F0 range stylization was performed with the function 'to manipulation' in Praat [3]. After manually inserting pitch points at local peaks or valleys, the whole corpus was manually labeled with Praat by adding F0 landmarks within the pitch track. Three simple steps were followed. First, pitch points were inserted at the beginning and the end of the intonation phrase; they were labeled respectively as I and FH/FL (depending on the final rise or fall within the pitch line). Second, local peaks or valley on prominent syllables were identified acoustically and visually, and they were labeled respectively as H* and L*. Third, any peak or valley on non-prominent syllables was labeled as H and L.

5.2. LTD measures

LTD measures are based on the analysis of F0 distribution. Values of F0 maximum (F0 max), F0 minimum (F0 min), F0 mean and F0 median were calculated over the entire sentences to measure pitch level. Measures analyzed for pitch span were: F0 maximum minus F0 minimum (max-min F0) in Hertz (Hz) and semitones (ST), standard deviation (SD), the difference between the 95^{th} and 5^{th} percentile (90% span), the difference between the 90^{th} and 10^{th} percentile (80% span), skewness and kurtosis. As F0 may not be normally distributed around the mean, skewness and kurtosis respectively signal the asymmetry or peaked distribution of values.

The selection of LTD measures for the analysis of pitch level and span was based on Mennen et al.'s [12]. Values for LTD measures were obtained

automatically by inquiring pitch info in Praat such as minimum, maximum, range, average, standard deviation, etc. A script was used to automatically calculate lists of values for different measures. In order to avoid pitch-tracking mistakes, spurious values on the pitch object visualizations were manually adjusted and, in some cases, erased.

Figure 1: F0 stylization process following [13].

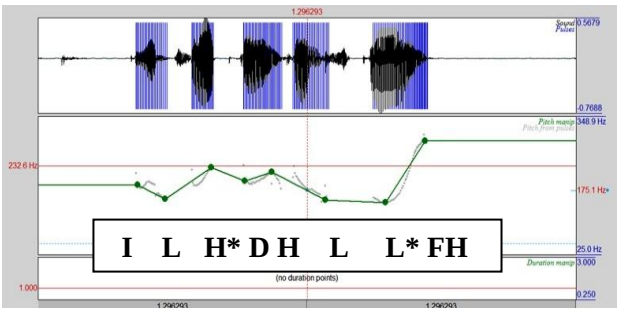


Table 1: Description of labels used to annotate the corpus.

Label	*Description*
I	Phrase initial value
H*i	Local peak at phrase starting point
H*	Local peak, prominent syllable
H	Local peak, non-prominent syllable
L*	Local valley, prominent syllable
L	Local valley, non-prominent syllable
FH	Final local maximum
FL	Final local minimum

6. RESULTS

Comparative analyses based on LTD and linguistic measures were drawn on the source languages (Am vs. It-It) and the target language (It-En) by calculating F0 range across speakers, sentence types, and gender (males vs. females).

6.1. Results from linguistic measures

After placing linguistic landmarks in peaks and valleys, a script in Praat was used to calculate F0 of each pitch point. Then, values were averaged across speakers (males vs. females) and language groups (Am vs. It-En vs. It-It). Values of linguistic measures were obtained for level (Tab. 2) and span (Tab. 3). In table 2, measures calculated for level were grouped according to native language, language spoken and sex of the subjects.

For F0 level, L*, L and FL were counted as the measures of valleys, corresponding to the bottom line of the pitch contour. H*i, H*, Hi and H identified peaks within the intonation contour, and thus the top line. The sentence initial and final target points, I and FL, were included because they stand for reference points for the F0 movements across the contours.

Table 2: Mean F0 values of linguistic measures for level, in Hz. M = male; F = female

Linguistic level	*Am M*	*It-En M*	*It-It M*	*Am F*	*It-En F*	*It-It F*
I	120	139	155	213	209	216
H*i	204	198	229	306	308	328
H*	139	179	163	292	254	352
Hi	158	158	188	279	288	320
H	150	175	210	263	231	326
L*	111	122	116	162	170	170
L	125	131	123	193	192	177
FL	92	111	104	150	148	164

For F0 span, selected measures were calculated to describe the pitch movements along the contours: I-L*, I-FL, H*i-L*, H*i-FL, H*-L*, H*-FL. As shown in tab. 3, landmarks such as Hi, H and L were not included in the measures for span because their values were less extreme than those of H*I, H* and L*. Results for span show that the widest pitch excursions are reached by the H*i-FL measure, while the narrowest span values are obtained by the I-FL measure.

The averaged values obtained from the linguistic measures for males and females are shown in Fig. 2 and 3, respectively.

