Intonation of Sentences with an NPI*

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This paper presents the results of a production experiment on the intonation of sentences containing a *negative polarity item (NPI)* in Tokyo Japanese. The results show that NPI sentences exhibit a *focus intonation*: the F_0-peak of the word to which an NPI is attached is raised, while the pitch contour after the NPI-attached word is compressed until the negation. This intonation pattern is parallel to that of *wh*-question, in which the F_0 of the *wh*-phrase is raised while the post-*wh*-contour is compressed until the question particle.

Keywords: Japanese, negative polarity item (NPI), focus intonation, wh-*question*

1 Introduction

This paper presents the results of a production experiment on the intonation of sentences containing a *negative polarity item* (henceforth, *NPI*) in Tokyo Japanese[1]. The experiment will examine how sentences with an NPI are phonetically realized.

NPIs are a group of words that can only appear in the scope of negation.[2] In the production experiment to be reported here, the NPI *sika* was used. *Sika*, together with the negation, means 'only / nothing but. . . ', as shown below.

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1 In this paper, we will only discuss intonation of Tokyo Japanese. For brevity, I will call it 'Japanese' for the rest of the paper.

2 There are some kinds of NPIs which appears non-negative environments as well (Ladusaw 1979). In this paper, however, we only use the so-called 'strong NPIs', which can only appear in the scope of negation. See Vasishth (1998) for other types of NPI in Japanese.

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(1) Mári-**sika** rámu-o nomíya-de nomá-**nakat**-ta
Mári-SIKA rum-ACC bar-LOC drink-NEG-PST
'Only Mari drank rum at the bar./No one but Mari drank rum at the bar.'

There has been a claim that NPI sentences has a certain prosodic constraint: the NPI and the negation must be within the same prosodic phrase (Hirotani 2005; Lee and Tomioka 2001; Tomioka 2004). The main goal of the paper is to examine the intonation of sentences like (1) and see if the claim is supported experimentally. As we will see below, the results of the experiment actually confirms the claim. Three phonetic phenomena are observed in the sentences with a *sika*-phrase: (i) F_0-rise of the word to which *-sika* is attached, (ii) the F_0-downtrend of the post-NPI material, and (iii) the pitch reset after the negation.

This intonation pattern of NPI sentences is parallel to that of *wh*-questions, in which the F_0 of the *wh*-phrase is raised while the post-*wh*-contour is compressed until the question particle that binds the *wh*-phrase. Following Ishihara (2005, 2007b), we will call this intonation *focus intonation (FI)*. An FI is characterized by three phonetic phenomena: (i) an F_0-rise of the focused phrase, (ii) a F_0-downtrend of the post-focal material, and (iii) the pitch reset after the scope of the focus. The results of the experiment suggest that an NPI, together with its licenser (i.e., negation), induces an FI within the scope of the negation.

The paper is organized as follows. In the next section (§2), we will briefly review the intonation of *wh*-questions (§2.1), a previous claim about the intonation of NPI sentences (§2.2), and the assumptions about FI taken in this paper (§2.3). §3 explains the details of the production experiment. The result of the experiment will be presented in §4, followed by discussion in §5.

2 Background

2.1 Focus Intonation in *Wh*-questions

It has been observed that a Japanese *wh*-question sentence obligatorily exhibits an FI: The F_0-peak of the *wh*-phase is raised (*focal F_0-rise*) while the F_0-peaks of the post-*wh*-phrases are lowered (*post-focal F_0-downtrend*) (Maekawa 1991, 1997). Furthermore, Deguchi and Kitagawa (2002) and Ishihara (2002, 2003) claim that the phonological domain of the FI (henceforth, *FI domain*) and the semantic scope of *wh*-question shows a correspondence. A post-focal F_0-downtrend in a *wh*-question continues until the end of the scope of the *wh*-question, where the question particle that binds the *wh*-phrase appears.

For example, in a matrix *wh*-question like (2a), the post-focal downtrend continues until the end of the matrix clause, where the matrix question particle *no* appears (Figure 1), while in an indirect *wh*-question like (2b), the post-focal downtrend stops at the end of the embedded clause, where the question particle *ka* appears, and the pitch range is reset to the original, non-compressed level thereafter (Figure 2). This essentially means that the FI domain indicates the scope of the *wh*-question. (See Ishihara (2003, 2005) for explanation how this FI-*wh*-scope correspondence is derived.)

(2) a. *Matrix* wh-*question*

Náoya-wa [Mári-ga **náni**-o nomíya-de nónda to]
Naoya-TOP Mari-NOM what-ACC bar-LOC drank that
ímademo omótteru **no**?
even.now think Q
'What$_i$ did Naoya still think that Mari drank t_i at the bar?'

b. *Indirect* wh-*question*

Náoya-wa [Mári-ga **náni**-o nomíya-de nónda **ka**]
Naoya-TOP Mari-NOM what-ACC bar-LOC drank Q

ímademo obóeteru
even.now remember
‘Naoya still remembers what$_i$ Mari drank t_i at the bar.’

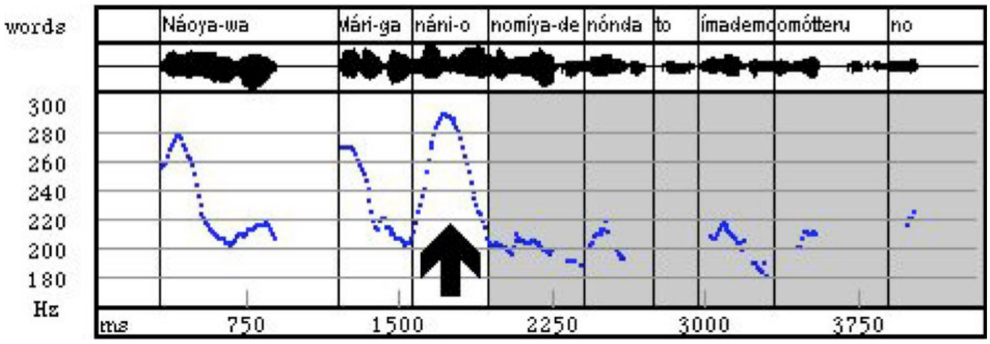


Figure 1: Matrix *wh*-question

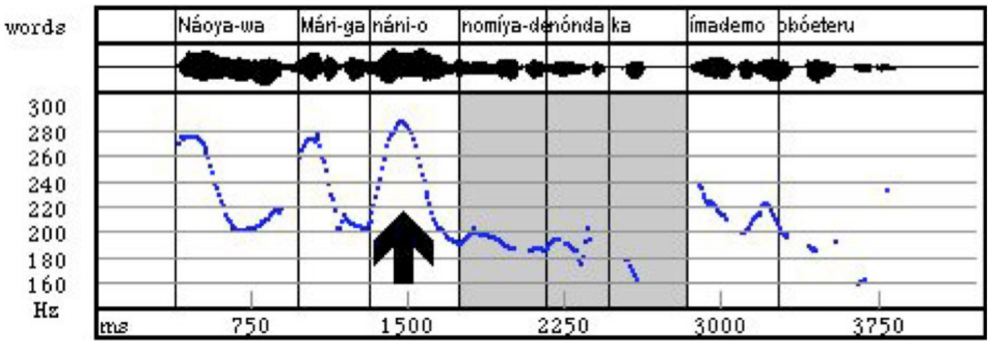


Figure 2: Indirect *wh*-question

A similar claims has been made from a processing point of view. Hirotani (2005) claims that a processing principle called *Scope-Prosody Correspondence (SPC)* requires that a *wh*-phrase and the question particle binding it be in the same prosodic phrase, namely *Major Phrase (MaP)*, in order for the *wh*-scope to be interpreted properly. According to the standard assumption about Japanese FI (e.g., Pierrehumbert and Beckman 1988; Nagahara 1994; Truckenbrodt 1995), which is adopted by Hirotani, but not in this paper (see §2.3 below), MaP is the domain of FI. Therefore it is equivalent to say in our terms that SPC requires that the *wh*-phrase and the question particle be in a single FI domain.

