

Intrinsic Pitch is not a universal phenomenon: Evidence from Romance languages

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Introduction

This work examines the relation and interaction between speech production and speech perception with respect to the micro-prosodic phenomena “Intrinsic F0” versus “Intrinsic Pitch”:

With regard to speech production, Intrinsic F0 describes the dependence of the fundamental frequency on vowel height: Other things being equal, close vowels show a higher F0 compared to open vowels. With regard to speech perception, Intrinsic Pitch describes the dependence of the perceived vowel pitch on the height of the presented vowel: Close vowels are perceived with a lower pitch impression compared to open vowels. The aim of this work is to investigate similarities and differences by conducting a combined examination of the phenomenon “IF0-IP”, comparing cross-linguistic influences on the one hand and musical education influences on the other hand.

Research on speech production showed that Intrinsic F0 differences are found throughout all languages and language families (Whalen and Levitt 1995): Stress-timed languages, syllable-timed languages and tone languages show nearly the same Intrinsic F0 amount and distribution. This finding underpins a biomechanical explanation on basis of the human vocal tract properties, although other theories argue for an active increase of acoustic differences between different vowels.

Research on speech perception generally acknowledges that perceptual Intrinsic Pitch differences are found for Germanic languages: Due to the strong evidence in speech production data, it is argued (Fowler and Brown 1997) that listeners compensate for automatically occurring F0 height differences, which might lead to difficulties for stable prosodic parsing. However, other explanations for Intrinsic Pitch claim that the pitch differences are introduced due to the special properties of the human auditory system (psychoacoustic theory), e.g. masking and non-linearity. Silverman (1987) showed that in phrasal context Intrinsic Pitch can be used to evoke accent differences perception by changing the IF0 height of stressed vowels.

Interestingly, empirical Intrinsic Pitch data is only available for the Germanic languages English and German, although it is generally claimed to be a universal phenomena.

In the current study we aim at a cross-linguistic validation of Fowler’s compensation theory by expanding experimental data on Intrinsic Pitch to typologically diverse languages such as Romance and tone languages.

Previous studies (Pape et al. 2005) gave evidence for a strong cross-linguistic difference when comparing Intrinsic Pitch results for the Romance language Catalan with German. Furthermore, the before-mentioned psychoacoustic theory could not be supported by our data.

Methods

Apart from the linguistic background of the listener the phenomenon of Intrinsic Pitch differences has been found to be strongly affected by musical education (Rauscher and Hinton 2003). Therefore this experiment was carried out in a fully crossed experimental design with the factors language background and musical education (professional musicians versus non-musicians). We used a standard 2I2AFC procedure, testing for two different isolated vowels in all possible orders in a single vowel pair comparison. The first experimental part tests for the German vowel pair /i: α:/ which maximally differs in vowel height. The second part examines vowel pairs for the listeners’ native language (thus e.g. Spanish vowels /i: α:/ for Spanish subjects). The F0 differences to be tested were PSOLA pitch-shifted in the range of $\pm 10\text{Hz}$ (2.5Hz steps), proven to be sufficient to drive the full amount of Intrinsic Pitch differences. The terminology was absolutely clear for the participants in their native language and the

Romance language listeners were not educated in one of the Germanic languages. For each condition around 30 listeners were tested. The experiment used isolated vowels (cut from a stressed /mVme/ context), since only so a consistent interpretation without inclusion of macroprosodic phenomena could be guaranteed. Clearly, the continuation of Silvermans experiments is promising, but due to the necessary inclusion of a large parameter space is not undertaken in the present experimental series.

Results

The main new finding is that the number of listeners not sensitive to the given pitch task is much higher for all Romance languages than for German. Spanish and Portuguese have the highest number with 46% of the non-musicians showing *pitch-insensitivity*. Italian with 23% is in between, and German shows the lowest number with 6%. Thus, here for nearly half of the Romance language listeners Intrinsic Pitch differences cannot be extracted. This gives clear evidence that Intrinsic Pitch is a language-dependent phenomenon. The insensitivity found is independent of the stimulus identity, which could be shown in the comparison of the German and native stimuli condition. Thus, the native stimulus condition did not increase sensitivity for the task.

When analyzing the valid Intrinsic Pitch values for the *remaining* pitch-sensitive listeners, the following results are obtained: When pooled over all German listeners, for the vowel height comparison /i α/ it is found that the values significantly differs, although with a lower value than in the classical literature. However, when separately examining the different populations, it is seen that no statistical difference is obtained, neither for the professional musicians nor non-musicians. Thus, Intrinsic Pitch is generally present in German, but the significance of the phenomenon can not be shown when examining populations contrasting in the (important) factor musical education.

With regard to cross-linguistic differences, it is found that for all languages Intrinsic Pitch was absent for professional musicians. Further, when examining the occurring differences in musical education, it could be shown that across all languages the the values significantly differ when comparing professional musicians with non-musicians. Thus, here important evidence is given that increased musical education significantly influences the occurrence and distribution of Intrinsic Pitch. For the non-musicians, only inconsistent patterns are found, For Italian the results are clearer: Here, Intrinsic Pitch is present for the native vowel condition. Thus, Italian presents a special case: It seems that Intrinsic Pitch is present only for the population of non-musicians and the native vowels.

Conclusion

In summary, it is given evidence that Intrinsic Pitch definitely has to be classified in a language-specific manner: For the Romance languages Spanish and Portuguese, Intrinsic Pitch is mostly not verifiable. This finding points to the idea that speakers of Germanic languages indeed use a cue to parse the vowel pitch into a prosodic and vowel height component, and therefore are completely able to solve the pitch tasks asked for in our experimental conditions. Our findings on German also corroborate the idea of micro-prosodic compensation is valid, probably with the aim of compensating for speech production F0 differences.

Since it is shown in the literature that Romance languages use F0 similarly for prosodic marking, our results seem to indicate the following hypothesis: In Romance languages, Intrinsic F0 as an additional vowel height cue is not discriminately used, resulting in the observed pitch-insensitivity for the Romance languages Spanish and Portuguese. Whether this lack of the cue Intrinsic Pitch is due to the much smaller vowel inventory in these languages or to other phenomena will be examined in further research. The intermediate position for the Italian language supports the ideas of Gili Fivela and Zmarich (2005): They showed by articulatory data that Italian is a mixture of stress-timed and syllable-timed languages. Our results confirm this typological classification with the Italian listeners showing a higher pitch-discrimination and more stable Intrinsic Pitch values compared to Spanish and Portuguese, but significantly worse than the German listeners.