Pitch analysis workshop

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Voice Unit
Psychology Department
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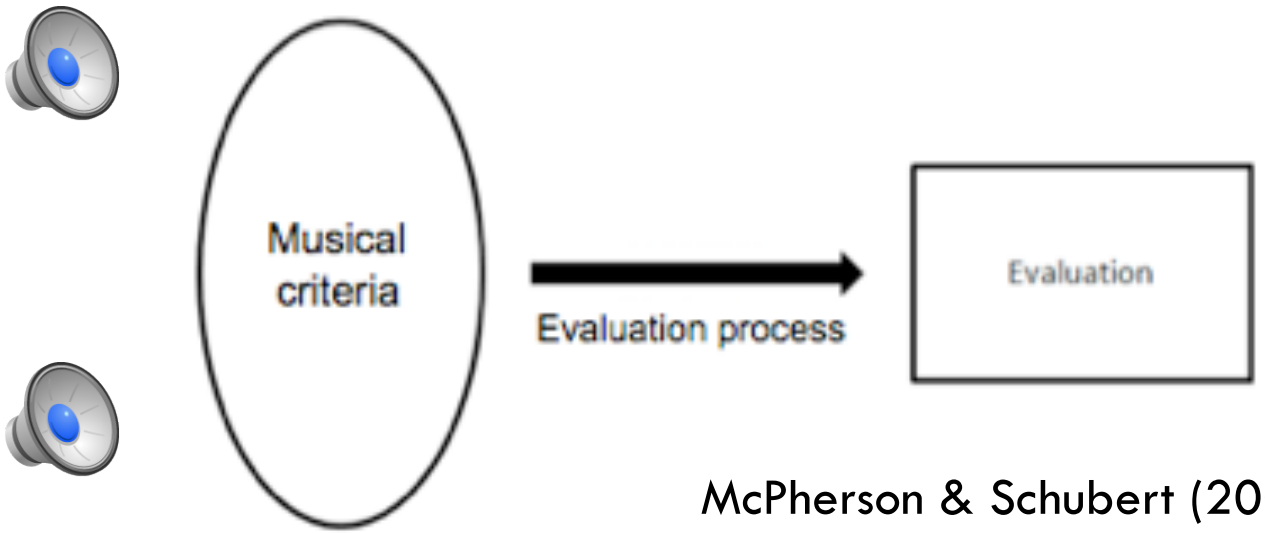
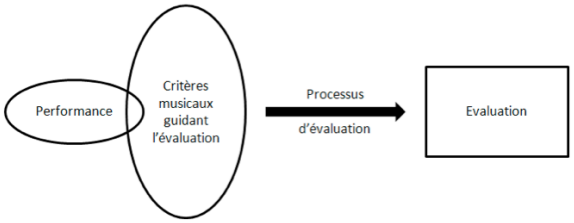
Is it in tune?



McPherson & Schubert (2004)



Is it in tune?

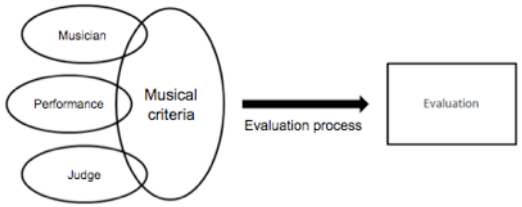
- Judges

  (e.g. Alcock, Passingham, Watkins, & Vargha-Khadem, 2000a; Alcock, Wade, Anslow, & Passingham, 2000b; Hébert, Racette, Gagnon, & Peretz, 2003; Kinsella, Prior, & Murray, 1988; Lévêque, Giovanni, & Schön, 2012; Prior, Kinsella, & Giese, 1990; Racette, Bard, & Peretz, 2006; Schön, Lorber, Spacal, & Semenza, 2004; Wise & Sloboda, 2008)

- But factors influencing the judges

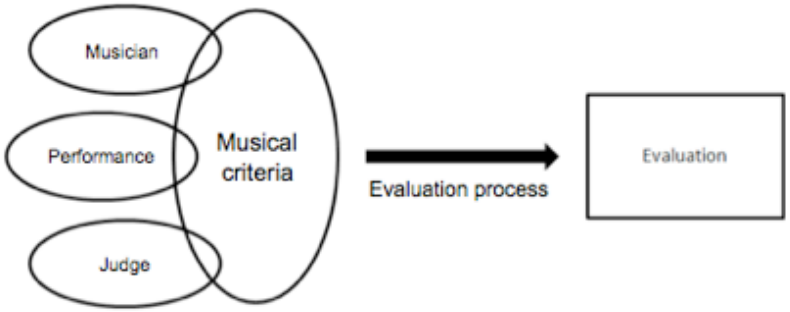
  (Godlovitch, 1998; Landy & Farr,1980; McPherson & Thompson, 1998)

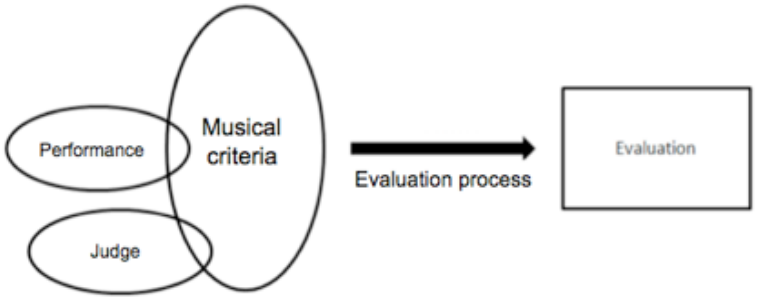
  - Musician (Behne & Wöllner, 2011; Davidson & Edgar, 2003; Elliott, 1996)
  - Behavior on stage (Howard, 2012; Juchniewicz, 2008; Kurosawa & Davidson, 2005; Wapnick et al., 1998, 2000)
  - Facial expressions (Livingstone, Thompson, & Russo, 2009)
  - Appearance / attractiveness (Ryan & Costa-Giomi, 2004; Wapnick, Darrow, Kovacs, & Dalrymple, 1997; Wapnick et al., 1998, 2000)
  - Attire (Griffiths, 2008, 2010; Wapnick et al., 2000)

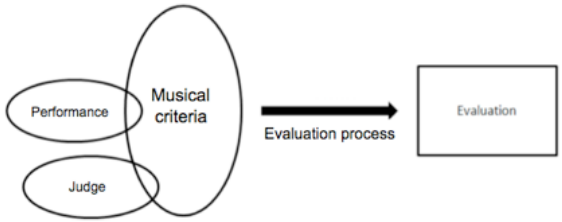


Is it in tune?

- Presentation of the music performance (i.e. visual and/or auditory) (Connell, Gay, & Holler, 2013, Howard, 2012; Thompson, Graham, & Russo, 2005; Thompson & Russo, 2007; Tsay, 2013)
- Context of the evaluation (Hash, 2013; Larrouy-Maestri & Morsomme, 2013; Sheldon, 1994)



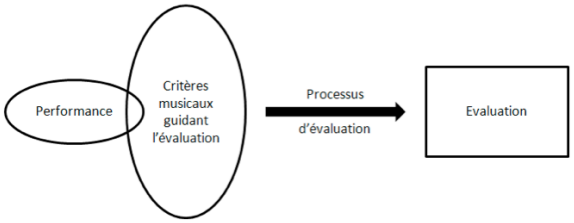




Is it in tune?

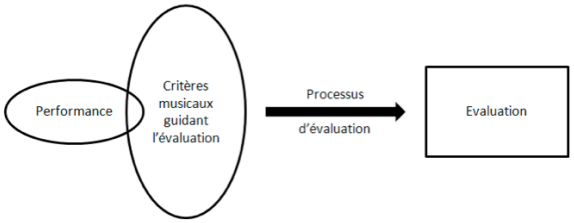
- If recordings
  - Gender of the judge (Wapnick et al., 1997)
  - Musical preferences (Glejser & Heyndel, 2001)
  - Familiarity (Kinney, 2009)
  - Judges' expectations (Cavitt, 1997; Duerksen, 1972; Larrouy-Maestri & Morsomme, 2013)
  - Expertise (e.g. Hutchins, Roquet, & Peretz, 2012; Larrouy-Maestri, Roig-Sanchis, & Morsomme, 2013)
  - Tempo and length (Wapnick, Ryan Campbell, Deek, Lemire, & Darrow, 2005)
  - Size of intervals (Russo & Thompson, 2005; Vurma & Ross, 2006)
  - Timbre (Hutchins et al., 2012)

➔ **Computer-assisted method**



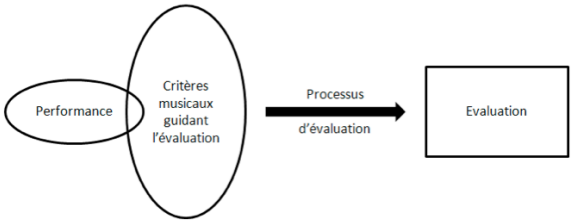
Is it in tune?