Strictly speaking, there is one difference between Hirotani's claim and the one proposed by Deguchi and Kitagawa (2002) and Ishihara (2002, 2003). The requirement of Hirotani's SPC is weaker than that of the other proposals in that the pitch reset after negation is not obligatorily expected in Hirotani's SPC. We will discuss pitch reset in the results and the discussion sections (§4.3, §5.2). In any case, it is a well-observed fact that *wh*-phrase, together with a question particle, triggers an FI, so that they are grouped prosodically into a single FI domain.

2.2 Negative Polarity Items (NPI) and FI

A similar claim has been made for sentences containing an NPI (cf. Hirotani 2005; Lee and Tomioka 2001; Tomioka 2004). Hirotani (2005) claims, extending her analysis of *wh*-question, that SPC requires that an NPI and the negation binding it be in the same MaP.

If a processing principle like SPC expects such a prosodic marking for a NPI-NEG relation, we would also expect in terms of production that an NPI and a negation trigger an FI to be included in the same prosodic domain, just like a *wh*-phrase and a question-particle trigger one. I will call this hypothesis *NPI-FI Hypothesis*:

(3) *NPI-FI Hypothesis*

An NPI triggers an FI within the domain of negation.

a. A *focal F_0-rise* of the phrase to which an NPI attaches.
b. A *post-focal downtrend* on all the material following the NPI until the negation that binds the NPI.
c. A *pitch reset* after the negation.

For example, if an NPI and a negation are in the embedded clause as in (4a), an FI would appear only within the embedded clause, starting from the phrase to which the NPI is attached (*Mari*) until the verb to which the negation *-nakat-* is attached (*noma-* 'drink'). The pitch range will be reset after the embedded clause.

On the other hand, if the NPI and the negation are in the matrix clause as in (4b), the FI would appear on the matrix clause (and contain the entire embedded clause in its domain). In (4b), the F_0 of the matrix subject *Naoya* will be raised, while all the F_0-peaks thereafter will be lowered until matrix verbal complex head containing negation *iwa-nakat-ta* 'say-NEG-PST'.

(4) a. *NPI in the embedded clause*

Náoya-wa [Mári-**sika** rámu-o nomíya-de nomá-**nakat**-ta to]
Naoya-TOP Mári-SIKA rum-ACC bar-LOC drink-NEG-PST that
Yúmi-ni itta
Yumi-DAT said
'Naoya said to Yumi that only Mari drank rum at the bar.'

b. *NPI in the matrix clause*

Náoya-**sika** [Mári-ga rámu-o nomíya-de nónda to]
Náoya-SIKA Mari-NOM rum-ACC bar-LOC drank that
Yúmi-ni iwa-**nákat**-ta
Yumi-DAT say-NEG-PST
'Only Naoya said to Yumi that Mari drank rum at the bar.'

This FI-NPI hypothesis, as far as I know, has never been experimentally examined in terms of production.[3] In this paper, therefore, I will present the results of the production experiment testing the FI-NPI hypothesis.

[3] For a perception experiment, see Hirotani (2005).

2.3 Definitions

Before going into the details of the experiment, let us make clear the definitions of the phonetic phenomena to be examined in the experiment. I will assume that FI can be detected by the three phonetic phenomena listed in (5). They are schematically illustrated in Figure 3 and 4:

(5) a. F_0-rise on the focused phrase (e.g., *wh*-phrase, NPI)
b. post-focal F_0-downtrend
c. pitch reset after FI domain.

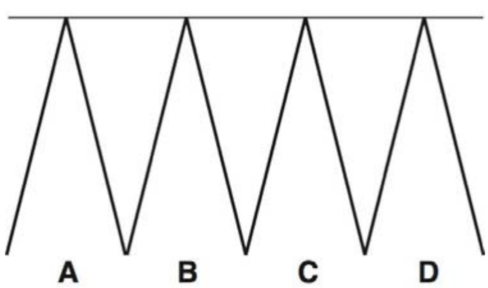


Figure 3: Default contour (No FI)

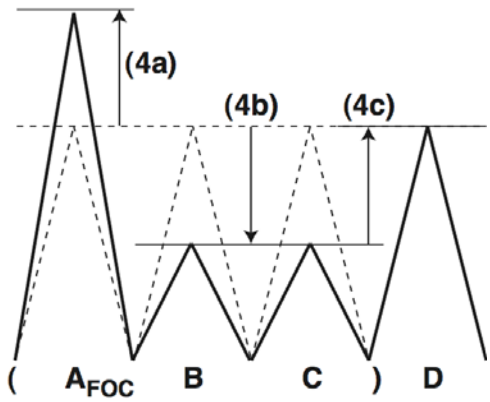


Figure 4: FI (Focus A; FI domain A–C)

I will assume that focus *F_0-rise* (5a) is a phonetic effect that raises the F_0-peak of the phrase bearing (semantic) narrow focus, and that *post-focal F_0-downtrend* (5b) is a phonetic effect that compresses the pitch range of the post-focal material. In other words, an FI is created as a result of direct manipulation of pitch range. In the schematic illustration in Figure 4, the pitch range of the focused phrase (A) is expanded, while that of post-focal elements (B and C) is compressed, resulting in lower F_0-peaks for these phrases. *FI domain* is the phonological domain in which (5a) and (5b) apply. In Figure 4, the FI domain, indicated by brackets ( ), contains A, B, and C.

The assumptions taken here depart from the standard analyses of FI in Tokyo Japanese (e.g., Pierrehumbert and Beckman 1988; Nagahara 1994; Truckenbrodt 1995; Selkirk 2003; Sugahara 2003), in which FI is analyzed as a manipulation of Major Phrase boundaries. Under these analyses, focus F_0-rise is explained as an insertion of MaP boundary on the left of focused phrase,[4] and post-focal downtrend as *downstep* as a result of MaP boundary deletion at the post-focal area. In other words, in the standard analyses, a MaP behaves as an FI domain.

In the assumption adopted in this paper, on the other hand, FI is a phonetic phenomenon independent of any prosodic phrasing or downstep. This means that a MaP phrase may appear within an FI, and that downstep may take place independently of the phonetic effects of FI listed in (5). In other words, the domain of downstep (MaP) and the domain of the FI (FI domain) are not necessarily identical. See Ishihara (2007a,b) for arguments for this assumption about FI.[5] See also Kubozono (this volume) for experimental evidence against the standard "FI = MaP" analysis.

