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Phonetic variation of f_0 range in L1 and L2: A comparison between Italian, English and Spanish native and non-native speakers

This work was carried out with the purpose of investigating the use of language-specific features of pitch span and level in L2. Different languages were investigated: on the one hand, we analysed productions in L2 Spanish and English, uttered by Italian learners with different proficiency levels; on the other hand, we analysed productions in L2 Italian uttered by Spanish and English speakers. The results show a very heterogeneous situation: to some extent, learners seem to be sensitive to f_0 excursion and modulation of the L2 input they receive; however, these intonational features of Target Language speech: i) are out of non-native speaker's control, ii) do not affect all the aspects of L2 productions, and iii) present a high degree of inter-speaker variability.

Key words: Pitch range, L2 prosody, foreign language learning, transfer, topic.

1. *Introduction*

1.1 Theoretical background

Several studies state the relevance of the pitch range parameter and its relative modulations for the prosodic analysis of intonational contours (Mennen, 1998; Mennen, Schaeffler & Doherty, 2007; Busà, Urbani, 2011; Urbani, 2013). The frequency excursion of speech is an element of great importance, which can be influenced by the speaker, the sentence, and the language under investigation. In particular, the speaker's pitch range provides information about his/her biological characteristics (such as age and gender; Traunmüller, Eriksson, 1995; Mennen, *et al.*, 2007); it is also indicative of a series of individual and more specific features of the speaker, such as his/her smoking habit, regional variety, and level of education (Urbani, 2013). Additionally, para-linguistically motivated variation of utterances can be found, which expresses speakers' emotional attitudes and states of mind (i.e. surprise or boredom; Ohala, 1983; Rosenberg, Hirschberg, 2005). Finally, pitch range modulations are closely linked to linguistic functions and language-specific meanings.

A number of recent studies underline the fact that languages differ in the way they use the pitch range. Among others, Mennen *et al.* (2007) refer to the differences in the global pitch range in native speakers of different mother languages (L1s), even if presenting similar physiological features, when producing utterances in their relative L1. Additionally, Zimmerer, Juegler, Andreeva, Moebius & Trouvain (2014), present an overview of the differences among languages, stating that "lan-

guages differ with respect to the pitch range they use, their exact pitch contours and the exact placement of pitch changes" (Zimmerer *et al.*, 2014: 1037).

The strong language specificity of pitch range represents a major hurdle for Second Language (L2) learners. In the literature on L2 Acquisition, at least two different phenomena have been attested with regard to pitch range: on the one hand, several studies (Mennen, Schaeffler & Docherty, 2012; Mennen, Schaeffler & Dickie, 2014; Zimmerer *et al.*, 2014) attest the occurrence of prosodic transfer, which means that the language-specific features of pitch range are transferred from the learners' L1 to the Target Language (TL). On the other hand, other studies observe a narrower pitch range excursion compared to both the L1 and TL; in other words, L2 speech is characterized by an overall smaller modulation. This pitch range compression has been observed in a number of cross-linguistic studies investigating and comparing different pairs of languages (Finnish learners of Russian in Ullakonoja, 2007; Italian learners of English in Busà *et al.*, 2011; Busà, Stella, 2012; French learners of German and German learners of French in Zimmerer *et al.*, 2014).

Different explanations to this phenomenon have been proposed: Ullakonoja (2007), for example, finds that pitch compression is stronger in the first stages of L2 learning than in more advanced stages, showing the link between compression and general L2 proficiency. Other studies (Busà *et al.*, 2011; Zimmerer *et al.*, 2014), on the contrary, propose a link between the pitch compression and the state of insecurity of the learners, which means that a less modulated – therefore compressed – pitch contour in L2 speech might be caused by psychological rather than linguistic reasons.

1.2 Object of the study

The object of our study is an analysis of the f_0 range excursion in L2, in order to verify the occurrence of two phenomena largely attested in language learning: *transfer* and *pitch range compression*.

The study makes a comparison between Italian and two other languages (English and Spanish) in order to highlight cross-linguistic differences in the use of pitch range; then, it investigates the use of pitch range in L2 productions of different group of speakers, all having Italian as L1 or L2.

This work is part of a wider research project, which aims to monitor the development of prosodic competences in Italian-speaking learners of different foreign languages. So far, results have been obtained regarding Italian learners of Spanish (Savy, Luque Moya, 2014; Luque Moya, Savy, 2017) and English (Orrico, Cataldo, Savy & Barone, *forthcoming*). These studies have investigated a series of prosodic parameters:
– Global Profile (GP), the overall trend of the curve
– Nuclear Accent (NA), the phonetic characteristics of the nuclear prominence
– Terminal Contour (TC), the phonetic realization of the final portion of the curve
– Topic, the temporal alignment of the f_0 peak in the Topic
– Range, the overall pitch range excursion of the curve.

Generally speaking, results obtained from these studies reveal a strong presence of phonetic transfer from L1 to the TLs, with a fairly low percentage of learners pro-

ducing intonational contours slightly closer to the TL or adopting other solutions (for a more detailed account, see Savy, Luque Moya, 2014; Orrico *et al.*, *forthcoming*; Luque Moya, Savy, 2017). A different result, however, was registered for the learners' pitch range in English L2, revealing a gradual approach to the TL norm. The explanation proposed is that pitch range has greater perceptual salience for non-native speakers than the other parameters taken into account.

Given the results of the previous studies, we want to test two hypotheses:
– H1: Transfer; language-specific features of pitch range will be transferred from learners' L1 to the TL;
– H2: Pitch range compression; L2 speech will show a narrower pitch range than learners' L1, regardless of the speakers' L1 and TL.

2. *Methodology*

The present section reports a description of the methodology used for our research; it includes specifications of the dataset used for the productions, the recruited speakers, the methods.

2.1 Dataset

The present study uses a limited dataset of data coming from larger corpora specifically built for the previous studies (Savy, Luque Moya, 2014; Orrico *et al.*, *forthcoming*; Luque Moya, Savy, 2017). The dataset consists of yes/no questions in the three languages in analysis; questions present a SVC (Subject-Verb-Complement) syntactical structure and a *Topic+Comment* information structure[1]. Since, as is well known, the prosodic level correlates with the syntactical level by means of pragmatic-informative structures[2], we chose to have comparable informative structures in the languages under investigation, namely the *Topic+Comment* structure.

In Italian and Spanish, the *Topic+Comment* information structure is possible for both declarative and interrogative sentences, due to a similar and free order of constituents. On the contrary, in English, the *Topic+Comment* structure seems to be possible for declarative sentences only, since interrogatives require the inversion between the verb and the subject (VSC[3], e.g. "Is the rectangle coloured?"). However, SVC syntactical structures (*Topic+Comment* information structure) appear to be possible also for interrogative sentences in spontaneous speech. For this reason, we have elicited both canonical questions (SVC) and other forms (SVC), which appear "non canonical", but totally possible and admissible in informal/spontaneous speech.

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[1] Phrasal constituents constitute the units of the information structure, covering roles of pragmatic nature. The information structure of the utterances is based on the two categories of Topic and Comment. The Topic is the entity or the entities that the proposition is about, and represents the referent of the proposition (Gundel, 1988; Lambrecht, 1994); the Comment is what is said about the Topic.
[2] For a detailed review see Savy, Alfano (2016).
[3] We use SVC instead of SVO in order to emphasize the fact that the C element does not always designate a direct object.