- Computer-assisted method
  - Not new
    - Singing Assessment and Development (SINGAD) (Howard & Welch, 1989)
    - Elmer and Elmer's method (2000)
  - Seems preferred (Dalla Bella, Berkowska, & Sowinski, 2011)
- Objectives
  - Possible causes of "poor pitch singing" (for reviews, see Hutchins & Peretz, 2012; Pfordresher et al., 2007)
  - Singing proficiency in the general population or singers profile (Dalla Bella & Berkowska, 2009; Dalla Bella, Giguère, & Peretz, 2007; Pfordresher & Brown, 2007; Pfordresher, Brown, Meier, Belyk, & Liotti, 2010)



Is it in tune?

- Tasks
  - Pitch-matching
    - Complex tones (Amir, Amir, & Kishon-Rabin, 2003; Hutchins & Peretz, 2012; Moore, Keaton, & Watts, 2007; Nikjeh, Lister, & Frisch, 2009; Pfordresher & Brown, 2007, 2009; Pfordresher et al., 2010)
    - Voice of the participant (Hutchins & Peretz, 2012; Hutchins, Larrouy-Maestri, & Peretz, in press; Moore et al., 2008; Pfordresher & Mantell, 2014)
  - Melodic sequences (Granot et al., 2013; Pfordresher & Brown, 2007, 2009; Pfordresher et al., 2010)
  - Full melodies (Dalla Bella et al., 2007, 2009; Hutchins et al., in press; Larrouy-Maestri et al., 2013a, 2014; Pfordresher et al., 2010)
- Procedure (manual or automatic)
- Tools
  - Praat
  - Yin (+ matlab)
  - Melodyne
  - Ircam's tools (Paris, France)



Is it in tune?

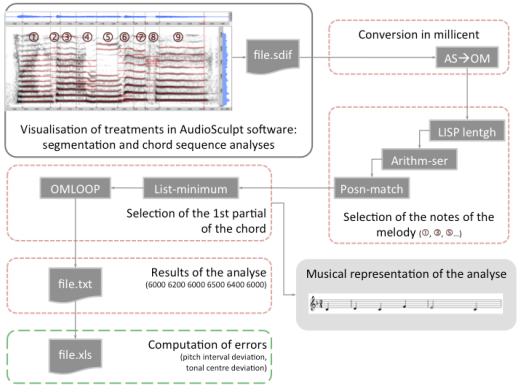
- If pitch-matching
  - Tone performed compared to the target tone: absolute pitch
  - Deviation calculated relatively to equal temperament
- If melodic sequences
  - Like for the pitch-matching task
  - Intervals performed compared to intervals expected: relative pitch
  - Both (Berkowska & Dalla Bella, 2013; Dalla Bella et al., 2007; Granot et al., 2013; Pfordresher et al., 2010)
- If full melodies
  - Like for pitch-matching and melodic sequences
  - Pitch stability (Dalla Bella et al., 2007)
  - Tonal deviation (Larrouy-Maestri & Morsomme, 2013, 2014)
  - Number of modulations (Larrouy-Maestri et al., 2013)

Three steps

Three steps

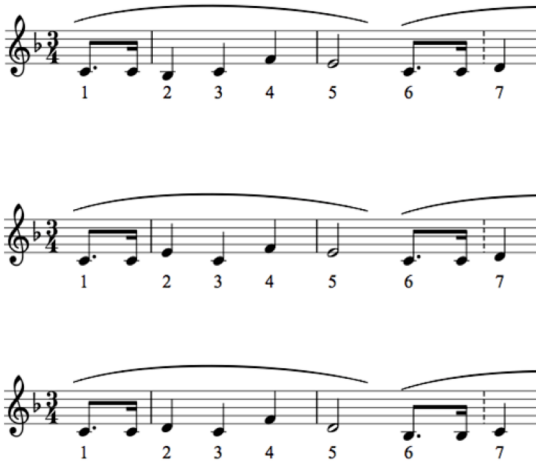
Manual segmentation

AudioSculpt (Ircam)



F0 information

AudioSculpt and OpenMusic (Ircam)



Quantification of errors

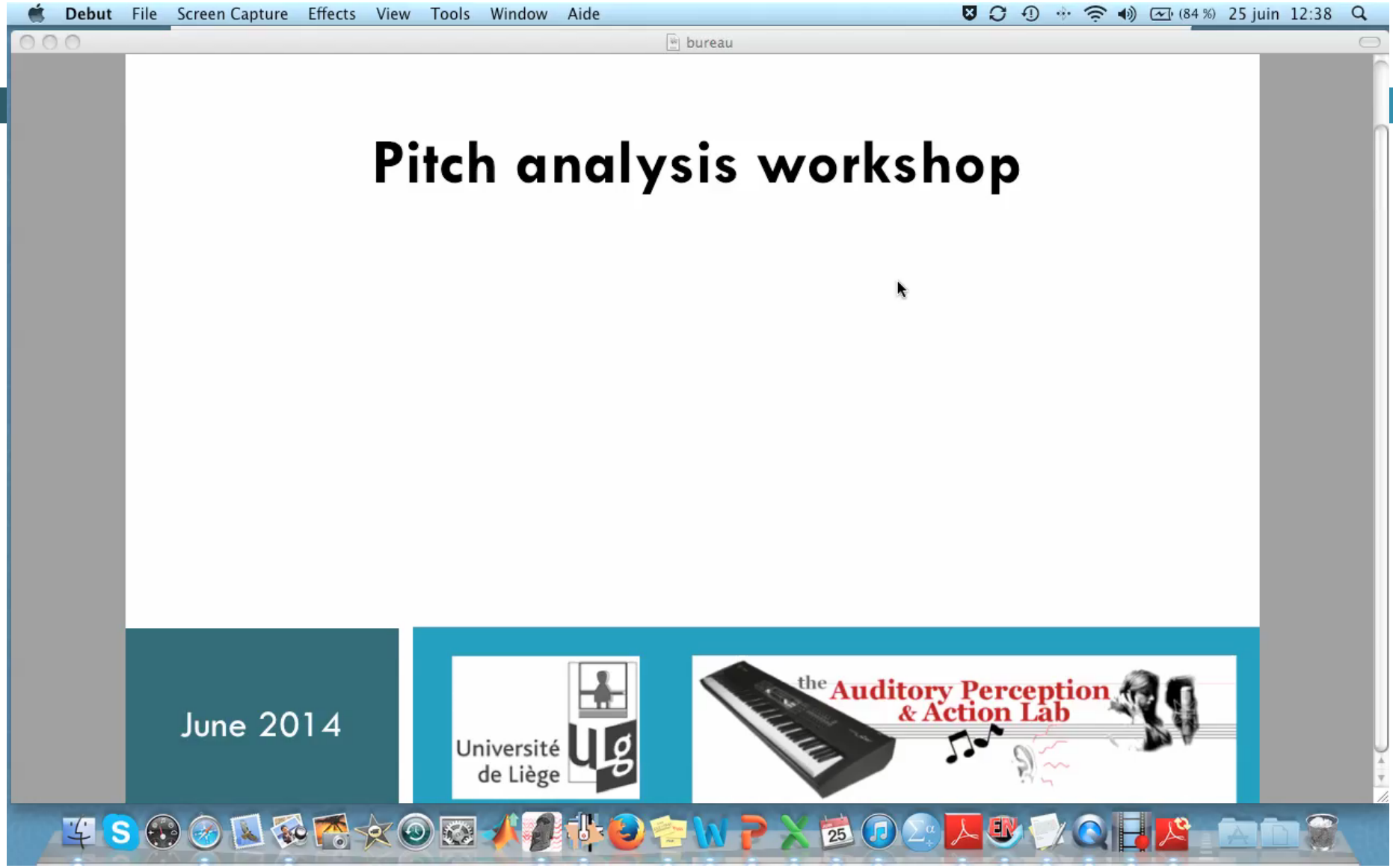
Excel (Microsoft)

Larrouy-Maestri, P., & Morsomme, D. (2014). Criteria and tools for objectively analysing the vocal accuracy of a popular song. *Logopedics Phoniatrics Vocology*.