Pitch reset (5c) is a phenomenon which cancels the effect of post-focal downtrend after the FI domain. In Figure 4, where the FI domain is assumed to be (A B C), the compressed pitch range of the post-focal material (B and C) is reset to the original pitch range (horizontal dotted line) at the end of the FI domain. As a result, the phrase outside the FI domain (D) has the non-compressed pitch height.

This means that a pitch reset after the post-focal downtrend will indicate the end point of the FI domain. In the indirect *wh*-question in (2b) above, for example, an FI is observed in the embedded clause: Focus F_0-rise raises the F_0-peak of the *wh*-phrase *nani-o*; the post-focal downtrend compresses the pitch

4 In Selkirk's (2003) analysis, it is *Intonation Phrase* boundary that is inserted, although the basic idea remains the same.

5 How the prosodic phrasing and FI (under the assumption adopted here) interact with each other is discussed in Ishihara (2007b).

contour after the *wh*-phrase until the end of the embedded clause, where the question particle *ka* appears; and the pitch range is reset to the original height after the question particle. The FI domain in this case is between the *wh*-phrase and the question particle.

As it turned out from the results of the experiment, there are two different ways in which pitch reset is realized. In some utterances a high peak is observed only on the phrase after the embedded clause, while in other utterances another sharp F_0-rise appears on the complementizer of the embedded clause, and creates a higher peak than that of the following phrase. Sample pitch contours are given in Figure 5 and 6. These two samples are taken from the recordings of the same sentence from a single speaker.

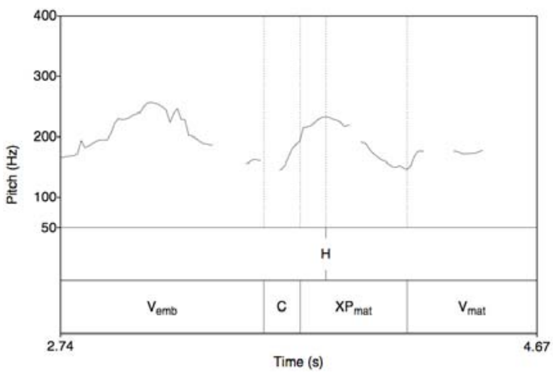


Figure 5: XP-type pitch reset

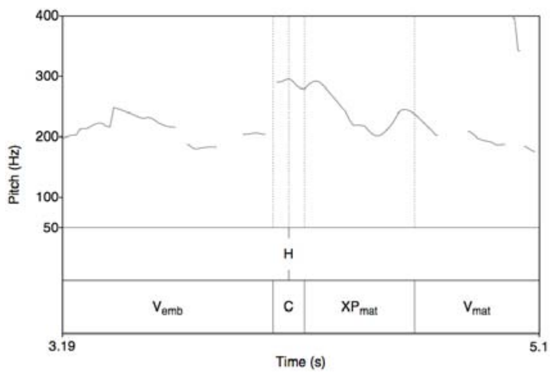


Figure 6: COMP-type pitch reset

In Figure 5, the last mora of the embedded clause, which is the complementizer (C), is realized low, and a high peak appears on the following phrase (XP_{mat}). In Figure 6, on the other hand, the complementizer bears a higher peak than the following phrase.

From this fact, I tentatively assume that the pitch reset is realized either on the first high peak of the next prosodic domain, or at the end of the F_0-lowered prosodic phrase as some kind of boundary tone. For expository purposes, I will call the first type of pitch reset *XP-type* (pitch reset realized on the XP following the embedded clause), and the latter *Comp-type* pitch reset (pitch reset realized on the embedded clause complementizer).

Although some speakers seemed to have a tendency to use Comp-type more frequently than reset in a consistent manner, it appears that both variations are available for everyone. But crucially, it seems that the choice of XP-type/Comp-type is also strongly dependent on the experiment conditions. We will discuss this phenomenon more in detail in §5.2. It is sufficient here just to keep in mind that there are two different places where the pitch reset may be realized.

3 Experiment

3.1 Goal

The goal of this experiment is to examine the validity of the NPI-FI hypothesis in (3). More specifically, it is designed to check whether the following phenomena listed in (6), repeated below, are actually observed. If NPI sentences are to trigger FIs just like *wh*-questions, these phenomena are expected in their pitch contours.

(6) a. F_0-rise on NPI
  b. F_0-lowering on post-NPI material
  c. F_0-reset on post-negation material

3.2 Method

Subjects Four females, AH, CS, CK, NM, and a male, YY, all non-linguists brought up in Tokyo or surrounding areas.

Stimuli 8 sets of 3 types of target sentences (24 total, see §3.3 and Appendix A for detail)

Presentation of the stimuli Stimuli are mixed with 112 filler sentences (used as stimuli for other experiments), provided in a pseudo-randomized order (so that two sentences from the same example set are not presented in a row). Each sentence is presented to the subject on a computer screen, one at a time. Each subject makes 3 recordings of the entire set of stimuli. Each recording session uses a different pseudo-randomized order of the sentences.

Task Subjects are asked first to read the sentence (aloud or quietly) to understand the meaning of the sentence, and then to read aloud for the recording.

Data exclusion The results are first analyzed for each subject. After the examination of the data, one of the five subject's (NM) data is excluded from the final analysis. In NM's data, not only the expected contrasts, but also other syntax/semantics-related phenomena expected in an utterance (e.g., downstep, utterance final rising intonation for questions) were not attested. The data only showed the time-dependent declination effect.[6] This fact suggests that the subject did not pay sufficient attention to the syntax/semantics of the sentences, and read them merely as sequences of words. Such data would not tell us anything important for our purpose. (See Appendix B for the individual results.)

Data normalization The data from four of the five subjects (excluding NM's data) are normalized to see if the embedded FI can be observed as a general property among these speakers, using a normalization method adopted in Truckenbrodt (2004). All the measured values are transformed according to the following linear transformation:

$$\text{transformed\_value} = (\text{original\_value} - \text{Av}_S(R_2))/(\text{Av}_S(R_1) - \text{Av}_S(R_2))$$

[6] This tendency of NM's data has been consistently observed for other experiments as well (cf. Ishihara 2003).

where $\mathrm{Av}_S(R_n)$ is the speaker-specific mean F_0-value of the two reference point R_1 and R_2. This formula rescales the mean of R_1 measurements to 1 and the mean of R_2 measurements to 0, for each speaker. The following two values are chosen as the reference points (R_1, R_2) for the normalization:

(7) *Reference points for the normalization formula*

R_1: Mean highest F_0-value of the embedded clause subject (P1 in (9)).

R_2: Mean lowest F_0-value of the phrase immediately following the embedded clause (i.e., L tone immediately after P3 in (9))[7]

Equipment The recorded data was digitized using SimpleSound on a Macintosh PowerBook G3. Segmentation and F_0 measurement was done using Praat (Boersma and Weenink 1992–2007) with the help of Praat scripts. After the half-automated measurement, I checked the data using Praat one by one to make sure that the measurements were done appropriately by the scripts. When some wrong measurement points were found, I modified them by hand and updated the results. Statistic data analysis was done using R.