An example of the selected kind of question in the three languages is reported:
– "La balena è grande?" in Italian
– "¿El albergue es cómodo?" in Spanish
– "The rectangle is colored?" in English.

In these structures the topic is made up of different words for each language, trisyllabic words which differ according to the position of the lexical stress; we chose three paroxytone words (*bambino, budino, balena* for Italian, *albergue, bodega, helado* for Spanish, *December, September, fiancée* for English) and three proparoxytone (*rondine, albero, dondolo* for Italian, *péndulo, cámara, águila* for Spanish, *triangle, rectangle, pullover* for English).

The dataset has been elicited by means of a reading task: speakers had to carefully and silently read the context, trying to imagine themselves in it, and read aloud only the target sentences.

Table 1 - *Example of context from the corpus used for the elicitation*

TRIANGLE

Your neighbour asks you to look after Angelo, her 4-year-old son, while she goes shopping. Angelo is sitting on his bed looking at a book with a lot of pictures and figures. He is shy and not really talkative so you start asking questions about the book to break the ice:

Is there a triangle?

He answers no, but you saw one while he was flipping through the book so you ask:

And that triangle?

2.2 Speakers

The participants of this research are speakers belonging to two groups:
– Italian native speakers (It-L1)
– Spanish and English native speakers (Sp-L1, En-L1).

Selection criteria and groups' characteristics are shown below.

Participants of the first group are 44 Italian (L1) learners of Spanish or English (Sp-L2/En-L2); they are all female students at the University of Salerno. They were selected through sociolinguistic questionnaires in order to control for some common requirements: all the students and their families had to come from and live in the area of Salerno, so as to ensure a certain degree of homogeneity for the L1 variety; the students had to never have spent significant periods abroad, and therefore never have acquired their L2 in Spanish- or English-speaking countries; the students had to specify their current academic year, so that we were able to further classify them on the basis of their linguistic competence in L2. According to the CEFR levels (Council of Europe, 1996), students were divided into three groups: group A (with an A2/B1 level of competence, corresponding to second-year students at University of Salerno), group B (B2 level of competence, corresponding to third-year students), and group C (C1 level of competence, corresponding to fifth-year students). To these, we added a

group of 7 advanced learners who have studied for at least six months in a Spanish- or English-speaking country, according to the language they are studying (group E).

Speakers belonging to the second group of participants are Spanish (3) and English (3) native speakers; they have lived in Italy for at least 15 years and they are all foreign language teachers of the Italian learners.

All the participants of the two groups represent both native and non-native speakers of the research; in other words, Italian native speakers represent the Italian L1 model of reference and, since they are foreign language learners, they also constitute the groups Sp-L2 and En-L2[4].

Conversely, Spanish and English native speakers represent the model of reference of their relative L1 and constitute the group of Italian non-native speakers (It-L2). The It-L2 speakers are a subgroup of the native speakers of Spanish (2) and English (1). These speakers should be considered as a control group, since they have been selected by means of different criteria. In particular, these speakers have been selected to collect additional data to support or reject the hypothesis about pitch compression (see § 1.1): a narrower pitch excursion in all the groups would indicate that the phenomenon of compression is a typical characteristic of interlanguages.

All the speakers have produced utterances in both their L1 and L2.

The following summary table reports the exact number of the speakers, divided into the different groups, the number of productions and the total of the utterances that has been actually analysed.

Table 2 - *Number of speakers, number of productions and total of utterances analysed*

	Groups of speakers	n° of speakers	n° of productions	total
L1	IT L1	5	6	28
	SP L1	3	6	18
	EN L1	3	5	11
SP L2	SP L2 – group A	10	6	53
	SP L2 – group B	7	6	36
	SP L2 – group C	8	6	37
	SP L2 – group E	3	6	16
EN L2	EN L2 – group A	8	5	38
	EN L2 – group B	5	5	24
	EN L2 – group C	6	5	25
	EN L2 – group E	4	5	16
IT L2	SP > IT	2	6	12
	EN > IT	1	6	6

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[4] The Italian-speaking speakers are learners either of Spanish or of English. Therefore, Sp-L2 and En-L2 are two different subgroups of the Italian native speakers.

2.3 Analysis

The first phase of analysis of the productions has been carried out through the INTSINT international labelling system (Hirst, Di Cristo, 1998); thus, the preliminary prosodic analysis of the curves aims to obtain a phonetic description of the contours. For the intonational analyses of the study we have used the software Praat for the pitch track extraction (Boersma, Weenink, 2007) and the script Prosomarker for the stylization of the f_0 curve (Origlia, Alfano, 2012).

In a second phase, pitch range has been closely examined; in this respect, the analyses have taken into consideration a subdivision of the intonational contours into three prosodic domains[5] and an investigation of pitch range for each of the domains:
– Global Profile (GP), which concerns the entire curve and the overall trend of the contour; it gives a general idea about the overall dynamics and the intonational profile.
– Topic, which requires the description of the alignment of the tonal peak in the Topic[6].

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[5] These prosodic domains (see below within the text) have been taken into consideration by other models of intonational analysis, such as the IPO (Cohen, 't Hart, 1967; 't Hart *et al.*, 1990), the MAS (Cantero, 2002; Font-Rotchés, Cantero, 2009), the autosegmental-metrical models (Silverman, Beckman, Pitrelli, Ostendorf, Wightman, Price, Pierrehumbert & Hirschberg, 1992).
According to the IPO model, pitch movements are classified as "configurations", sequences of single constituents. The GP corresponds to the root, the only mandatory configuration of the contours; the Topic and the TC correspond to the constituents, which can precede or follow the root, respectively. The model requires the definition of a grammar, the intonational inventory of a specific language, built from the combination of pitch movements.
The MAS model carries out an analysis at the linguistic level according to which intonational contours present a structure divided in three elements, different functional constituents of intonational contours. Our individuation of three prosodic domains within intonational contours corresponds to such a tripartition. The three elements are: *anacrusis*, the portion of the curve composed by the unstressed syllables preceding the first peak; *cuerpo* ("body" or "declination"), which consists of the syllables between the first peak and the Nucleus, corresponding to the last stressed syllable of the contour; *inflexión final*, which covers the final portion of the contour, from the Nucleus to the end of the curve. This last domain is regarded as the element which best permits the definition of the contour melody. Despite the tripartition of the curves, the MAS model does not identify constituents according to their linguistic functions, but only on the basis of their phonetic characteristics.
The AM model, on the other hand, does not recognize prosodic domains, but it analyses tonal events which constitute intonational contours and signal different prosodic constituents. Therefore, a first constituent could be represented by an Intermediate Phrase by means of phrase accents, corresponding to the position of the Topic; on the other hand, the GP is described as a sequence of Pitch Accents. Finally, as is well known, the TC, the last portion of the contour, consists of both Phrase Accents and Boundary Tones, representing the edge tones of the curve and conveying the pragmatic information of the utterance.
In most intonational models, a particular status is attributed to the TC, as the portion which carries the overall information needed to distinguish between declaratives and yes/no questions.
[6] In SVC structures the Topic section is found at the beginning of the sentence. Such a constituent can present a specific intonational realisation, representing in such cases an independent prosodic unit (Crocco, Savy, 2007). For this reason, a description of the Topic as a separate prosodic domain provides an interesting parameter to be investigated.