Step 1 – Segmentation + analysis

AudioSculpt (Ircam, Paris, France)

Step 1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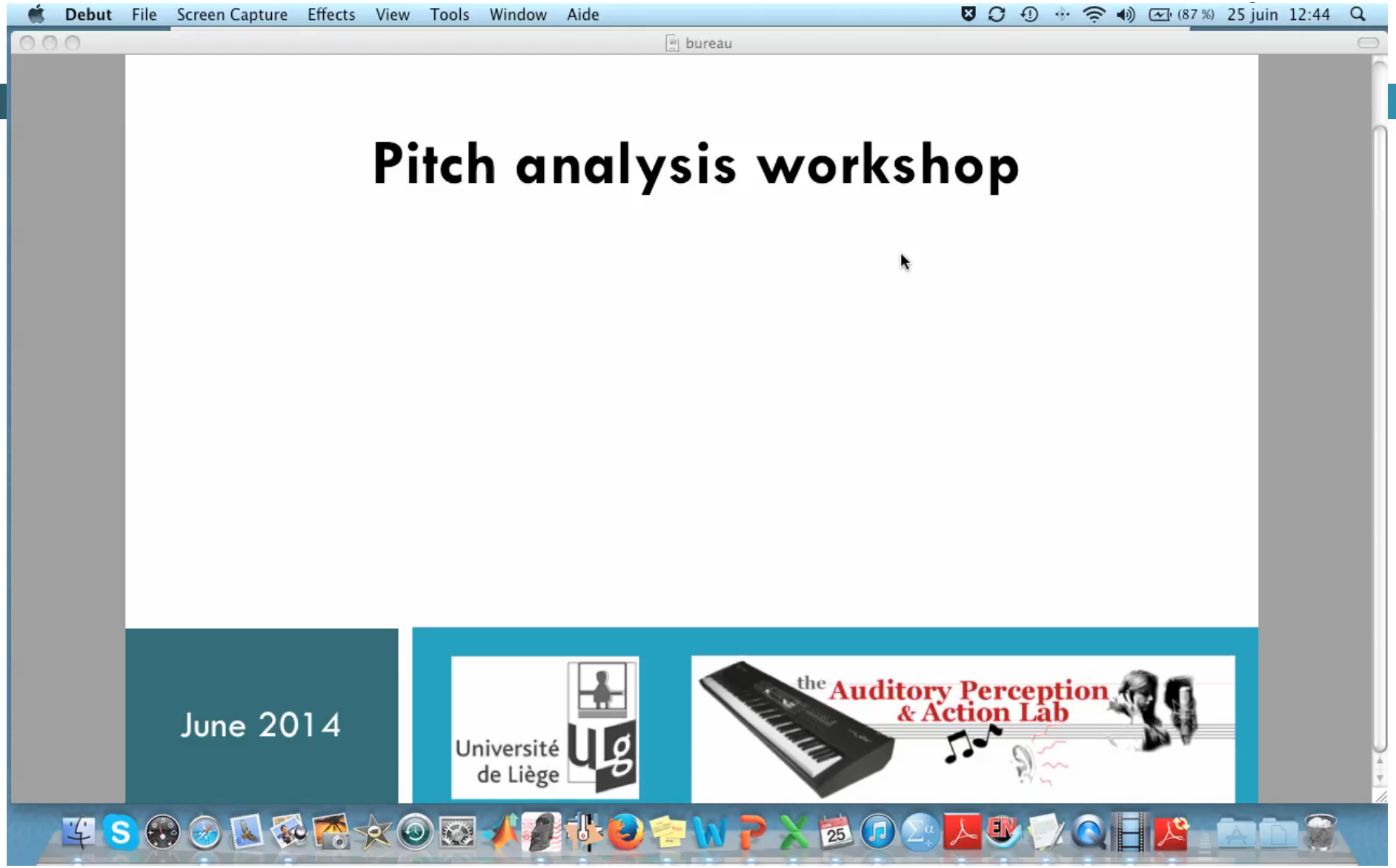
Step 1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Step 1
Procedure

- Open file
- Sonogram + F0 (FFT)
- Markers to select each note (visual and audio cues)
  - Vowels
    - essential acoustic information about the pitch
    - mark the beginning of a musical sound

      (Sundberg & Bauer-Huppmann, 2007)
  - Comparison analyzes with different segmentation strategies (with or without attacks and links between notes) (Pfordresher & Brown, 2007)
    - strong correlation (r> .99)
- Chord sequence analysis
- Save analysis

Step 1
Discussion

- Advantages
  - Masking noise if necessary
  - Adaptation of analysis parameters
  - Whatever the instrument and the piece
- Why not automatically?
  - Automation requires a good quality of the signal
    - Presence of silence or alteration of the sound within tones can lead to a segmentation of the signal
    - A tone with unstable F0 could be considered as two separate elements
  - Complicated for melodic context
    - No silence between the tones
    - Not always a consonant
  - Not so time consuming and avoids segmentation errors

Step 1
Alternatives

- Several possibilities to extract F0

  (for reviews, see Gomez, Klapuri, & Meudic, 2003)

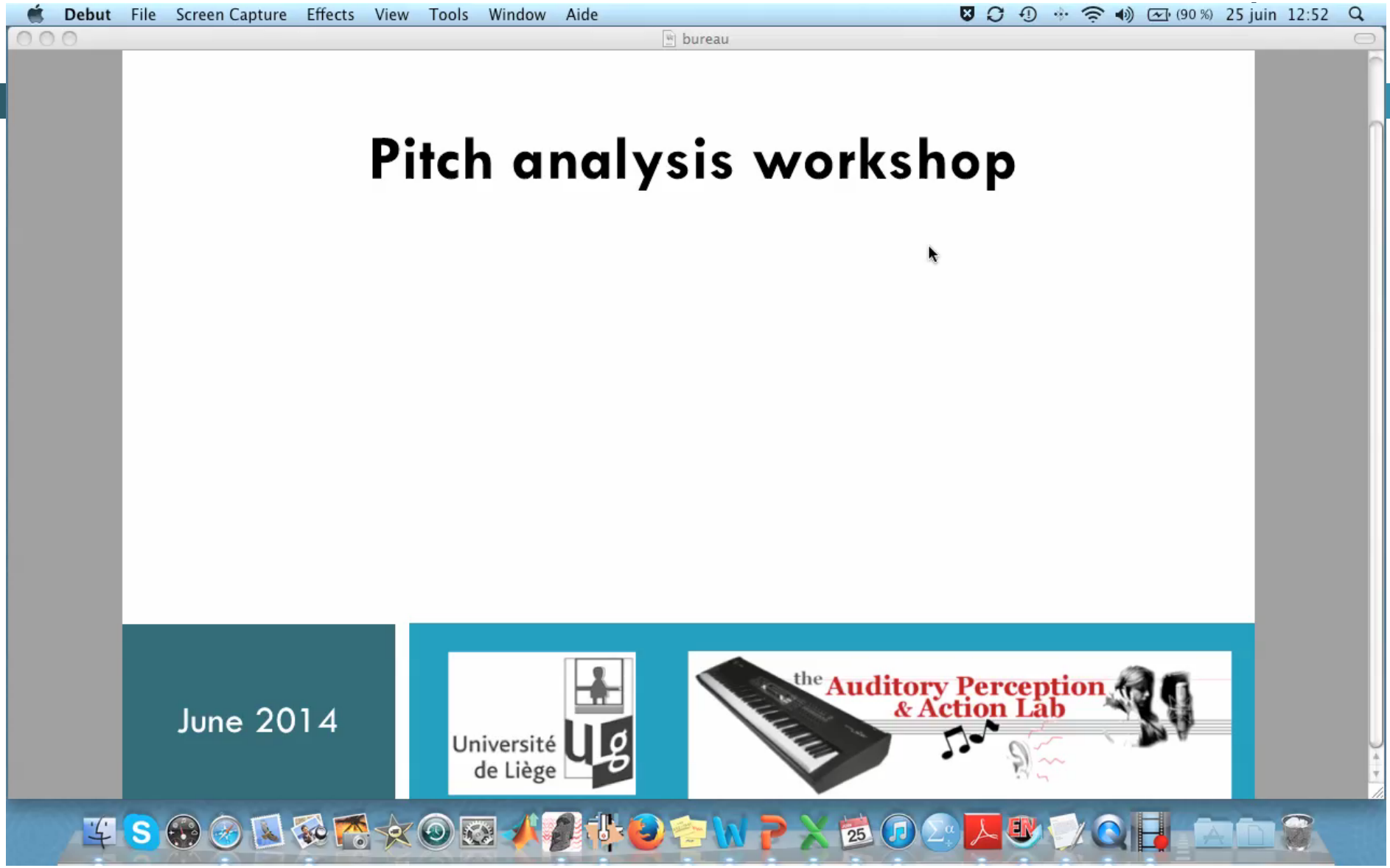
  - Three main groups of algorithms (workshop Bing-Yi)
  - Favor the time information, the spectral information, or both

- Analytical tools
  - Melodyne
    - Can choose “melodic”, “percussive” or “polyphonic”
    - Quid of the difference
  - Praat
    - Autocorrelation method seems preferable for vocal analysis (Boersma, 1993)
    - Mostly used but many octave errors
  - Yin algorithm
    - Improved version of the autocorrelation method (De Cheveigné & Kamahara, 2002)
    - Used by Hutchins & Peretz (2012), Hutchins, Larrouy-Maestri, & Peretz (in press)
  - Recent comparison of Praat and Yin
    - Perhaps a preference for Yin (less octave errors)