3.3 Stimuli

In the experiment, I used the NPI *-sika*, which, together with negation, means 'only'. Three sentence types are compared in the experiment. Below is one of the eight stimulus sets used in the experiment. (See Appendix A for the complete stimulus sets). A is the control sentence with no NPI. B has an NPI and a negation in the embedded clause, while C has an NPI and a negation in the matrix clause.

[7] There are cases where the highest peak of the phrase is realized at the end of the phrase (i.e., on the PP/case-marker). In such a case, the lowest point before P3 is measured.

(8) A. *No NPI (Control)*

Náoya-wa [Mári-ga rámu-o nomíya-de nomá-**nakat**-ta to]
Naoya-TOP Mari-NOM rum-ACC bar-LOC drink-NEG-PST that
Yúmi-ni itta
Yumi-DAT said
'Naoya said to Yumi that Mari didn't drink rum at the bar.'

B. *NPI in the embedded clause*

Náoya-wa [Mári-**sika** rámu-o nomíya-de nomá-**nakat**-ta to]
Naoya-TOP Mári-SIKA rum-ACC bar-LOC drink-NEG-PST that
Yúmi-ni itta
Yumi-DAT said
'Naoya said to Yumi that only Mari drank rum at the bar.'

C. *NPI in the matrix clause*

Náoya-**sika** [Mári-ga rámu-o nomíya-de nónda to]
Náoya-SIKA Mari-NOM rum-ACC bar-LOC drank that
Yúmi-ni iwa-**nákat**-ta
Yumi-DAT say-NEG-PST
'Only Naoya said to Yumi that Mari drank rum at the bar.'

In order to check the three prosodic phenomena listed in (6), the F_0-peaks of the following three phrases in each stimulus sentence are measured. They are labeled P(eak)1, P2, and P3, respectively, as shown in (9) below. As mentioned in §2.3, there are two places where a pitch reset is realized: the embedded clause complementizer (C_1) or the phrase following it (YP). Therefore I decided to measure the F_0 of both words and used whichever higher as the value for P3.

(9) *Labels of the relevant F_0 peaks*

$[_{CP_2}$ Subj$_2$ $[_{CP_1}$ Subj$_1$ XP ... V_1-NEG C_1] YP V_2(-NEG)]
P1 P2 P3* P3

*Only when this peak is higher than that of YP.

P1: Embedded clause subject (Subj$_1$)

P2: Material immediately following the embedded clause subject (XP)

P3: The matrix phrase immediately following the embedded clause (YP) (Or the embedded clause Complementizer (C$_1$), if its F_0 is higher than YP)

The expected FIs in the stimuli in (8) is schematically illustrated in (10) ($\boxed{\text{Box}}$ indicates the F_0-rise, and underline indicates the F_0-downtrend). In the control stimulus A, no FI is expected. The pitch contour of this sentence would be a default pitch contour. B has an NPI-NEG pair in the embedded clause. Accordingly an FI is expected between the NPI-attached word, i.e., the embedded clause subject (Subj$_1$) and the embedded clause verbal complex (V-NEG). After the FI, F_0-downtrend effect should be cancelled by pitch reset. In C, an NPI-NEG pair is in the matrix clause. Therefore F_0-rise is expected on the matrix subject (Subj$_2$), and F_0-downtrend is expected until the end of the sentence.

(10) *Schematic representation of (8)*

				P1	P2		P3	
A.	$[_{CP_2}$	Subj$_2$	$[_{CP_1}$	Subj$_1$	XP … V$_1$-NEG	C$_1$]	YP V$_2$	]
B.	$[_{CP_2}$	Subj$_2$	$[_{CP_1}$	$\boxed{\text{Subj}_1}$-NPI	XP … V$_1$-NEG	C$_1$]	YP V$_2$	]
C.	$[_{CP_2}$	$\boxed{\text{Subj}_2}$-NPI	$[_{CP_1}$	Subj$_1$	XP … V$_1$	C$_1$]	YP V$_2$-NEG	]

3.4 Predictions

From (10), we can make predictions regarding the three peaks P1, P2, and P3.

P1 At P1 (embedded clause subject), we expect to observe a F_0-rise effect in B sentence, because in B an NPI is attached to this phrase. Also, we expect a post-focal F_0-downtrend in C sentence, because in C the matrix subject is attached an NPI and accordingly triggers an F_0-downtrend on the following phrases. As a result, P1 in B and C are expected to show difference in terms of F_0-height compared to the control stimulus A: B is higher than A (=(11a)), and C is lower than A (=(11b)).

(11) *Predictions for P1*

a. $A < B$ (due to F_0-rise in B)
b. $A > C$ (due to F_0-lowering in C)

P2 At P2, F_0-downtrend is expected both in B and C, because in both sentences, P2 follows the NPI-attached phrase. Accordingly, P2 in B and C is lower than that of the control sentence A, where no F_0-lowering is expected.

(12) *Predictions for P2*

a. $A > B$ (due to F_0-lowering in B)
b. $A > C$ (due to F_0-lowering in C)

P3 Lastly, at P3 we expect a pitch reset in B. According to the NPI-FI hypothesis in (3), the FI in B should be found only within the embedded clause. Therefore, the F_0-peak of the phrase after the embedded clause should exhibit a pitch reset. If that's the case, P3 should become as high as the control case, A.

In C, on the other hand, FI is expected in the matrix clause. Therefore the F_0-downtrend is expected to continue on P3. As a result, we predict that P3 is lower than that of A and B.

(13) *Predictions for P3*

a. $A = B$ (due to pitch reset in B)
b. $A > C$ (due to F_0-lowering in C)
c. $B > C$ (due to pitch reset in B and F_0-lowering in C)

4 Results

Figure 7 shows the normalized means of P1, P2, and P3, with 95% confidence interval. (See Appendix B for individual results.) As will be shown below, all the predictions are supported by the results.

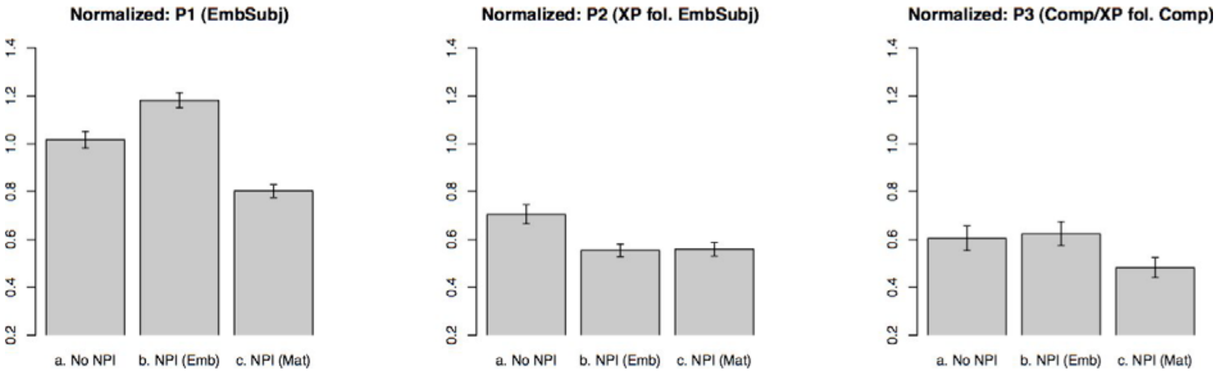


Figure 7: Normalized Means of P1, P2, and P3, with 95% CIs

4.1 P1

The predictions for P1 (11) are repeated below:

(11) *Predictions for P1*

a. A $<$ B (due to F_0-rise in B)

b. A $>$ C (due to F_0-lowering in C)

As we can see in Figure 7, the two predictions for P1 are borne out. B is significantly higher than A (1 sided t-test, t(190) = -6.9697, p $<$ 0.0001), and C is significantly lower than A (t(181.078) = 9.6701, p $<$ 0.0001). [8]

As for the individual results, the expected F_0-rise in B (i.e., (11a)) were observed in all subjects except one marginal result from KS (1-sided t-test, t(46)

[8] For the t-tests here and hereafter, the F test is done to check the variance of the two samples. If the two variances are not equal, Welch's correction is made on t-test.