– Terminal Contour (TC), which defines the final portion of the curve, from the nuclear accent to the end.

TC and Topic represent two local events with their precise dynamics.

In the present study, measurements of accentual events (level and excursion of the accent) are not treated, as they are not included within the objectives of this work.

The analyses conducted for each of the three domains employs the Long-Term Distributional (LTD) methodology, which considers the f_0 distribution within the speaker's performance (Patterson, 2000; Mennen *et al.*, 2012). In addition, the pitch range has been investigated according to the two dimensions of level and span; the former, also referred to as "register", concerns the overall relative pitch height, the latter pertains the excursion between f_0 maximum and minimum showing pitch variations within each utterance[7]. A series of measures for each domain has been taken in support of the general interpretation of the pitch range parameter, calculated in Herz (Hz) or semitones (ST).

– GP: f_0 maximum and f_0 minimum (Hz), mean f_0 (Hz), median f_0 (Hz), standard deviation (ST), 100% span (ST), 90% span (ST), 80% span (ST), skew (ST), kurtosis (ST). These measures serve as control data to take account of the imbalances which could characterise the curves; in particular, values of skew and kurtosis specify the degree of distribution of the curve.

– Topic: f_0 maximum and f_0 min (Hz), 100% span (ST).

– CT: f_0 maximum and f_0 minimum (Hz), 100% span (ST), slope[8] (ST).

In addition to Patterson (2000) and Mennen, Schaeffler & Docherty's (2012) measurements for pitch level, we calculated the range of f_0 values mostly exploited by the speaker, in order to distinguish it from f_0 local phenomena (peaks and valleys). In our view, this parameter represents a robust indicator for pitch level.

We also argue that the range of values most frequently exploited by a speaker in an utterance is a language-specific feature, therefore potentially susceptible of transfer.

These measurements were performed by dividing the f_0 excursion of each utterance into five regular strips, each of which contains the 20% of the excursion. The strips were numbered from 1 to 5. according to their position with respect to the median[9]:

– Strip 1: low values;
– Strip 2: mid-low values;
– Strip 3: median values (in which the median value is located);
– Strip 4: mid-high values;
– Strip 5: high values.

For each production we calculated the percentages of f_0 values per strip.

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[7] A more in-depth discussion regarding these two dimensions is reported in Ladd (2008); he states that the terms of level and span are often used together "under the catch-all term 'pitch range'" as it does exist a tight covariance between the two aspects.

[8] The slope was calculated as the ratio between the span and the duration of the TC.

[9] The choice to calculate strips of pitch level which are not linked to absolute values represents a form of "rudimentary normalisation", since an actual procedure of normalisation has not yet been possible due to problems regarding the refining of the methodology.

Table 3 summarises by means of an example the total of measurements which have been conducted.

Table 3 - *Example of the list of measurements divided according to the three domains (GP, TC, Topic)*

GP level (Hz)	**Max**		388,13
	Min		180,04
	Mean		239,83
	Median		244,3504
	Frequency zone	**from**	221,65
		to	263,27
GP span (ST)	**Standard Deviation**		2,66
	Range (100% Span)		13,30
	90% Span		7,45
	80% Span		6,46
	Skew		0,31
	Kurtosis		0,44
TC	**Span (ST)**		10,83
	Slope (ST)		0,04
	Max (Hz)		388,13
	Min (Hz)		207,63
Topic	**Max (Hz)**		280,16
	Min (Hz)		180,04
	Span (ST)		7,66

As the last phase of analysis, the obtained data have been subjected to an analysis of variance, the ANOVA test, in order to verify their statistical significance among the different groups of speakers.

3. *Results*

In the following sections we present data resulting from the analysis. The first part of results is the outcome of a description of the L1s under investigation, while the second is the outcome of a systematic comparison between the L1 and the L2 of each group of speakers.

3.1 Native productions

Native productions are described in two steps: a detailed description of the characteristics related to pitch range based on the set of measurements explained in § 2.3; a cross-linguistic comparison aimed to identify the parameters that differentiate the three languages.

Table 4 shows the measurements performed for L1 speakers of the three languages, based on the mean of speakers' values.

Table 4 - *Measurement of the L1s based on the mean of the speakers' values*

		It	Sp	En
GP Level (Hz)	Max	298.92	312.83	415.83
	Min	177.35	159.21	196.39
	Mean	217.83	230.41	262.31
	Median	207.95	230.99	242.31
	Frequency zone	strip 1	strip 1-5	strip 1
GP Span (ST)	Standard Deviation	2.42	3.49	3.59
	Range (100% span)	8.94	11.66	12.94
	90% Span	7.77	10.50	11.32
	80% Span	6.20	8.99	9.37
	Skew	0.73	-0.18	1.02
	Kurtosis	-0.29	-0.84	0.30
TC	Span (ST)	3.73	8.42	7.97
	Slope (ST)	0.01	0.04	0.03
	Max	227.79	284.42	402.32
	Min	182.49	174.44	256.73
Topic	Max (Hz)	298.68	268.39	265.19
	Min (Hz)	187.69	167.85	205.63
	Span (ST)	7.93	8.10	4.44

Before commenting the results in Table 4 a caveat must be given.

The indexes of kurtosis provide information about the extreme values (the highest and lowest ones) of the distribution; the fact that this index is close to zero in the three languages tells us that the distribution is mesokurtic (*i.e.* similar to a normally distributed data set).

In addition, the indexes of skew (indicating the symmetry of the distribution) clearly differentiate Spanish from the other two languages; in particular, Spanish looks much more symmetric than the others, with an index of skew that is closer to zero, and median and mean that are very close to each other. This is confirmed by results about the most frequent values, which are spread out along the five strips. As for English and Italian, they have higher positive values for skew, indicating a higher concentration of the distribution within the lower values. This is confirmed again by the calculation of the frequency zone, located around the lowest values (strip 1). Furthermore, English appears to be somewhat less symmetric than Italian, suggesting an even higher concentration of values in strip 1.

Therefore, in order to avoid redundancy in the presentation of the results, we selected a subset of measurements to be presented in the following sections:

– 100% span: chosen over 90% and 80% because it most significantly signals differences cross-linguistically, since the most frequent values in Italian and English are pooled along the lowest values, which would not be taken into account by 80% and 90% span;
– Frequency zone: examined with respect to the median, since it is reported to be a better indicator for pitch level (De Looze, Hirst, 2008; D'Imperio, Cavone & Petrone, 2014);
– Topic span;

– TC span;
– F_0 peak alignment in the Topic[10].

We present for each language a stylization of the curve and the relative values, which has been built as follows: it is not an actual curve, but rather a symbolic-descriptive interpretation of data presented in Table 4 aimed at providing an overview of values and trends in the L1s.