Step 2 – Treatment

OpenMusic (Ircam, Paris, France)

Step 2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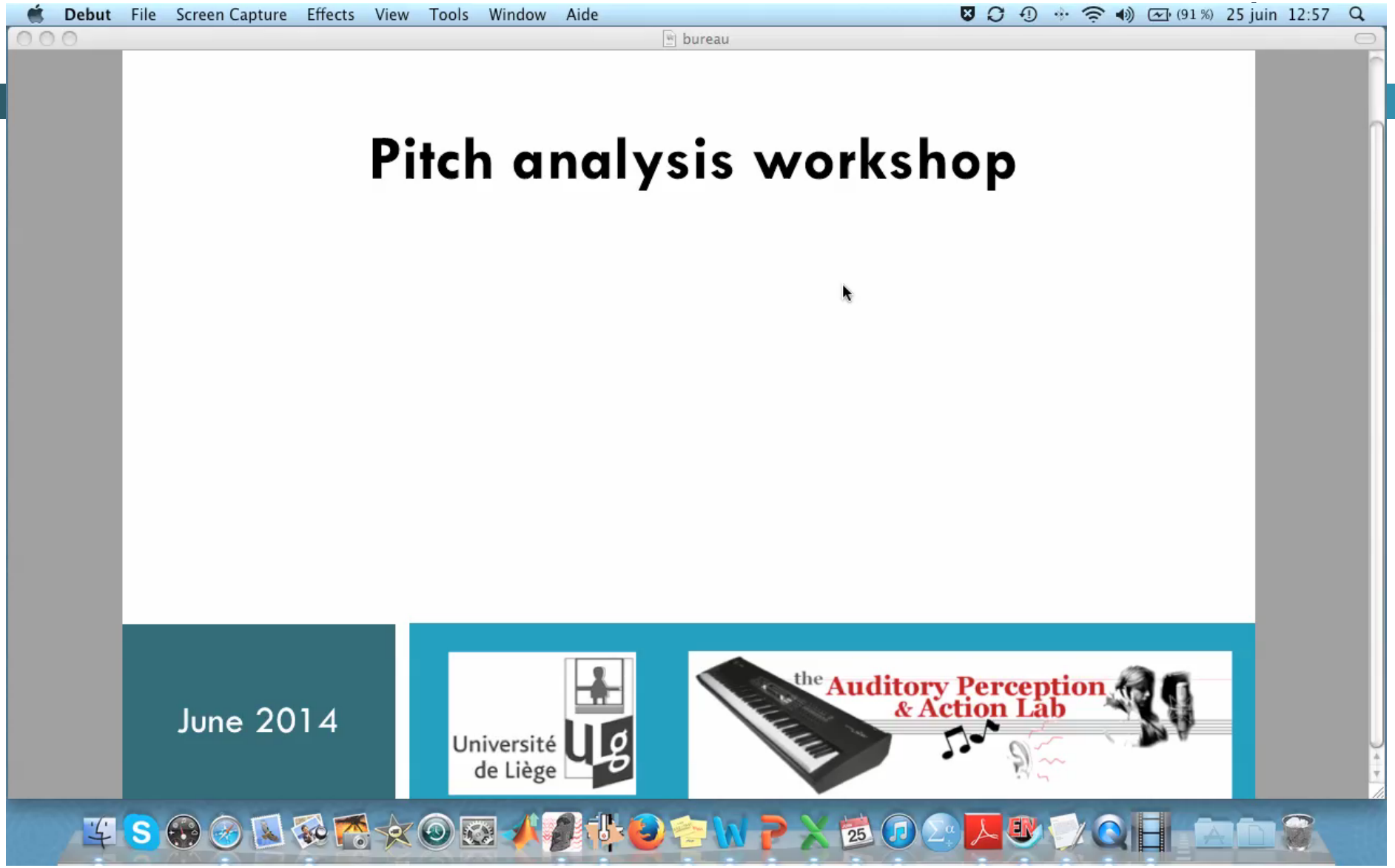
Step 2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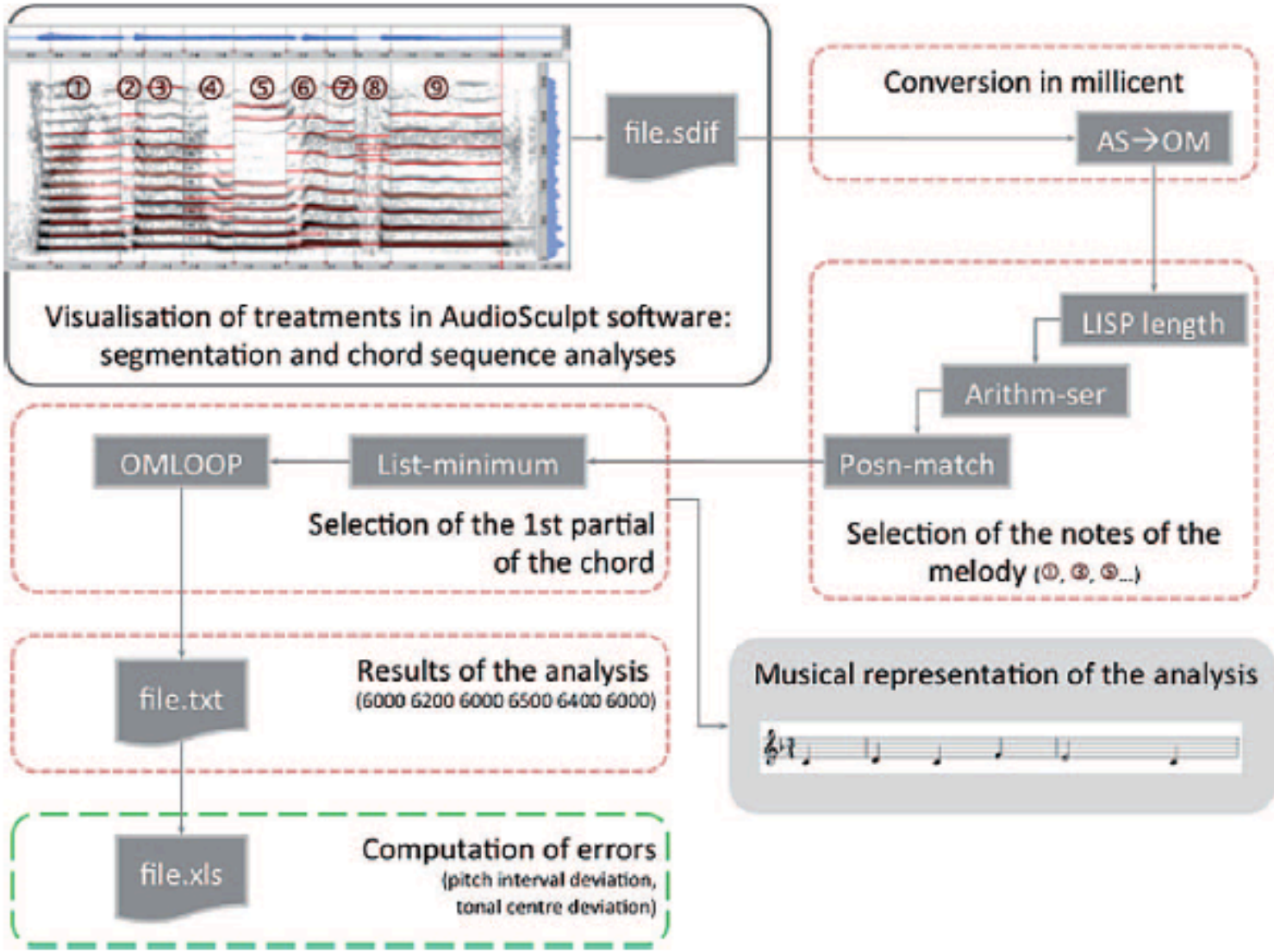
Step 2
Procedure