$= -1.8067$, $p = 0.03868$).[9] From these results, we can conclude that the F_0-rise on the NPI-attached word is a quite steady phenomenon.

The F_0-lowering effect expected in C (i.e., (11b)) was statistically significant in three subjects' (AH, CS, YY), but not in KS's data (1-sided t-test, $t(38.671) = 0.7764$, $p = 0.2211$). In fact, KS did not show any F_0-lowering effect in P2 and P3, either. Given that KS's F_0-rise effect was also only marginally significant, it may be the case that she does not exploit FI for prosodic marking of NPI sentences. It will be shown later, however, that she uses a particular way of NPI-domain marking, namely strong 'upstep' after the negation.

All in all, the F_0-rise effect and F_0-lowering effect expected in P1 were both confirmed by the results (except KS's).

4.2 P2

The predictions for P2 (12) are repeated below:

(12) *Predictions for P2*

a. $A > B$ (due to F_0-lowering in B)
b. $A > C$ (due to F_0-lowering in C)

Again, both predictions are borne out in the normalized results, as shown in Figure 7. B and C are both significantly lower than A (A vs. B: 1 sided t-test, $t(160.981) = 6.2665$, $p < 0.0001$; A vs. C: 1 sided t-test, $t(171.153) = 5.853$, $p < 0.0001$).

Individually, KS did not show any clear sign of F_0-lowering effect, as mentioned above. Therefore neither of the contrasts in (12) are statistically significant in her results. The other three subjects (AH, CS, YY) showed statistically significant contrasts both for (12a) and (12b).

9 In fact, this contrast was also statistically significant in NM's result, which was excluded in the final analysis. This contrast, however, is the only significant contrast found in NM's data.

4.3 P3

The predictions for P3 (13) are repeated below:

(13) *Predictions for P3*

a. $A = B$ (due to pitch reset in B)

b. $A > C$ (due to F_0-lowering in C)

c. $B > C$ (due to pitch reset in B and F_0-lowering in C)

First of all, it is clear from Figure 7 that C is lower than A and B. The contrasts were both statistically significant in the normalized result (A vs. C: 1-sided t-test, t(182.464) = 3.6626, $p < 0.001$; B vs. C: 1-sided t-test, t(190) = 4.2952, $p < 0.0001$). This means that (13b) and (13c) were supported by the normalized data.

As for (13a), in order to check the equivalence of the mean F_0 of A and that of B, I used the Two One-Sided T-tests (TOST) method (Hönig and Heisey 2001; Berger and Hsu 1996). In this method, we will check whether the F_0-mean difference between A and B (d) will fall within the range of a certain equivalent threshold ($\pm\Theta$). Here I set the threshold as $\pm10\%$ of the mean F_0 of the control stimuli (A). This essentially means that if the mean difference between A and B (d) is within the range of -10% and $+10\%$ of the F_0-mean of A (i.e., $-\Theta < d < \Theta$), we will conclude that A and B are equivalent. This can be checked by running two one-sided t-tests, with the following null and alternative hypotheses:

(14) *Null / alternative hypotheses tested by TOST*

a. Test 1: $\mathscr{H}_0 : d \leq -\Theta$

$\mathscr{H}_A : -\Theta < d$

b. Test 2: $\mathscr{H}_0 : \Theta \leq d$

$\mathscr{H}_A : d < \Theta$

where

$$d = \mathrm{Mean(B)} - \mathrm{Mean(A)}$$
$$\Theta = \mathrm{Mean(A)} \times 0.1$$

As it turned out, although the null hypothesis of Test 1 was rejected as predicted ($t(96.444) = 2.6589$, $p < 0.01$), the null hypothesis of Test 2 was not ($t(96.444) = -1.3993$, $p = 0.08246$). Therefore our prediction (13a) was not fully confirmed from the normalized result.[10]

This result, however, seems to be due to one subject's result that has an extremely different tendency from the others. KS's result was different form the others in that B is significantly higher than A at P3 (see Appendix B.3). In other subjects' data (AH, CS[11], YY), there is no such big difference between A and B. In fact, the results of TOST show that A and B are the same in these speakers' data. Therefore, if we exclude KS's data on P3, we can conclude that A and B are actually the same. We will consider possible explanation for KS's unexpected result in the discussion section (§5).

As for the other subjects' data, AH and YY's results were basically parallel to that of normalized data, namely, A and B are at the same height (=(13a)), and C is significantly lower than A and B (=(13b), (13c)). Therefore these subjects' data basically confirms all the three predictions for P3.

CS's data did not show any significant contrasts among A, B, and C. This appears to contradict (13b) and (13c). However, it was a general tendency in CS's utterances that the pitch range is strongly narrowed down toward the end the utterance, so that all the expected contrasts (not only for this experiment, but also for other experiments, whose stimuli are inserted in the recordings as fillers)

10 If we set the threshold as $\pm 15\%$ of the F_0-mean of A, the both null hypotheses were both rejected. (Test 1: $t(98.248) = 3.6563$, $p < 0.001$; Test 2: $t(98.248) = -2.4026$, $p < 0.01$)

11 As mentioned below, CS's data did not show the contrasts expected at P3 (=(13b) and (13c)) either. Therefore the lack of difference between A and B in her data does not necessarily confirm their equivalence. See below.

were unable to detect. Given that, the lack of expected difference between C and the other two conditions is presumably due to an independent reason, most likely relatively strong declination effect, and hence would not necessarily falsify the predictions.

In sum, predictions for P3 was generally confirmed by the normalized as well as the individual results, except a couple of cases (KS's unexpected F_0-rise in B; the lack of contrast in CS's utterance).

5 Discussion

5.1 NPI-FI hypothesis

In the previous section, I presented the results of the experiment. The results generally confirmed the predictions for P1, P2, and P3. These predictions concern the prosodic phenomena listed in (6), repeated below, which are the indications of FI in NPI sentences.

(6) a. F_0-rise on NPI
  b. F_0-lowering on post-NPI material
  c. F_0-reset on post-negation material

Given that all these predictions are confirmed by the results, we can conclude that the NPI-FI hypothesis in (3) is supported by the result of this experiment. This means that NPI sentences exhibit an FI, just like *wh*-questions. This conclusion suggests that *wh*-questions and NPI sentences share the same kind of phonological process (or, in constraint-based terms, they are subject to the same sets of prosodic constraints).