3.1.1 It-L1

Italian L1 (Figure 1) presents a wide Topic in terms of range excursion (span: 7.9 ST); f_0 peak is aligned with the stressed syllable of the Topic.
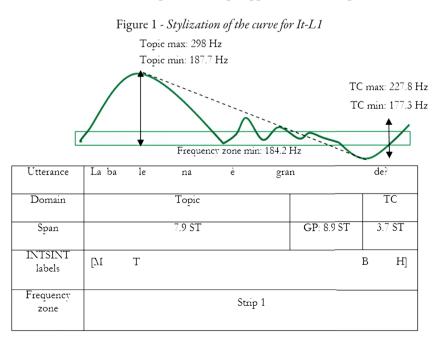
With respect to the GP the model is characterized by a gradually declining trend from the top (298.9 Hz), set at the beginning of the curve, to the bottom (177.3 Hz), set in the final portion of the curve, with a global span of 8.9 ST.

The TC shows a very narrow span if compared with the Topic and the GP domains (3.7 ST).

Moreover, from the analysis of this model, we can notice that the Top (T) of the entire contour corresponds to the f_0 peak aligned with the stressed syllable of the Topic, while the bottom coincides with the TC.

In the light of the above, for this model we can add that most of the curve appears to be modulated around low frequencies; in fact, the frequency zone corresponds to strip 1 (min: 184.2 Hz; median: 207.95 Hz).

In such a situation, the wide span of the Topic appears to be a local phenomenon.

Figure 1 - *Stylization of the curve for It-L1*

Utterance	La ba	le	na	è	gran		de?
Domain			Topic				TC
Span			7.9 ST			GP: 8.9 ST	3.7 ST
INTSINT labels	[M	T				B	H]
Frequency zone				Strip 1			

Topic max: 298 Hz
Topic min: 187.7 Hz
TC max: 227.8 Hz
TC min: 177.3 Hz
Frequency zone min: 184.2 Hz

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[10] In the present work we add preliminary results about the tonal alignment of the Topic, which are currently being investigated for another study (see Savy, Alfano & Orrico, *to appear*).

3.1.2 Sp-L1

Spanish L1 (Figure 2) is characterised by a wide overall modulation. The span of the Topic measures 8.1 ST; it shows a rising trend which reaches the f_0 peak at the right boundary of the intermediate phrase of the Topic. Such a configuration is described in the literature as "flat-rising" with the f_0 peak aligned with the last syllable (see Savy, Luque Moya, 2014).

As a whole, data concerning the GP confirm the wide range excursion and the high modulation of this model (GP span: 11.6 ST; max: 312.8 Hz; min: 159.2 Hz).

The rising trend toward the right boundary and the wide range excursion observed in the Topic recurs in the TC (TC span: 8.4 ST).

As for pitch level, it appears that the f_0 values are distributed rather homogeneously along the five strips, with a relatively lower percentage of occurrences in the median strips.

Figure 2 - *Stylization of the curve for Sp-L1*

Utterance	El pen du lo está col ga do?		
Domain	Topic		TC
Span	8.1 ST	GP: 11.6 ST	8.9 ST
INTSINT labels	[M H		B T]
Frequency zone	Strip 1-5		

3.1.3 En-L1

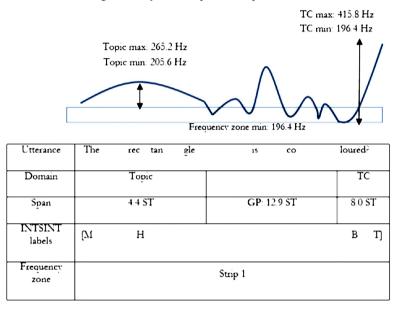Figure 3 shows the stylisation of En-L1.

En-L1 shows a very narrow excursion and flat profile for the Topic domain (span: 4.4 ST) and the f_0 peak is aligned with the stressed syllable.
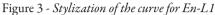
Data regarding the GP show a very wide global excursion (span: 12.9 ST; max: 415.8 Hz; min: 196.4 Hz).

The TC presents a rising trend and a very wide span (8 ST).

Because of the data regarding the narrow span of the Topic, we can state that the overall wide modulation of English concentrates on the central and the final portion of the curve, therefore mostly on the domains of GP and TC.

The frequency zone covers the low frequencies of the curve and it is set at strip 1 (min: 196.4 Hz; median: 242.31 Hz); such a situation shows that the majority of the excursion of En-L1 is made up of episodic peaks within the contour.

Figure 3 - *Stylization of the curve for En-L1*

Utterance	The	rec tan	gle		is	co		loured?
Domain		Topic						TC
Span		4.4 ST			GP: 12.9 ST			8.0 ST
INTSINT labels	[M	H						B T]
Frequency zone				Strip 1				

3.1.4 Comparison between It-, Sp- and En- L1

The following is a descriptive summary of the parameters found for the L1s, according to the parameters we chose to use for the modelling (§ 3.1).

It-L1 is described as follows:
– Topic: wide excursion (7.9 ST)
– GP: declining trend from the Topic to the TC (8.9 ST)
– TC: narrow excursion (3.7 ST)
– Alignment of the Topic f_0 peak: with the stressed syllable
– Frequency zone: strip 1.
  Sp-L1:
– Topic: wide excursion (8.1 ST)
– GP: wide excursion and high modulation (11.6 ST)
– TC: wide excursion (8.4 ST)
– Alignment of the Topic f_0 peak: with the last syllable (right boundary)
– Frequency zone: strip 1-5
  En-L1:
– Topic: narrow excursion and flat profile (4.4 ST)
– GP: wide excursion (12.9 ST)
– TC: rising trend and wide excursion (8 ST)
– Alignment of the Topic f_0 peak: with the stressed syllable

– Frequency zone: strip 1.

For the calculable parameters, an analysis of variance (Anova) has been conducted in order to identify statistical significance; on the contrary, for descriptive data, such as the alignment of the f_0 peak of the Topic and the frequency zone, this has been a qualitative type of analysis.
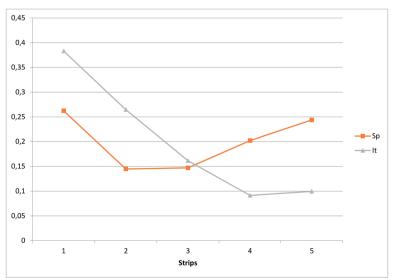
The comparison has been carried out taking into consideration on the one hand It- and Sp-L1 (see Table 5), and on the other hand It- and En-L1 (see Table 6). A comparison between Sp- and En-L1 falls outside the scope of our work.

Table 5 - *Contrastive parameters between It- and Sp-L1. In bold the four statistically contrastive parameters are reported*

	It-L1	Sp-L1	Significance
Topic span	7.9 ST	8.1 ST	p = 0.82
GP span	8.9 ST	11.6 ST	p = 0.001
TC span	3.7 ST	8.4 ST	p = 0.009
Alignment of Topic f_0 peak	stressed syllable	end of Topic	significant
Frequency zone	strip 1	strip 1-5	significant

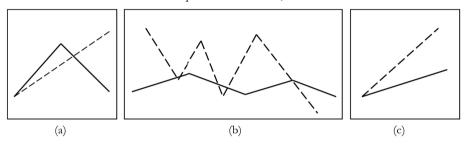As can be seen, the parameters which diversify It- from Sp-L1 (Figure 4a, 4b, 4c) are:
– GP span
– TC span
– Alignment of the Topic f_0 peak with the stressed syllable or to the end of the Topic
– Frequency zone (Graph 1), set at the low values of the curve (strip 1) or distributed along the five strips (strip 1-5).