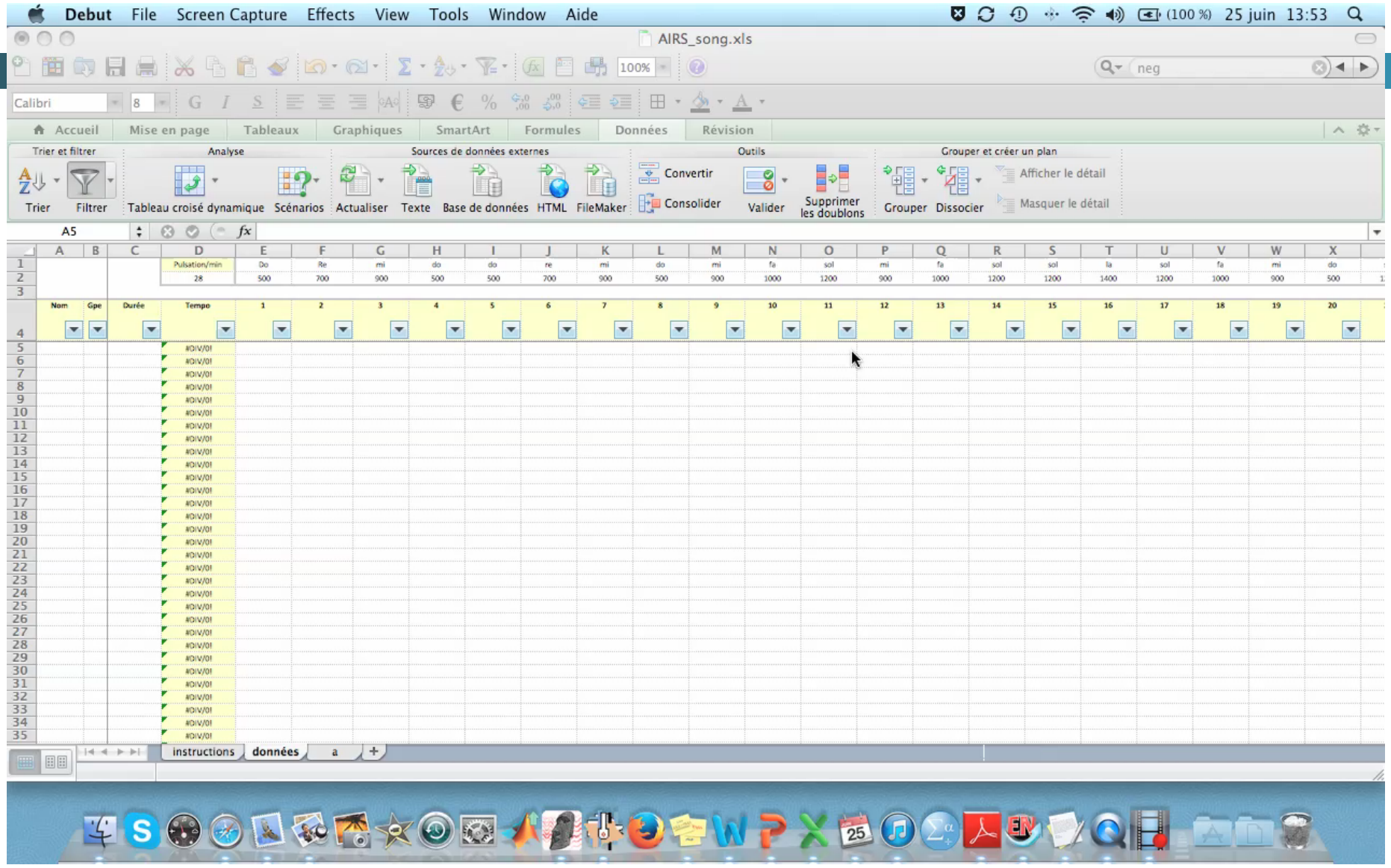
Step 2
Discussion

- Advantages
  - Adaptative
  - Automatic
  - Whatever the instrument and the piece
  - Possibility to visualize the results as text.file or on a musical score
- But
  - Experimental end sensitive material
  - Not free
  - Only on macintosh
  - Necessity of programing skills

Step 3 – Computation of errors

Excel (Microsoft)

Step 3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Analyse
Sources de données externes
Outils
Grouper et créer un plan
Trier
Filtrer
Tableau croisé dynamique
Scénarios
Actualiser
Texte
Base de données
HTML
FileMaker
Convertir
Consolider
Valider
Supprimer les doublons
Grouper
Dissocier
Afficher le détail
Masquer le détail
instructions
données
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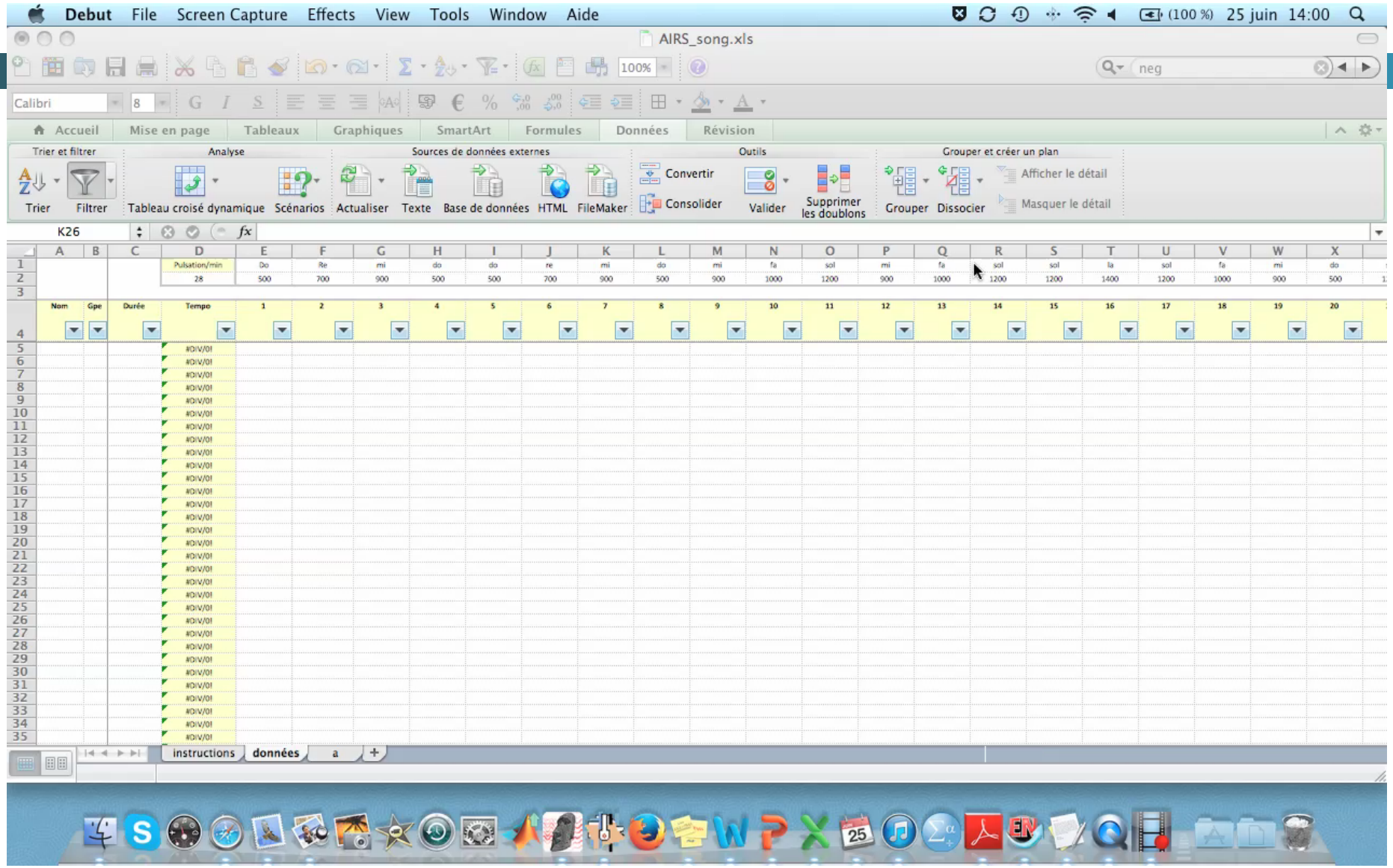
Step 3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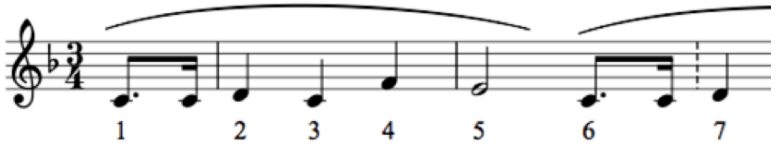
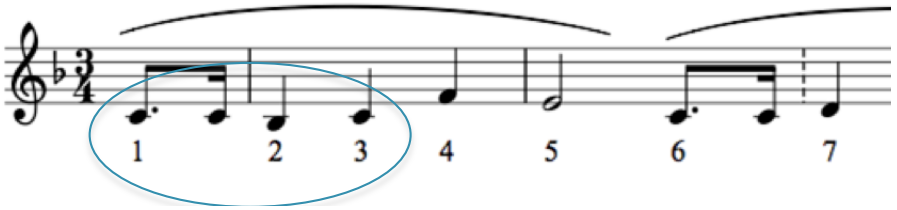
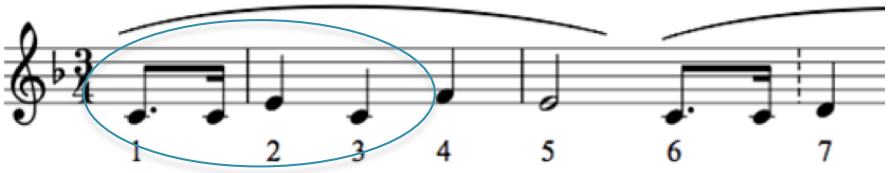
Step 3
Musical criteria