This means that the results confirm the claim made by Deguchi and Kitagawa (2002) and Ishihara (2002, 2003) (cf. §2.1), which predicts a correlation between the scope of focus (in this case, the scope of negation that binds the

NPI) and the prosodic domain of the post-focal downtrend. A pitch reset was consistently observed when the NPI and the negation appear in the embedded clause, while such a reset is absent if they appear in the matrix clause. On the other hand, Hirotani's (2005) SPC analysis, which does not predict the one-to-one correlation between prosodic phrasing and semantic scope, would require an additional explanation for the consistence correlation found in the experiment presented here.

5.2 XP-type and Comp-type Pitch Reset

As mentioned in §2.3, I used two different measurement points for P3, assuming that there are two types of pitch reset, XP-type (P3 in (9), repeated below) and Comp-type (P3*).

(9) *Labels of the relevant F_0 peaks*

$[_{CP_2}$ Subj$_2$ $[_{CP_1}$ Subj$_1$ XP … V$_1$-NEG C$_1$] YP V$_2$(-NEG)]

P1 P2 P3* P3

The frequency of the use of Comp-type varies from subject to subject (AH: 80.6%; CS: 43.1%; KS: 40.3%; YY: 63.9%). If we compare the use of Comp-type according to the stimuli types, however, we find an interesting tendency common to all the subjects. That is, the Comp-type pitch reset is used more frequently in B, and less frequently in C, than A (see Table 1). CS's data did not show these contrasts, but this is not surprising given that her data generally do not show any significant contrast expected in P3, as mentioned in §4.3.

This fact suggests that when a pitch reset of an FI is expected, speakers tend to realize the high peak on the complementizer more frequently than in the cases where it is not expected. If we consider the Comp-type pitch reset as some kind of phrase-boundary tone, this tendency seems to make sense. Given that NPI-sentences trigger an FI and creates an FI domain between NPI-attached word

Subject	A	B	C	Total
AH	87.5	95.8	58.3	80.6
CS	41.7	45.8	41.7	43.1
KS	50.0	54.2	16.7	40.3
YY	62.5	83.3	45.8	63.9
Total	60.4	69.8	40.6	56.9

Table 1: Frequency of Comp-type Pitch Reset (%)

and NEG-attached verbal complex, pitch reset is realized as a boundary tone at the end of the FI-domain.

5.3 KS's unexpected contour on P3

We saw in §4.3 that KS's F_0-mean of P3 in B sentence is raised much higher than expected. This F_0-rise is of different kind from the focus F_0-rise, which was only marginally significant at P1 in her data. It seems also different from pitch reset, which is supposedly reset the pitch range to the original height, i.e., supposedly as high as the control stimulus A.

I tentatively suggest it is upstep (Truckenbrodt 2002). Caroline Féry (p.c.) pointed out that the amount of F_0-rise expected for pitch reset and that for upstep are predicted to be different. The pitch reset resets the pitch-range relative to the one set by the prominence of the previous domain (i.e., in (9), relative to the pitch range set by the NPI-attached phrase, Subj_1). Upstep, on the other hand, resets the pitch range relative to the topmost pitch range (i.e., relative to matrix subject, Subj_2).

It is plausible to consider that KS uses upstep, instead of F_0-lowering and pitch reset, after the embedded clause to mark the domain of NPI-NEG relation. Recall that KS did not show clear FI effects, especially in terms of F_0-lowering. Since she exploits no F_0-lowering to mark the domain of NPI-NEG relation, she indicates the end point by raising the F_0-peak at the end of the domain. Further research is needed to find out whether this F_0-rise is an upstep phenomenon, or how often such a pattern can be found in other speakers.

5.4 F_0-peak on the NEG-attached V-complex

Although we did not discuss at all in this paper, the F_0-realization of the verbal complex (which includes negation) could have been a point of discussion. It may be the case that the pitch reset takes place not after the negation, but on the negation. Unfortunately, however, the F_0 of the verbal complex was not systematically measured in this experiment. I had an impression during the measurement that this peak seems to be consistently raised to some extent. This means that negation might be outside the FI triggered by NPI. Since I did not measure this peak, no definite statement can be made regarding this F_0-peak. Therefore it is not clear whether the post-NPI F_0-lowering ends before this phrase or after it. I leave this question for future research.

6 Conclusion

In this paper, I presented the experimental results that shows the existence of FI in NPI sentences. The characteristic phonetic phenomena of FI, i.e., (i) F_0-rise on the focused phrase, (ii) post-focal F_0-downtrend, and (iii) pitch reset after the FI domain, are all attested in the data. This result indicates the parallelism between NPI sentences and *wh*-question, both of which exhibit FI to mark the semantic relation between the two elements (NPI-NEG for the former, *wh*-phrase and question particle for the latter).

Aside from the main concern of the paper, we also discussed two types of pitch reset realization, which we called XP-type and Comp-type, as well as a sharp F_0-rise used by one subject to mark the end of NPI-NEG domain, which I tentatively consider as an upstep phenomenon. The exact properties of these variations still need to be examined. I will leave this question for future research.

Appendix A Stimulus Sets

A.1 *Nomiya* set

(1A) Náoya-wa [Mári-ga rámu-o nomíya-de nomá-nakat-ta to] Yúmi-ni itta
Naoya-TOP Mari-NOM rum-ACC bar-LOC drink-NEG-PST that Yumi-DAT said
'Naoya said to Yumi that Mari didn't drink rum at the bar.'

(1B) Náoya-wa [Mári-**sika** rámu-o nomíya-de nomá-**nakat**-ta to] Yúmi-ni itta
Naoya-TOP Mári-SIKA rum-ACC bar-LOC drink-NEG-PST that Yumi-DAT said
'Naoya said to Yumi that only Mari drank rum at the bar.'

(1C) Náoya-**sika** [Mári-ga rámu-o nomíya-de nónda to] Yúmi-ni iwa-**nákat**-ta
Náoya-SIKA Mari-NOM rum-ACC bar-LOC drank that Yumi-DAT say-NEG-PST
'Only Naoya said to Yumi that Mari drank rum at the bar.'

A.2 Roommate set

(2A) Náoya-wa [Mári-ga Yúmi-o ruumuméito-ni erabá-nakat-ta to] Yúuzi-ni osieta
N.-TOP M.-NOM Y.-ACC roommate-DAT choose-NEG-PST that Yuji-DAT told
'Naoya told Yuji that Mari didn't choose Yumi as a roommate.'

(2B) Náoya-wa [Mári-**sika** Yúmi-o ruumuméito-ni erabá-**nakat**-ta to] Yúuzi-ni osieta
N.-TOP M.-SIKA Y.-ACC roommate-DAT choose-NEG-PST that Yuji-DAT told
'Naoya told Yuji that only Mari chose Yumi as a roommate.'

(2C) Náoya-**sika** [Mári-ga Yúmi-o ruumuméito-ni eránda to] Yúuzi-ni osie-**nákat**-ta
N.-SIKA M.-NOM Y.-ACC roommate-DAT chose that Yuji-DAT tell-NEG-PST
'Only Naoya told Yuji that Mari chose Yumi as a roommate.'