Table 3: Mean F0 values of linguistic measures for span, in Hz. M = male; F = female

Linguistic span	*Am M*	*It-En M*	*It-It M*	*Am F*	*It-En F*	*It-It F*
I – L*	10	17	38	50	39	46
I – FL	28	27	50	62	60	52
H*I – L*	93	76	113	144	138	158
H*I – FL	112	87	125	156	159	164
H* – L*	28	57	46	129	84	182
H* – FL	47	68	58	141	105	188

In fig. 2, it is shown that the It males used similar F0 level in L1/L2 with a wider pitch span in their L1, as compared to their L2. The non-initial peaks (H* and H) have significantly lower values in the pitch pattern used by Am males (139 Hz for H* and 150 Hz for H) than It males (163 Hz for H* and 175 Hz for H).

Contrary to males, the female speakers of this experiment tried to adapt their pitch patterns in L2 to the native speakers' model. This can be inferred by the fairly similar values obtained for initial peaks (I, H*i, Hi) and valleys (L*, L, FL).

Figure 2: Average values of linguistic measures (male spkrs).

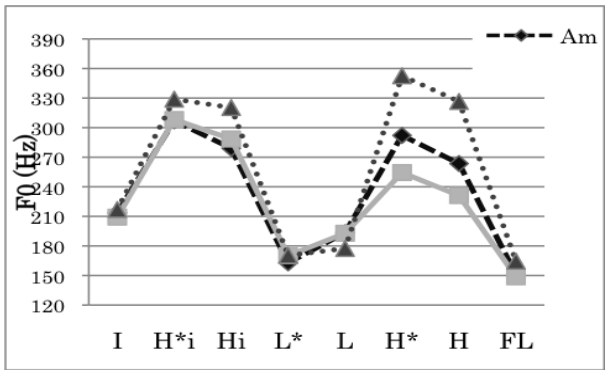
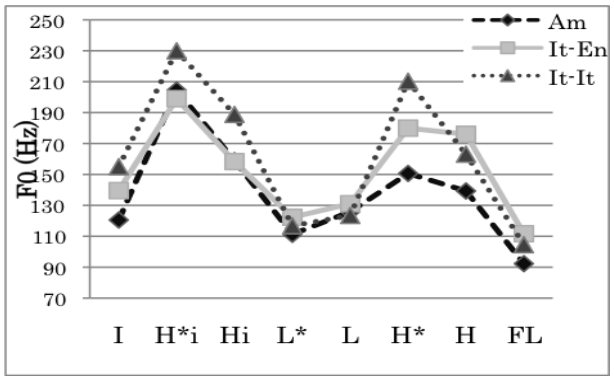


Figure 3: Average values of linguistic measures (female spkrs).



However, significantly different values were obtained for non-initial peaks (H* and H). As shown in fig. 3, the It females had very high values in It-It (352 Hz for H* and 326 Hz for H) and low values in It-En (254 Hz for H* and 231 Hz for H). When speaking English, It subjects lowered their non-initial peaks so much that they obtained values even inferior to those of Am females (see table 2).

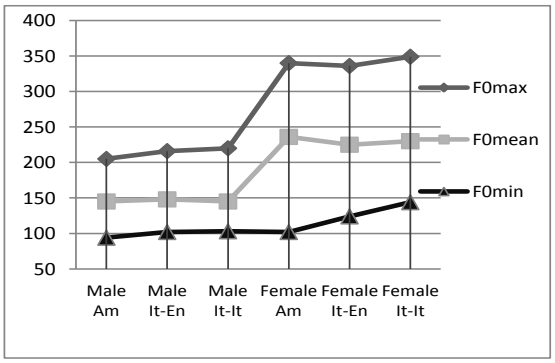
6.2. Results from LTD measures

Data from LTD measures showed that F0 level across males was fairly similar, no matter the language. However, Am males had lower values for F0 min (94 Hz) and F0 max (205 Hz), as compared to It-En (102 Hz for F0 min; 216 Hz for F0 max) and It-It (103 Hz for F0 min; 220 Hz for F0 max). On a linear scale, Am men had a lower F0 range than It men with a difference of about 10 Hz. Italians used slightly lower values for English.

The data analyzed for females replicated the results obtained for males: the trend was similar, with the highest values for It-Italians, lower F0 values for It-En and the lowest F0 measures for Am. However, as shown in fig. 4, the differences across groups were much more extreme for female than male subjects. F0 min values were dramatically different across groups.

While Am women had very low F0 min (102 Hz), It-It women showed a mean F0 of 144 Hz and It-En a mean F0 of 124 Hz. Less dramatic F0 excursions occurred within F0 mean and F0 max values across the groups. The graph in fig. 4 shows the distribution of the F0 max, mean and min in Hz, for the three language groups, evidencing clear differences in pitch level patterns across genders.