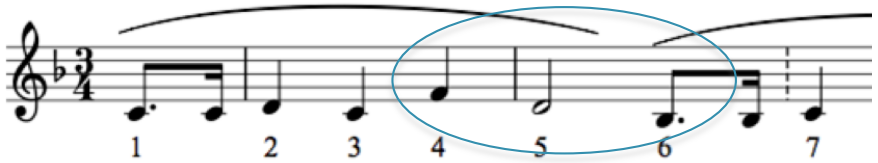
Contour error



Interval deviation



Modulation



Step 3
Procedure

- Insert reference in cents for each note
- Import text file
- Computation of errors
  - Contour error
    - Detect wrong direction of an interval
  - Interval precision
    - Compute the average difference between expected/performed intervals
  - Respect of tonal center
    - Same but intervals between « important » tones
  - Number of modulations
    - Interval deviation of more than a semitone (100 cents)
    - Not compensated

Step 3
Example

- Example of « important » tones

		0	0	-700	-700	0	0	0
Nom	Gpe	|5-1|	|12-9|	|20-15|	|26-21|	|29-27|	|32-30|	|32-1|
man		70	64	104	164	64	60	364
woman		10	6	28	36	22	10	30

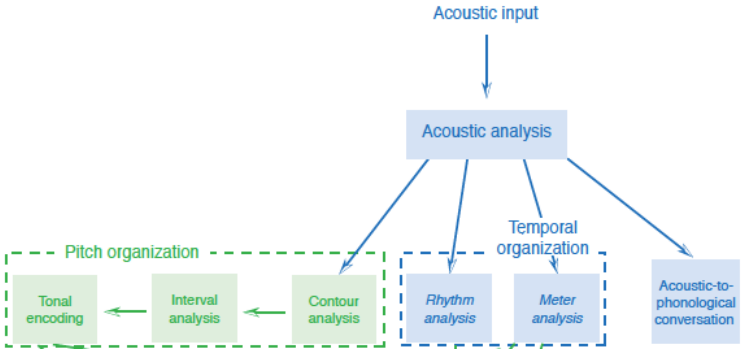
- Average of the tonal center deviations
  - Man = 100.5 cents
  - Woman = 20 cents

Choice of the musical errors

Choice of the musical errors

- Young age
  - Categorisation of contour errors:10 months (Ferland & Mendelson, 1989)
  - Discrimination of tonality and intervals (Hannon & Trainor, 2007; Gooding & Stanley, 2001; Plantinga & Trainor, 2005; Stalinski et al., 2008)
- Errors perceived by adults

  (Dowling & Fujitani, 1970; Edworthy, 1985; Stalinski et al., 2008; Trainor & Trehub, 1992)



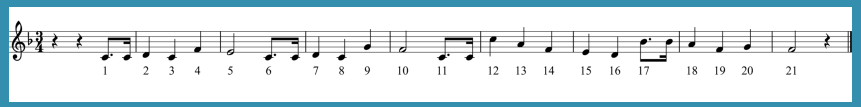
Peretz & Cortheart (2003)

- Particularly by musicians

  (Hutchins & Peretz, 2012; Hutchins et al., 2012; Micheyl et al., 2006; Russo & Thompson, 2005; Terviniami et al., 2005)

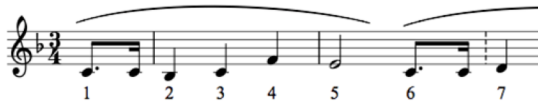
Choice of the musical errors

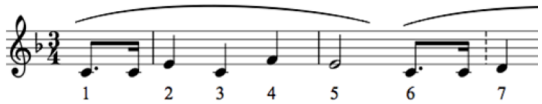
166 sung performances

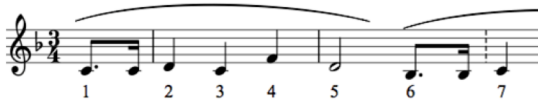


http://sldr.org/sldr000774/en

Acoustic analyses







18 Musicians

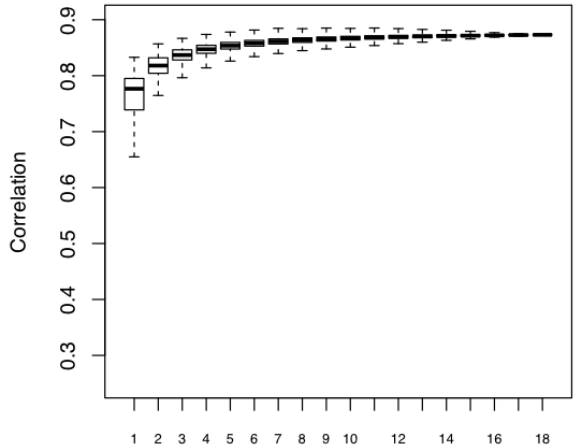
1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9

Out of tune — In tune

Choice of the musical errors

- 81% of the variance explained
  - $F(3,165) = 231.51$; $p < .01$
  - Pitch interval deviation: $\beta = 0.51$; $p < .001$
  - Respect of the tonality: $\beta = 0.45$; $p < .001$
- Precise definition among the expert judges
  - Mean judges' correlation:

    $r = .77$, $p < .01$



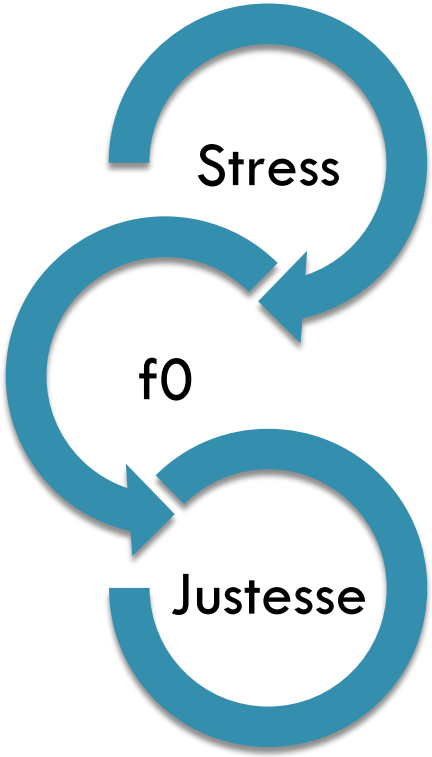
➔ **Perception of pitch accuracy based on two criteria**

Larrouy-Maestri, P., Lévêque, Y., Schön, D., Giovanni, A., & Morsomme, D. (2013). The evaluation of singing voice accuracy: A comparison between subjective and objective methods. *Journal of Voice*.

Choice of the musical errors

Effects of stress on interval deviation and tonality?

Bermudez et al. (2012)
Giddens et al. (2013)
Scherer et al. (1977)

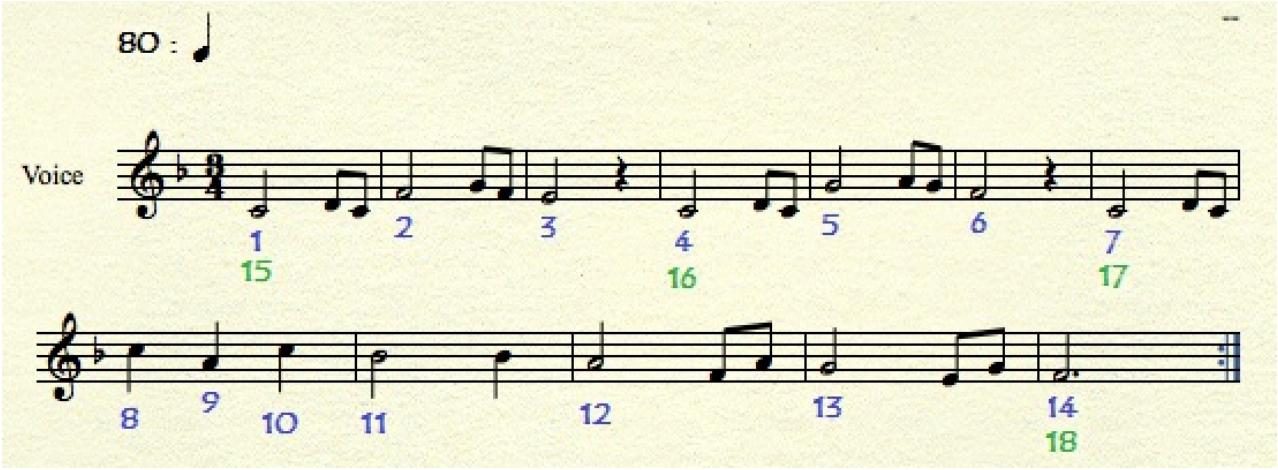


Craske & Craig (1984)
Hamann & Sobaje (1983)
Kenny (2011)
Yoshie et al. (2008, 2009)

?