A.3 *Erimaki* set

(3A) Mári-wa [Yúmi-ga Náoya-ni erímaki-o amá-nakat-ta to] Yúuko-ni osieta
Mari-TOP Yumi-NOM Naoya-DAT scarf-ACC knit-NEG-PST that Yuko-DAT told
'Mari told Yuko that Yumi didn't knit a scarf for Naoya.'

(3B) Mári-wa [Yúmi-**sika** Náoya-ni erímaki-o amá-**nakat**-ta to] Yúuko-ni osieta
Mari-TOP Yumi-SIKA Naoya-DAT scarf-ACC knit-NEG-PST that Yuko-DAT told
'Mari told Yuko that only Yumi knitted a scarf for Naoya.'

(3C) Mári-**sika** [Yúmi-ga Náoya-ni erímaki-o ánda to] Yúuko-ni osie-**nákat**-ta
Mari-SIKA Yumi-NOM Naoya-DAT scarf-ACC knitted that Yuko-DAT tell-NEG-PST
'Only Mari told Yuko that Yumi knitted a scarf for Naoya.'

A.4 Boston set

(4A) áru razió-kyoku-ga [Bósuton-wa gógo áme-ga furá-nai to]
some radio-station-NOM Boston-TOP afternoon rain-NOM fall-NEG that
tenki-yóhoo-de tutaeta
weather-forecast-at reported
'Some weather forecast reported that it won't rain in Boston in the afternoon.'

(4B) áru razió-kyoku-ga [Bósuton-**sika** gógo áme-ga furá-**nai** to]
some radio-station-NOM Boston-SIKA afternoon rain-NOM fall-NEG that
tenki-yóhoo-de tutaeta
weather-forecast-at reported
'Some weather forecast reported that it will rain only in Boston in the afternoon.'

(4C) áru razió-kyoku-**sika** [Bósuton-wa gógo áme-ga fúru to]
some radio-station-SIKA Boston-TOP afternoon rain-NOM fall that
tenki-yóhoo-de tutae-**nákat**-ta
weather-forecast-at report-NEG-PST
'Only a certain weather forecast reported that it will rain in Boston in the afternoon.'

A.5 *Aisiteru* set

(5A) Yúmi-wa [Yúuzi-ga Yúuko-o áisite-nái to] Mári-ni itta
Yumi-TOP Yuji-NOM Yuko-ACC love-NEG that Mari-DAT told
'Yumi told Mari that Yuji doesn't love Yumi.'

(5B) Yúmi-wa [Yúuzi-**sika** Yúuko-o áisite-**nái** to] Mári-ni itta
Yumi-TOP Yuji-SIKA Yuko-ACC love-NEG that Mari-DAT told
'Yumi told Mari that only Yuji loves Yumi.'

(5C) Yúmi-**sika** [Yúuzi-ga Yúuko-o áisiteru to] Mári-ni iwa-**nákat**-ta
Yumi-SIKA Yuji-NOM Yuko-ACC love that Mari-DAT tell-NEG-PST
'Only Yumi told Mari that Yuji loves Yumi.'

A.6 *Maneita* set

(6A) Yúuzi-wa [Yúmi-ga Náoya-o ié-ni manéita to] Yúuko-ni morásita[12]
Yuji-TOP Yumi-NOM N.-ACC house-DAT invited that Yuko-DAT divulged
'Yuji divulged to Yuko that Yumi invited Naoya to her house.'

(6B) Yúuzi-wa [Yúmi-**sika** Náoya-o ié-ni maneká-**nakat**-ta to] Yúuko-ni
Yuji-TOP Yumi-SIKA N.-ACC house-DAT invite-NEG-PST that Yuko-DAT
morásita
divulged
'Only Yuji divulged to Yuko that Yumi invited Naoya to her house.'

(6C) Yúuzi-**sika** [Yúmi-ga Náoya-o ié-ni manéita to] Yúuko-ni morasá-**nakat**-ta
Yuji-SIKA Y.-NOM N.-ACC house-DAT invited that Yuko-DAT divulge-NEG-PST
'Only Yuji divulged to Yuko that Yumi invited Naoya to her house.'

A.7 *Ookina mi* set

(7A) Náoya-wa [Mári-no kí-ni óokina mi-ga nará-nakat-ta no]-o
Naoya-TOP Mari-GEN tree-LOC big fruit-NOM be.borne-NEG-PST NL -ACC
nobotte tasikámeta
by.climbing checked
'Naoya checked Mari's tree didn't bare a big fruit by climbing.'

(7B) Náoya-wa [Mári-no kí-ni-**sika** óokina mi-ga nará-**nakat**-ta no]-o
Naoya-TOP Mari-GEN tree-LOC-SIKA big fruit-NOM be.borne-NEG-PST NL -ACC
nobotte tasikámeta
by.climbing checked
'Naoya checked that only Mari's tree didn't bare a big fruit by climbing.'

(7C) Náoya-**sika** [Mári-no kí-ni óokina mi-ga natta no]-o nobotte
Naoya-TOP Mari-GEN tree-LOC big fruit-NOM was.borne NL -ACC by.climbing
tasikamé-**nakat**-ta
check-NEG-PST
'Only Naoya checked Mari's tree bore a big fruit by climbing it.'

[12] The embedded clause of this sentence is supposed to contain negation. The sentence is nevertheless not excluded from the analysis, since the verbal complex itself is not the target of the measurement.

A.8 *Nomo* set

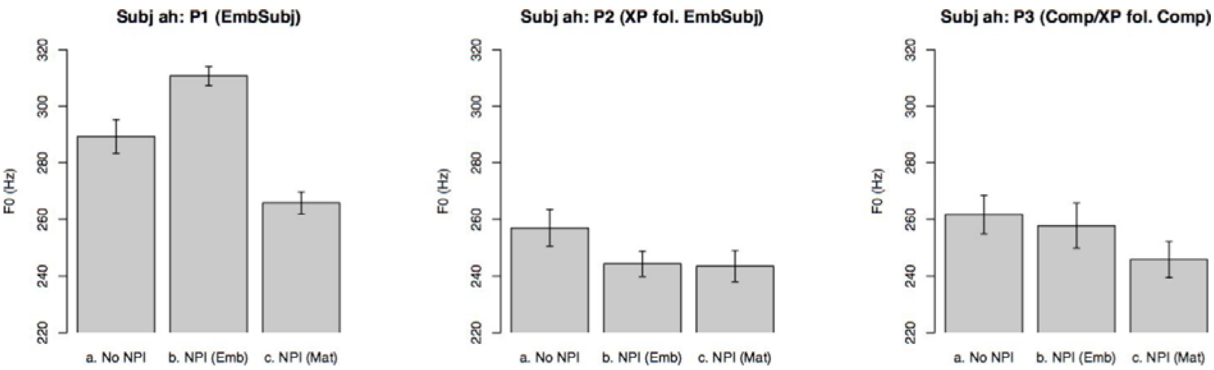
(8A) áru nyúusu-ga [Nómo-ga Mánii-ni nákkuru-o nagé-nakat-ta to]
some news-NOM Nomo-NOM Manny-DAT knuckleball-ACC pitch-NEG-PST that
óokiku hoozita
widely broadcasted
'Some news program widely broadcasted that Nomo didn't pitch a knuckleball to Manny.'