Graph 1 - *Distribution of the f_0 values in It- and Sp-L1*
Frequency zone

Therefore, the difference between Spanish and Italian lies in the greater modulation of the former, which results from the more homogeneous distribution of the f_0 values along the strips.

Figure 4 (a, b, c) - *Stylized representation of the parameters that diversify It- from Sp-L1. Figure 4a shows the alignment of the Topic f_0 peak with the stressed syllable (It-L1) or with the end of the Topic (Sp-L1, in dotted line). Figure 4b shows differences with regard to both GP span and frequency zone. Figure 4c shows the TC span (narrow span for It-L1, wide span for Sp-L1, in dotted line)*

(a)   (b)   (c)

Differences between It-L1 and En-L1 are shown in Table 6.

Table 6 - *Parameters diversifying It- from En-L1. In bold the three statistically significant values are reported*
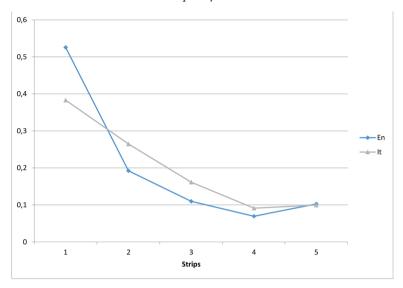
	It-L1	En-L1	Significance
Topic span	7.9 ST	4.4 ST	p = 0.001
GP span	8.9 ST	12.9 ST	p = 0.001
TC span	3.7 ST	8 ST	p = 0.009
Alignment of Topic f_0 peak	stressed syllable	stressed syllable	non-significant
Frequency zone	strip 1	strip 1	non-significant

The parameters of statistical significance that have been identified (Figure 5a, 5b, 5c) are:
– Topic span, that in En-L1 appears to be reduced by half compared to that of the It-L1
– GP span, since It-L1 is characterized by the narrowest global span
– TC span, since En-L1, as Sp-L1, ends with a wide excursion in that portion.
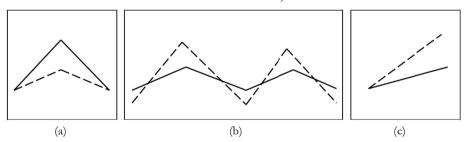
As can be seen, data regarding the f_0 peak in the Topic and the frequency zone do not show significant differences between this pair of languages. Nevertheless, Graph 2 shows the distribution of f_0 values along the five strips. It appears that both languages make an extensive use of the low values (strip 1); however, En-L1 has a much greater percentage of values in strip 1 than It-L1, which is also confirmed by the indexes of skew in the two languages (see Table 4).

Contrary to what we observed for Italian and Spanish, the differences between Italian and English do not result from the greater modulation of English, but only from a higher excursion.

Graph 2 - *Distribution of the f_0 values in It- and En-L1*
Frequency zone

Figure 5 (a, b, c) - *Stylized representation of the parameters that diversify It- from En-L1. Figure 5a shows the Topic span (wide span for It-L1, narrow span for En-L1, in dotted line). Figure 5b shows differences with regard to the GP span (narrow span for It-L1. wide span for En-L1, in dotted line). Figure 5c shows the TC span (narrow span for It-L1, wide span for En-L1 in dotted line)*

| (a) | (b) | (c) |

3.2 Non-native productions

Non-native productions (L2)[11] have been compared with the modelling profiles of speakers' mother language (L1) and target language (TL) described above, in order to verify if they transfer pitch range features from L1 or if they approach to the TL.

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[11] Non-native productions concern the three groups of Italian learners (group A, B, C) and the Experienced students (group E).

3.2.1 Sp-L2 (Italian speakers)

3.2.1.1 Topic

As we have seen in the comparison between It- and Sp-L1, the differences in Topic span did not result as statistically significant, while we have identified significant differences regarding the f_0 peak alignment.

As for L2 productions, we found that Italian learners of Spanish align the f_0 peak with the stressed syllable, following their L1 model (Figure 6a). Moreover, some alternative solutions in the L2 productions are found for learners belonging to level C, as they realize a displacement of f_0 peak toward different directions: in some cases toward the post-stressed syllable (Figure 6b), in others toward the pre-stressed syllable (Figure 6c), in others toward the last syllable, corresponding to the end of the Topic (Figure 6d).

These different solutions adopted by the L2 learners can be interpreted as different "attempts" made by the speakers to reproduce an intonation pattern consistent with the input they hear. At present, we do not have sufficient evidence to treat them as conscious attempts in the TL direction, or as generic efforts to drift apart from the L1 (see also Savy, Luque Moya, 2014; Orrico *et al.*, *forthcoming*).

In general, these results confirm the findings in Savy, Luque Moya (2014).

Figure 6a - *L2 production of an Italian learner of Spanish; the f_0 peak of the Topic is aligned with the stressed syllable*
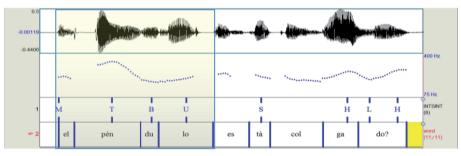

Figure 6b - *L2 production of an Italian learner of Spanish; the f_0 peak of the Topic is aligned with the post-stressed syllable*
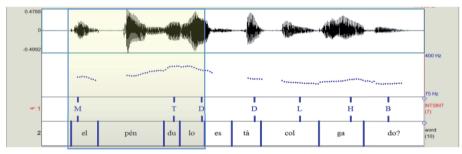
Figure 6c - *L2 production of an Italian learner of Spanish; the f_0 peak of the Topic is aligned with the pre-stressed syllable*
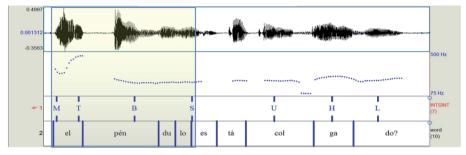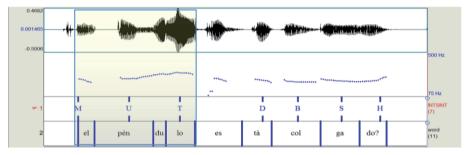

Figure 6d - *L2 production of an Italian learner of Spanish; the f_0 peak of the Topic is aligned with the last syllable of the Topic*

Our results (Table 7) show no significant differences with regard to the distribution of transfer phenomena and attempts among the three groups of learners (groups A, B, C: 64% of transfer, 36% of attempts). By contrast, the difference appears to be more significant as concerns group E, in which percentages of transfer and attempts are reversed (32% and 68%, respectively). However, if we drill down and look at the attempts by groups A, B and C we can see that Italian speakers align the f_0 peak with the pre-stressed syllable only in 2% of cases, to the post-stressed syllable in 7% of cases, to the last syllable of the Topic in a good 27% of cases.