Choice of the musical errors

- 31 students of conservatory
  - 2 levels
    - 1st year: 18 students
    - 2nd year: 13 students



Learning | Trial | Examination | Quiet situation

Choice of the musical errors

- Stress measurement
  - Heart rate
  - Competitive State Anxiety Inventory – 2 Revised (CSAI-2R) (Cox et al., 2003; Martinent et al., 2010)
    - Intensity of somatic and cognitive symptoms
    - Direction of symptoms (positive or debilitative)
- Singing voice evaluation
  - Interval deviation
  - Respect of tonal center

Choice of the musical errors

- Higher stress level for everybody
- Same increasement of stress
  - Except for the direction of somatic symptoms (much more negative for the 2nd year students)
- Contracted effects of stress on vocal accuracy

	1st level	2nd level
Interval precision	+	ns
Respect of tonal center	ns	-

➔ **Different evolution of the musical errors**

Larrouy-Maestri, P, & Morsomme, D. (2014). The effects of stress on singing voice accuracy. *Journal of Voice*.

Why not (only) pitch matching?

Why not (only) pitch matching?

Pitch-matching

(Amir et al., 2003 ; Granot et al., in press ; Hutchins & Peretz, 2012 ; Moore et al., 2007, 2008 ; Nikjeh et al., 2009 ; Pfordresher & Brown, 2007, 2009 ; Pfordresher et al., 2010 ; Watts et al., 2005)

Most used

Melodie

(Dalla Bella & Berkowska, 2009 ; Dalla Bella et al., 2007 ; Larrouy-Maestri et al., 2013, 2014; Wise & Sloboda, 2008)

Ecological but time consuming

Same information ?

Why not (only) pitch matching?

- 22 non musicians
- Recording of five different tones for each participant
- Three tasks
  - Full melody
    - Happy Birthday
    - Analysed according to Larrouy-Maestri & Morsomme (2014)
  - Vocal pitch-matching
  - Instrumental pitch-maching

Why not (only) pitch matching?

- Comparison slider and full melody
  - Interval deviation and tonal center: ns
- Comparison vocal pitch-matching and full melody
  - Interval deviation: $r(20) = .48$, $p = .02$
  - Tonal center: ns

➔ **Vocal pitch-matching provides indication**

➔ **But should not replace full melodic performance**

Hutchins, S., Larrouy-Maestri, P., & Peretz, I. (in press). Singing ability is rooted in vocal-motor control of pitch. *Attention, Perception & Psychophysics.*

Between in tune and out of tune

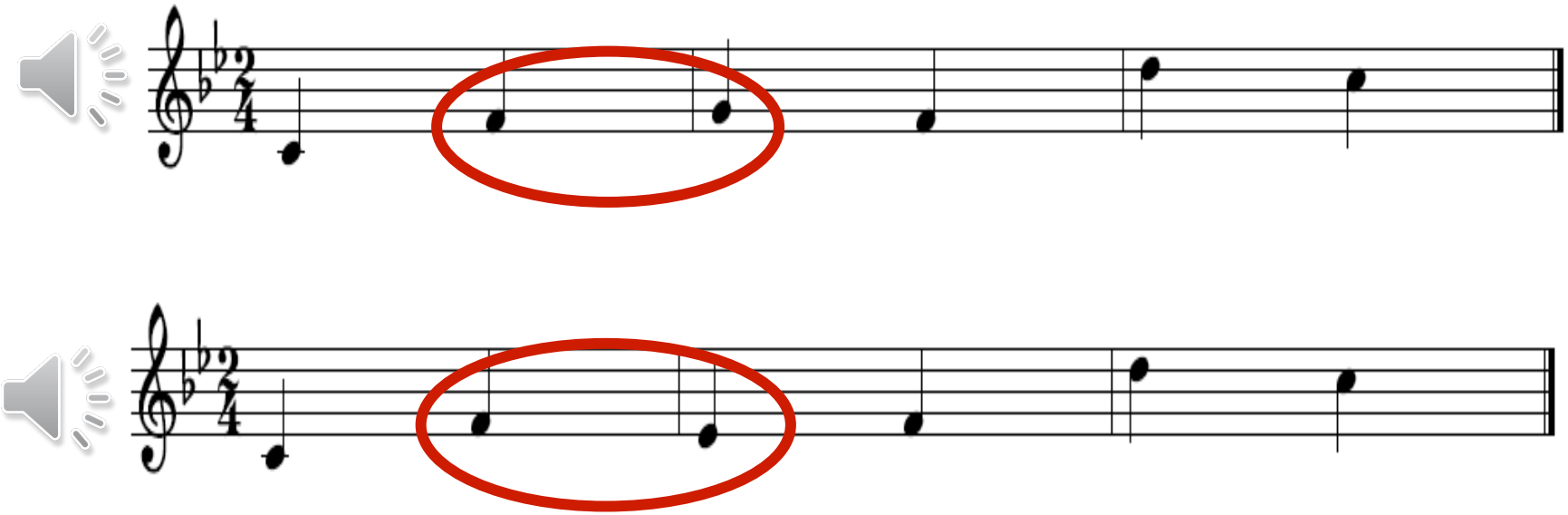
For now

- Pitch discrimination
  - http://www.musicianbrain.com/pitchtest/
  - http://tonometric.com/adaptivepitch/
- In a melodic context
  - Semitone (100 cents) (Berkowska & Dalla Bella, 2009 ; Dalla Bella et al., 2007, 2009a, 2009b ; Pfordresher & al., 2007, 2009, 2010)
  - Quartertone (50 cents) (Hutchins & Peretz; 2012 ; Hutchins, Roquet, & Peretz, 2012 ; Pfordresher & Mantell, 2014)

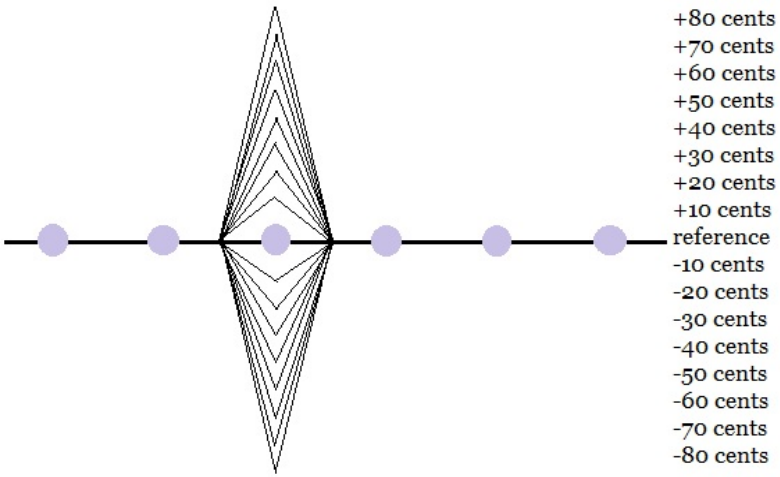
➔ **Which threshold in a melodic context?**