(8B) áru nyúusu-ga [Nómo-**sika** Mánii-ni nákkuru-o nagé-**nakat**-ta to]
some news-NOM Nomo-SIKA Manny-DAT knuckleball-ACC pitch-NEG-PST that
óokiku hoozita
widely broadcasted
'Some news program widely broadcasted that only Nomo pitched a knuckleball to Manny.'

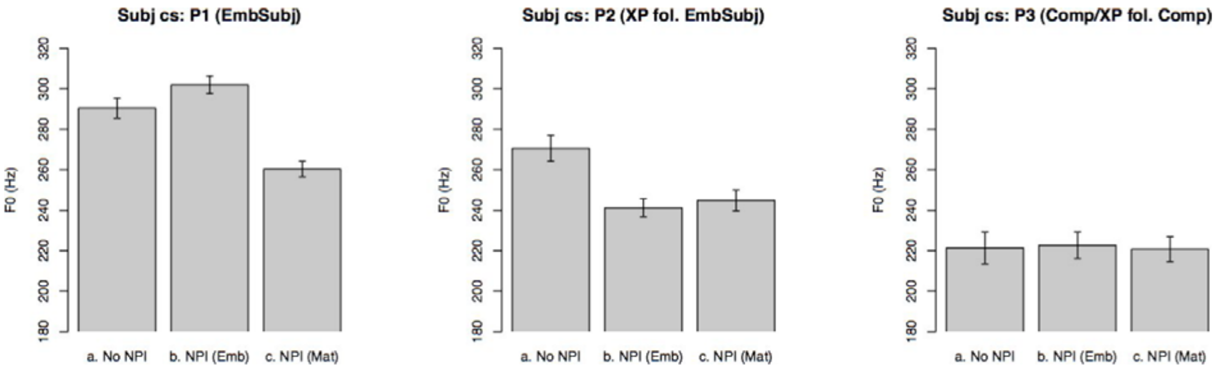
(8C) áru nyúusu-**sika** [Nómo-ga Mánii-ni nákkuru-o nágeta to] óokiku
some news-SIKA Nomo-NOM Manny-DAT knuckleball-ACC pitched that widely
hoozi-**nákat**-ta
broadcast-NEG-PST
'Only a certain news program widely broadcasted that Nomo pitched a knuckleball to Manny.'

Appendix B Individual Results

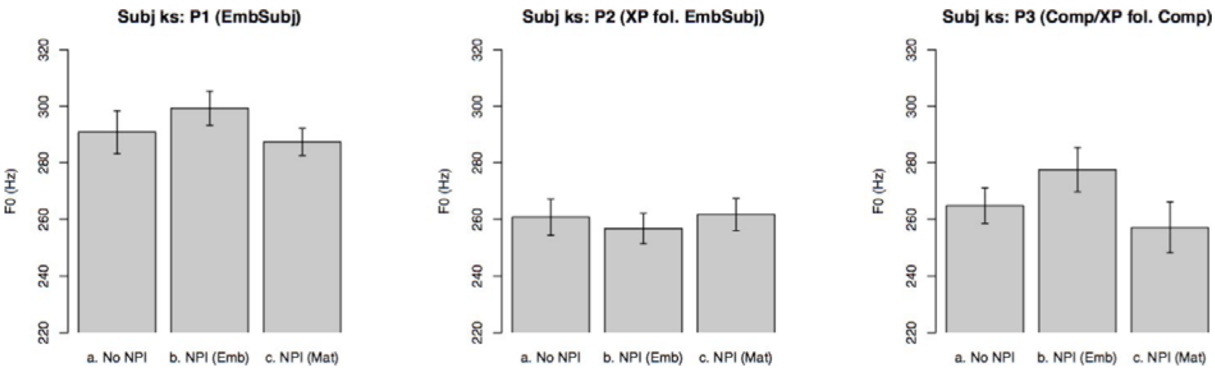
B.1 AH



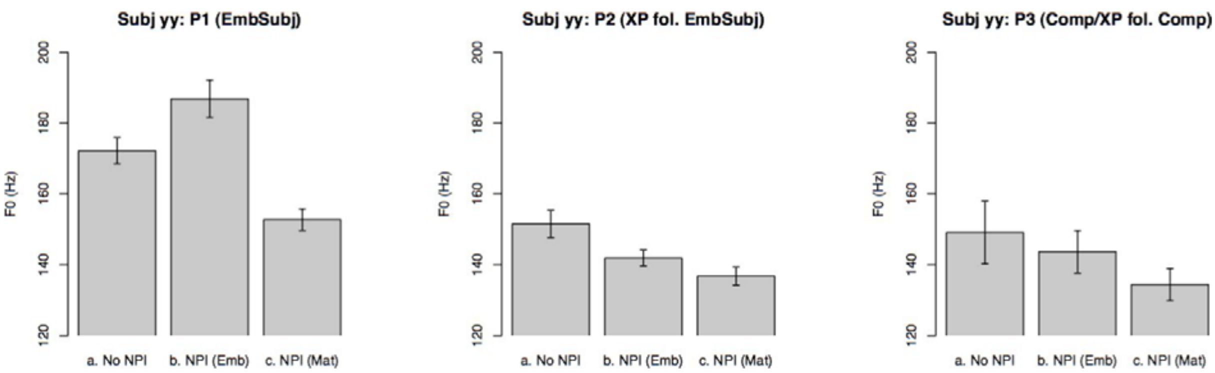
B.2 CS



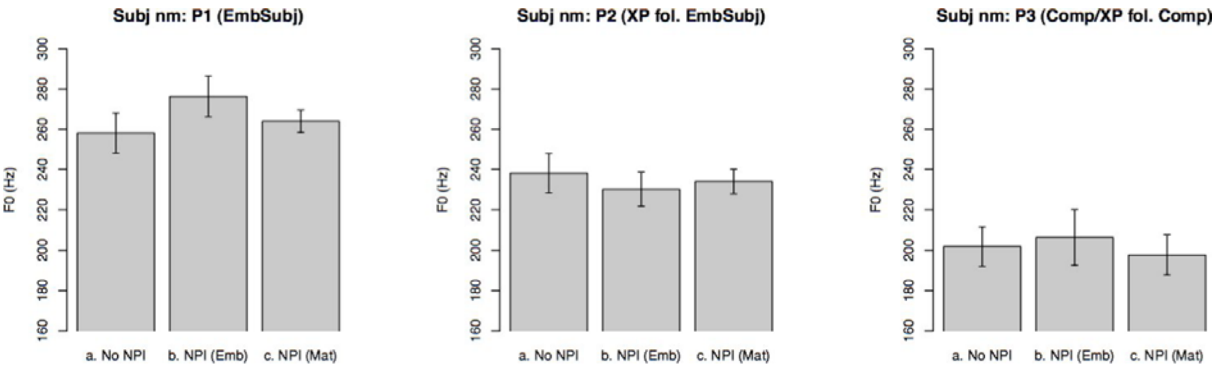
B.3 KS



B.4 YY



B.5 NM (NB: Excluded from the Normalization)



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