In addition, it is worth noting a better performance of group C with respect to groups A and B in realising the f_0 peak on the last syllable of the Topic (32% vs 26% and 22%; group C reaches the performances of group E).

Table 7 - *Percentages of f_0 peak alignment within the Topic in Sp-L2 productions*

	Group A	*Group B*	*Group C*	*A+B+C*	*Group E*
Transfer	61%	70%	62%	64%	32%
Attempts	39%	30%	38%	36%	68%
Pre-stressed syllable	4%	0%	3%	2%	6%
Post-stressed syllable	9%	8%	3%	7%	31%
Last syllable	26%	22%	32%	27%	31%

Such a result as a whole can lead us to consider these "attempts" as approximations to the TL, rather than mere drifts apart from the L1, also because of the evident "improvement" which involves all the groups of Italian speakers (from group A to E) and with a certain gradual approach.
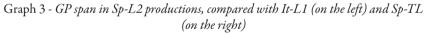
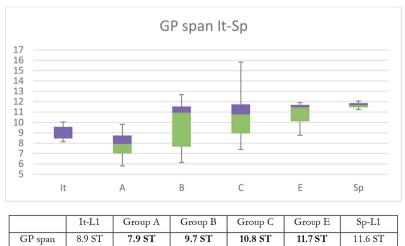### 3.2.1.2 Global Profile and frequency zone

The first statistically relevant parameter according to Anova, concerns the GP span; data of the three L1s and the L2 productions of Italian speakers are reported in Graph 3. The Anova test does not report significant differences among the three groups of learners ($p = 0.05$); despite this situation, we can make some generic observations.

All the L2 productions (groups A, B, C and E) present a high degree of internal variability and significant standard deviations with respect to the L1s.

Group A reports a minor span even compared to It-L1 and little variability (SD = 1.35), showing therefore a certain internal consistency. L2 productions of groups B and C are characterised by a pretty high variability (SD = 2.53 and 2.61. respectively), which could be interpreted as a possible sign of uncertainty; for group C, with respect to groups A and B, we registered a higher mean span. As concerns group E, the low degree of variability (SD = 1.70) and higher span values show a clearer tendency toward Sp-L1.
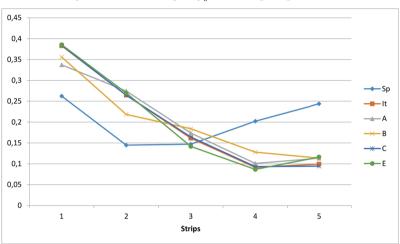
On the whole, we can note a progressive increase of L2 performance and an interesting transition from uncertainty to consistency. Looking at the groups in sequence, we can outline a gradual improvement as the speakers' L2 competence increases.

Graph 3 - *GP span in Sp-L2 productions, compared with It-L1 (on the left) and Sp-TL (on the right)*

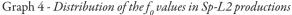|	It-L1	Group A	Group B	Group C	Group E	Sp-L1
GP span	8.9 ST	**7.9 ST**	**9.7 ST**	**10.8 ST**	**11.7 ST**	11.6 ST

As for pitch level, Graph 4 clearly shows that all the Italian speakers, regardless of the proficiency level, follow the Italian model: the highest percentages of f_0 values are located in strip 1.

Unlike the GP span, for which we registered a gradual improvement along the proficiency levels, values for pitch level is clearly transferred from the speakers' L1.

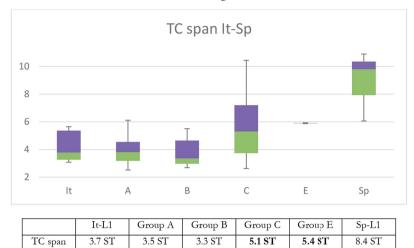Graph 4 - *Distribution of the f_0 values in Sp-L2 productions*

3.2.1.3 TC span

Signs of gradual improvement can be observed from the data regarding the TC span (Graph 5). It-L1 shows a very lower span compared to Sp-L1 (3.7 and 8.4 ST, respectively). Here too, there are no significant differences among the groups of Italian speakers according to Anova (p = 0.15); however, a description of the realizations of the TC is given in the following lines.

Groups A and B realize a very low TC span, roughly staying on the level of It-L1 (3.5 ST and 3.3 ST, respectively), with a fairly low variability (SD = 1.15 and 1.12. respectively). Better results regard data of groups C and E: they present a similar mean value of span (5.1 ST and 5.4 ST); while productions of group C show a higher variability (SD = 2.63), group E appears more systematic and regular (SD = 1.42)[12].

Results concerning the TC span as a whole, despite the partial improvements of groups C and E, do not show the evident gradualness observed in the GP domain (Graph 3). They present a situation of some controversy and a clearer evidence of transfer, as Italian speakers do not reach Sp-L1 values.

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[12] As group E consists of less speakers than group C, this last result needs to be verified.

Graph 5 - *TC span in Sp-L2 productions, compared with It-L1 (on the left) and Sp-L1 (on the right)*
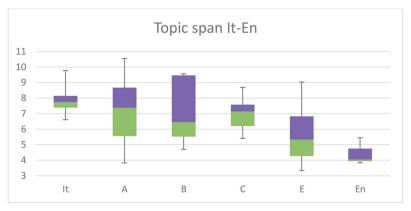

	It-L1	Group A	Group B	Group C	Group E	Sp-L1
TC span	3.7 ST	3.5 ST	3.3 ST	**5.1 ST**	**5.4 ST**	8.4 ST

3.2.2 En-L2 (Italian speakers)

The parameters diversifying It- from En-L1 concern the span values of the three domains.

3.2.2.1 Topic span

First of all, in the realization of the Topic in the L2 productions (Graph 6), a first evidence of transfer has been found; compared to the low span of Topic in En-L1 (4.4 ST), groups of learners A, B and C realize a quite higher span (7.3 ST, 7.1 ST and 7 ST, respectively) following the model of their L1 (7.9 ST).

Graph 6 - *Topic span in En-L2 productions, compared with It-L1 (on the left) and En-L1 (on the right)*

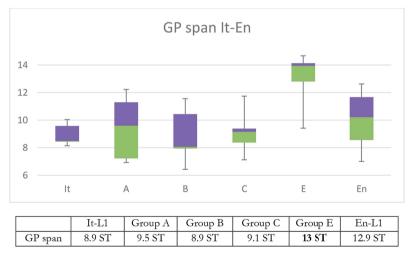|	It-L1	Group A	Group B	Group C	Group E	En-L1
Topic span	7.9 ST	7.3 ST	7.1 ST	7 ST	**5.8 ST**	4.4 ST

Although differences among the groups are not statistically relevant (p = 0.67), we can nevertheless comment the L2 productions.

Productions of both groups A and B show a certain degree of within-group variability (SD = 2.19 and 2.57. respectively) and a rather high span; even if on they keep the same span level of A and B, group C decreases in variability (SD = 0.99). Finally, in productions of group E the span level appears to be lowered on average (5.8 ST), although they present a high degree of variability (SD = 2.46).