Figure 4: F0 max, mean and min values in Hz by male and female subjects divided by group.



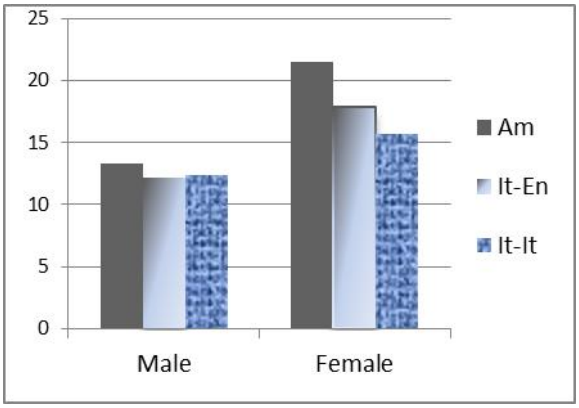
Data from LTD measures were tested with repeated measures and one-way ANOVAs.

For level (mean F0), the between-subject factor 'gender' was highly significant for all measures. The between-subject factors 'native speaker' and 'language' did not reach significance for level neither for males nor for females. On the contrary, a one-way ANOVA showed that F0 min was significantly different across languages both for males ($F(59) = 3.896$, $p=0.026$) and females ($F(59) = 6.018$, $p<0.004$). Repeated measures showed that the within-subject contrast of F0 level*native speaker ($F(1) = 8.17$, $p<0.005$) and F0 level*gender ($F(1) = 116.76$, $p<0.000$) were significant. By contrast, the within-subject contrast of F0 level*language did not reach significance. This suggests that the native language of the subjects played a relevant role in pitch variation.

F0 span of female subjects was much wider than that of males, which suggests that females displayed a wider F0 variation than males. However, previous studied claimed that logarithmic scales (e.g. ST) capture F0 span better than linear scales (e.g. Hz), by giving accurate evaluations of F0 intervals as they are perceived by the human auditory system [5, 12].

Thus, span was calculated also in ST. The bars in fig. 5 show the distribution of the F0 values in ST, for the three language groups, evidencing clear differences in pitch span patterns across genders and language groups.

Figure 5: Span values for male and female subjects.



Italian males had fairly similar pitch span when speaking in L1/L2, with span in It-It (12.39 ST) slightly larger than in It-En (12.14 ST). The value of span for the Am males was on average 1 ST larger than the span of the It males. This difference was sensibly bigger within females groups. Span values were: 21.47 ST for Am females; 17.88 ST for It-En females; 15,72 ST for It-En females.

For span (F0 max-min), the between-subject factor 'gender' reached significance for all measures tested. While the between-subject factor 'native speaker' was significant ($F(1) = 116.76$, $p<0.000$), the factor 'language' did not reach significance. A one-way ANOVA for span showed mild significant differences across languages if calculated in Hz. By contrast, span measured in ST was significantly different across the 'native speaker' and 'spoken language' factors for females ($F(59) = 6.105$, $p<0.004$) but not for males. This gives indications about a different trend among sexes. While It women significantly varied F0 span depending on the language spoken (L1 vs. L2), It males used a similar span across languages.

For skewness, the between-subject factor 'gender' was highly significant ($F(119) = 9.576$, $p<0.002$). Also for kurtosis, the between-subject factor 'gender' was statistically significant ($F(119) = 5.481$, $p<0.021$). The between-subject factor 'language' was statistically significant for skewness ($F(119) = 10.921$, $p<0.001$) but not for kurtosis ($F(119) = 0{,}533$, $p<0.467$). The 'native speaker' factor was statistically significant for skewness but not for kurtosis.

7. CONCLUSION

These preliminary results show that the Italians used higher pitch levels when speaking Italian and lower levels when speaking English. As for span, Italian females' span was wider in English and narrower in Italian, while Italian males' span was only slightly narrower in the L1 than in the L2. Thus, the data confirm the hypothesis that L2 speakers have narrower F0 span than L1 speakers. The second hypothesis, testing the impact of the L1 (Italian) transfer on L2 (English), was neither confirmed nor refused, due to the differences across genders. While the data from the male subjects showed that the L1 had an influence on the pitch range used in L2, the data from the female subjects did not.

These differences between genders may reflect the fact that 'cultural influences may be stronger for women's voice pitch than for that of men's' [8]. This implies that women have, in general, a greater motivation to replicate the native speakers' model [14]. This generalization needs to be confirmed by data from a larger sample of speakers.

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