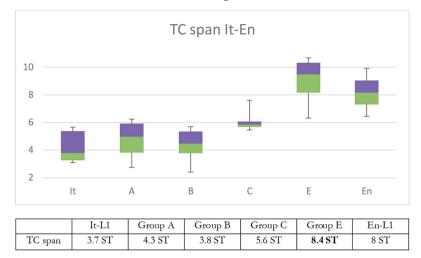### 3.2.2.2 Global Profile span

As for the GP span, shown in Graph 7. the analysis of variance shows that differences among the groups of Italian speakers are significant (p = 0.03). Results of groups A, B and C do not appear very different from their L1 model and show almost the same span level with different degrees of variability (SD = 1.98. 2.33 and 1.33. respectively); on the contrary, results of group E, in spite of the high internal variability (SD = 2.41), reach the TL span values (13 ST). Despite the significative differences among the groups, we cannot easily find a clear tendency in the productions by the different groups of learners.

Graph 7 - *Data of the GP span in En-L2 productions, compared with It-L1 (on the left) and En-TL (on the right)*

	It-L1	Group A	Group B	Group C	Group E	En-L1
GP span	8.9 ST	9.5 ST	8.9 ST	9.1 ST	**13 ST**	12.9 ST

3.2.2.3 TC span

Results concerning the TC span in En-L2 productions (Graph 8) present significant differences among the groups of Italian native speakers (p = 0.0008). As in the case of TC span in Sp-L2 productions, observations on groups A and B can be merged, as they both stay on the same level of It-L1 (4.3 and 3.8 ST, respectively). Group C occupies a mid position between L1 and TL (5.6 ST), while group E, even if with a high variability (SD = 1.96), approaches and exceeds En-L1 values (8.4 ST).

Graph 8 - *TC span in En-L2 productions, compared with It-L1 (on the left) and En-TL (on the right)*

	It-L1	Group A	Group B	Group C	Group E	En-L1
TC span	3.7 ST	4.3 ST	3.8 ST	5.6 ST	**8.4 ST**	8 ST

3.3 It-L2 (Spanish and English speakers)

In this last section of results, productions in Italian L2 are discussed. As mentioned in § 2.2. It-L2 speakers were not selected according the same criteria as the other groups: they are English and Spanish native speakers who have been living in Italy for at least 15 years, which makes them far more proficient L2 speakers than En- and Sp-L2. Therefore, the reader must bear in mind that the results presented and discussed about this group function as a way to test our H2 (see § 2.2).

Furthermore, we do not present any statistical data for this group of speakers, but only a qualitative analysis, since only few speakers agreed to participate (2 Spanish and 1 English).

3.3.1 Spanish speakers

As concerns Spanish speakers, we focused on the analysis of the Topic structure and the span of GP and TC.
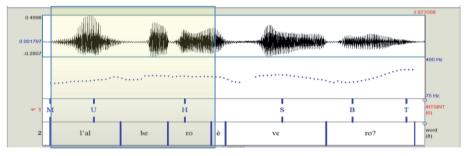
Results regarding the alignment of f_0 peak within the Topic are shown in Table 8. We draw attention to the fact that for It-L2 Spanish speakers we need to consider "attempts" the cases of f_0 peak retraction; we remind the reader that in Sp-L1 f_0 peak is normally aligned with the last syllable.

Table 8 - *Percentages of f_0 peak alignment within the Topic in It-L2 productions by Spanish speakers*

Transfer	58%
Attempts	42%
penultimate syllable	25%
stressed syllable	17%

As can be seen, in more than half of the cases (58%), Spanish speakers tend to maintain the alignment of the f_0 peak with the end of the Topic portion (Figure 7): such a realisation corresponds to a clear evidence of transfer.

Figure 7 - *L2 production of a Spanish speaker; the f_0 peak of the Topic is aligned with the last syllable of the Topic*

In the remaining 42% of cases, two different solutions (attempts) can be observed: in 25% of the productions, f_0 peak is aligned with the penultimate syllable, in 17% of the productions it is aligned with the stressed syllable; in this last case, the speakers realize the TL Topic configuration.

As for the GP domain, a movement toward TL is found too, but to a different degree in the two dimensions of level and span.
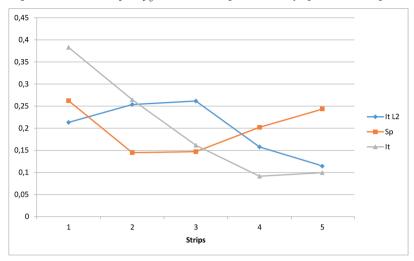
The span turns out to be so narrow as to overcome values of It-TL.

Table 9 - *Data of the GP span, the frequency zone and the TC span in It-L2 productions by Spanish native speakers*

	Sp-L1	It-L2	It-TL
GP span	11.6 ST	7.64 ST	8.9 ST

As for pitch level, Graph 9 shows that speakers keep exploiting all the five frequency strips homogeneously, following the pattern of their L1; however, it appears that they make a lesser use of the highest values (strips 4 and 5) and consequently increase the percentage of values in strips 2 and 3. which were not much exploited in Sp-L1.

Unlike the GP span, the TC span of L2 productions is narrower than Sp-L1, but not as narrow as It-TL (Table 10).

Graph 9 - *Distribution of the f$_0$ values in It-L2 productions by Spanish native speakers*

Table 10 - *Data of the TC span in It-L2 productions by Spanish native speakers*

	Sp-L1	It-L2	It-TL
TC span	8.4 ST	6.73 ST	3.7 ST

3.3.2 English speaker

Table 11 shows a summary of the productions of It-L2 by the English native speaker. Results about the Topic show a situation of partial movement toward TL, with a relative expansion of the Topic span.

As already observed for Spanish speakers, here again the span of the GP experiences a reduction, which overcomes It-TL.

A more evident improvement concerns the span of the TC, which was already particularly contrastive between English and Italian L1; productions show a clear flattening of the En-L1 span matching the values of It-TL.

Table 11 - *Topic span, GP span and TC span in It-L2 productions by a native English speaker*

	En-L1	It-L2	It-TL
Topic span	4.4 ST	6.4 ST	7.9 ST
GP span	12.9 ST	7.3 ST	8.9 ST
TC span	8 ST	3.7 ST	ST

4. *Discussion*

The data presented in § 3 can be divided in two main parts. The first one deals with the identification of the features of the L1s under consideration; the second part focuses on L2 productions, which we compared to both speakers' L1 and TL.

The analysis and comparison between pairs of L1s has pointed out some features of the curve that diversify Italian from English and Spanish (see § 3.1.4). With regard to It- and Sp-L1, we have identified four of these features. The first one is the alignment of the f_0 peak within the Topic: in It-L1 the peak is aligned with the stressed syllable of the word in position of Topic, while in Sp-L1 it is aligned with its right boundary. In the GP domain, differences concern both the span (narrow span for It-L1, wide span for Sp-L1) and the frequency zone (strip 1 for It-L1, strip 1 to 5 for Sp-L1), reflecting a greater modulation of the overall curve of Spanish compared to Italian (see § 3.1.4). The third parameter regards the TC, which in Italian has a narrower excursion than in Spanish.

The comparison between It- and En-L1 reveals that the two languages show significant differences relating to the span of the three domains under investigation. Specifically, It-L1 presents a wider Topic span and narrower GP and TC spans compared with En-L1.

In the second part of results (comparison of L2 productions with speakers' L1 and TL), we have observed that L2 learners do not behave homogeneously. Instead, different tendencies have been identified; in particular, we found:
– Sensitive parameters, which show a certain degree of learnability;
– Resistant parameters, for which we did not register any progress toward TL.

In other words, we define as "sensitive" all the parameters that are successfully reproduced by learners, or for which we registered some degree of improvement along the levels; conversely, we define as "resistant" those parameters that the learners transfer from their L1.

In Sp-L2 productions, we noted sensitivity with regard to the f_0 peak alignment of the Topic; in particular, groups C and E increase the percentages of f_0 peak alignment with the last syllable of the Topic, as in their TL structure (see § 3.2.1.1).

Table 12 - *Percentages of Topic f_0 peak alignment with the last syllable by Italian learners of Spanish*

It-L1	Group A	Group B	Group C	Group E	Sp-TL
f_0 peak aligned with the stressed syllable	% of f_0 peak alignment with the last syllable				f_0 peak aligned with the last syllable
	26	22	32	31	

There seems to be a certain degree of sensitivity in the range excursion of the GP domain too (see § 3.2.1.2), with an increase of span values in the different stages of the learning process, despite the high standard deviation, which testifies to a condition of uncertainty (Table 13). Such an increase of span is not accompanied by a greater modulation or pitch level variation: the frequency zone of Italian speakers in Sp-L2 productions stays the same as their L1.

Even if there is no exact continuity of change across the groups, what appears to be particularly relevant is the gradual improvement, which affects the learning process as a whole: although it concerns span values only (therefore local phenomena), such an improvement develops through the three levels of learners and group E.

Table 13 - *Values of the GP span and the frequency zone by Italian learners of Spanish*

	It-L1	Group A	Group B	Group C	Group E	Sp-TL
GP span	8.9 ST	7.9 ST	9.7 ST	10.8 ST	11.7 ST	11.6 ST
fr. zone	strip 1	strip 1	strip 1	strip 1	strip 1	strip 1-5
SD	0.82	1.35	2.53	2.61	1.70	4.65

As for the resistant parameters, we can call attention to TC (see § 3.2.1.3), in which the span is narrower compared to a Sp-TL (Table 14).

Table 14 - *Values of the TC span by Italian learners of Spanish*

	It-L1	Group A	Group B	Group C	Group E	Sp-TL
TC span	3.7 ST	3.5 ST	3.3 ST	5.1 ST	5.4 ST	8.4 ST
SD	1.20	1.15	1.12	2.63	1.42	5.31

On the contrary, in En-L2, the only sensitive parameter is the TC (see § 3.2.2.3); in this domain we have highlighted a clear improvement of span values for groups C and E, even if the former group does not reach the TL values (Table 15).

Table 15 - *Values of the TC span by Italian learners of English*

	It-L1	Group A	Group B	Group C	Group E	En-TL
TC span	3.7 ST	4.3 ST	3.8 ST	5.6 ST	8.4 ST	8 ST
SD	1.21	1.05	1.47	0.87	1.96	1.74

Instead, the span of Topic and GP (Table 16) preserve pitch excursion in accordance with the speakers' L1 e show therefore a persistence of transfer (It > En for the Topic, It < En for the GP; see § 3.2.2.1 and § 3.2.2.2).

Table 16 - *Values of Topic span and GP span by Italian learners of English*

	It-L1	Group A	Group B	Group C	Group E	En-TL
Topic span	7.9 ST	7.3 ST	7.1 ST	7 ST	5.8 ST	4.4 ST
SD	1.18	2.18888	2.570136	0.996304	2.457264	0.88
GP span	8.9 ST	9.5 ST	8.9 ST	9.1 ST	13 ST	12.9 ST
SD	0.82	1.98	2.33	1.33	2.41	2.25

Lastly, we need to consider that both the f_0 peak alignment of the Topic and the frequency zone of the GP between It- e En-L1 are similar.

With regard to It-L2 productions, it is necessary to discuss the results regarding the span of the GP. Both Spanish and English GP spans are wider than the Italian one: however, Spanish and English native speakers have produced in It-L2 a very narrow span, compared not only to their relative L1 but also to It-TL.

5. *Conclusions*

From the discussion of the results, we can conclude that there is a certain sensitivity and a selective attention to matters of range; such sensitivity:

1. lacks of intra-speaker and intra-group systematicity, therefore appears to be out of L2 speaker's control[13];
2. does not affect all the aspects of pitch range in L2;
3. does not affect the three domains in the same way;
4. presents a high degree of inter-speaker variability.

During the process of L2 learning, it seems that learners do not control the pitch modulations in the whole sentence, but rather they focus on only one of the three domains analyzed. We have only detected some attempts in L2 productions: such attempts involve a change of span (an increase for Italian speakers in Sp- and En-L2 and a reduction for Spanish and English speakers in It-L2). However, this change is mainly due to local phenomena rather than to a different kind of modulation. Indeed, pitch level values show a clear transfer from the speakers' L1s. Data regarding all the L2 speakers (Sp-, En- and It-L2) show that there is neither a generic span compression, nor a change of modulation.

Conversely, learners show a greater sensitivity to the Topic and the TC: in Sp-L2 learning, it prevails the different f_0 peak alignment, while in En-L2 learning an increase of the range excursion in the final portion of the curve has been observed. We think that the improvements found in the realization of TC could result from the attempts of the learner to realize tonal boundaries of the TL, which consequently involve changes of excursion; however, further evidence to support this hypothesis is needed. The deeper sensitivity to these parameters can be due to their distinctiveness between the speakers' L1 and TL: they are perceived by the learner, who succeeds in improving them during his learning process.

The fact that speakers do not realize all the features of the TL pitch range allow us to draw the conclusion that L2 learners never rule all the parameters together, but they concentrate on some more salient points in their productions, that seem to be highly relevant and sensitive to non-native speakers' attention. Moreover, we

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[13] In previous works (Savy, Luque Moya, 2014; Orrico *et al.*, *forthcoming*; Luque Moya, Savy, 2017) the lack of control detected in the implementation of L2 productions has been attributed to the lack of prosodic and metaprosodic competence of the learners; in fact, in most cases, their guided learning process does not involve the development of prosodic skills and metaprosodic awareness which would allow them to more easily reproduce and implement L2 intonational features.

must point out that all the observed phenomena result affected by a high degree of inter-speaker variability, reflecting different degrees of awareness and different kinds of attempts of each speaker.

Taking into consideration the discussion of the data and the results of the analyses, we would conclude that pitch range variations in L2 productions seem to be conditioned by the L1/TL combination. In other words, variations produced by non-native speakers are due to actual transfer phenomena from their L1, which affect and play a role in the TL learning process. Therefore, our results do not allow us to confirm the hypothesis of pitch compression in L2 (H1), as found by previous study, but we can accept the hypothesis that pitch range features of the curve are transferred from L1 to L2.

In the light of the conclusions of this work, in the future we intend to conduct a series of perceptual experiments in order to examine in depth and verify the perceptual salience of the range parameter. Furthermore, we believe we should investigate to a much greater extent the inter-speaker variability, relating it to a more detailed analysis of the TL input.

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