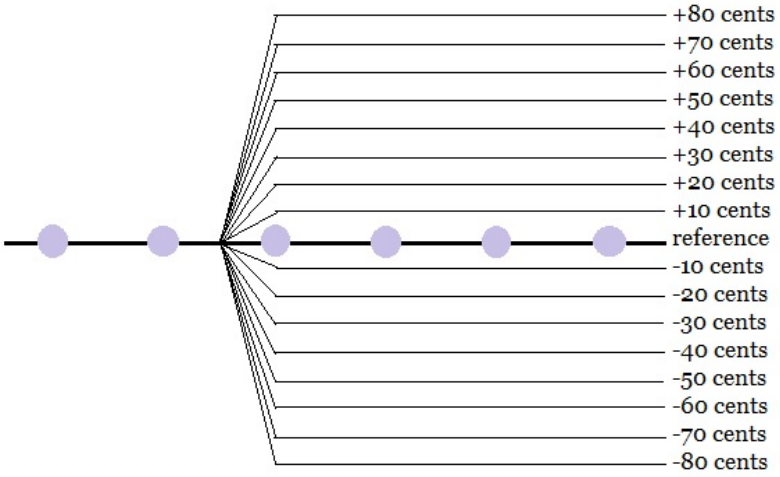
➔ **Is it stable?**

- Melodic contour: ascending or descending

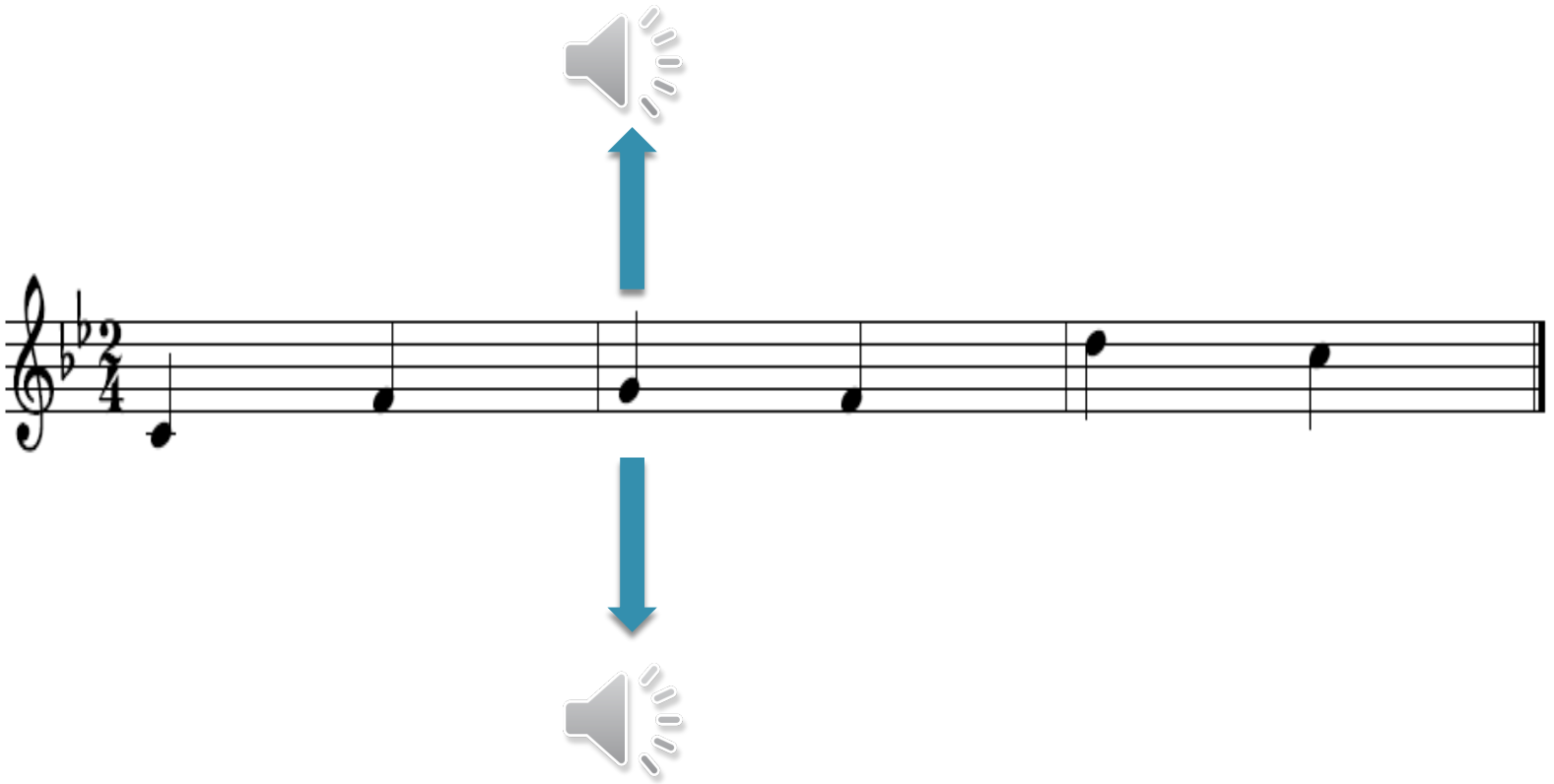


- Musical criteria





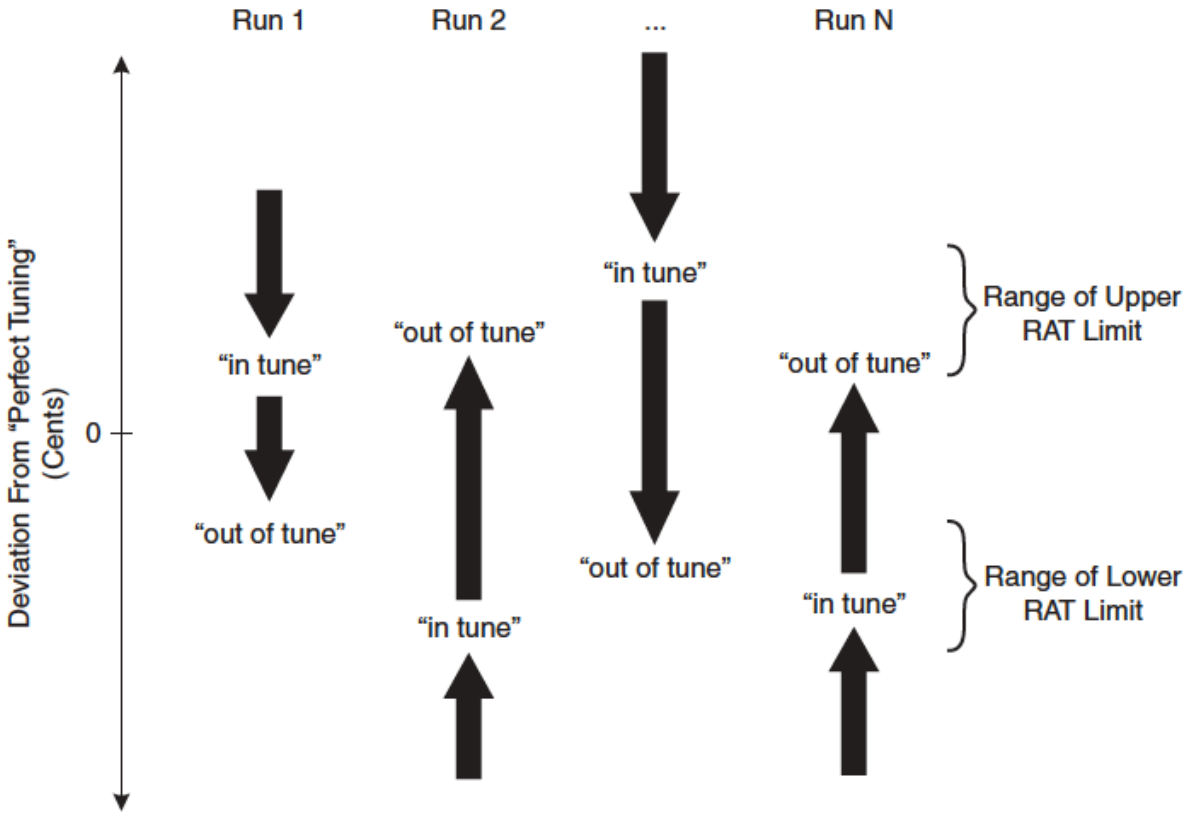
- Error type: enlargement or compression



Method

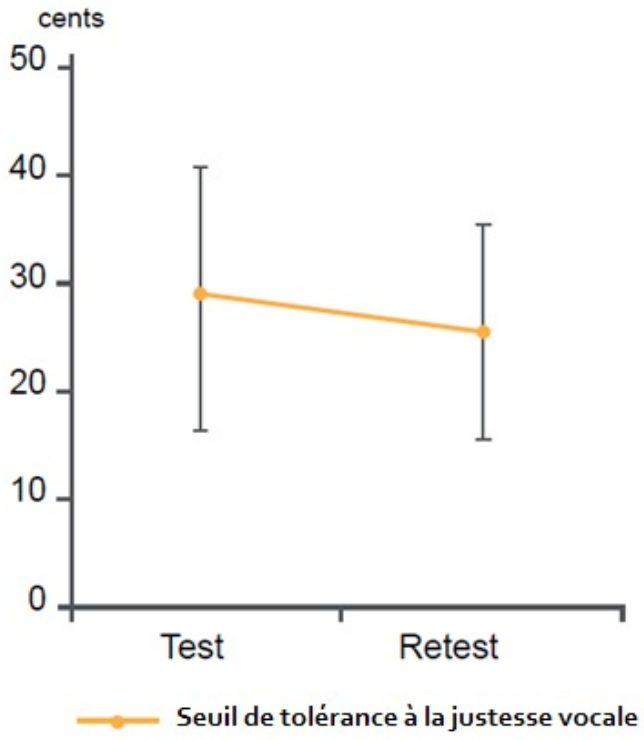
- Design 2x2x2
  - Melodic direction
  - Musical criteria
  - Error type
- Participants
  - 30 non musicians (M = 23.33; SD = 3.53)
  - Audio, MBEA, questionnaires
- Test-retest
  - 7 to 16 days
- Methods of limits (Van Besouw et al., 2008)

Method


Run 1
Run 2
...
Run N
Deviation From "Perfect Tuning" (Cents)
0
"in tune"
"out of tune"
"out of tune"
"in tune"
"in tune"
"out of tune"
"out of tune"
"in tune"
Range of Upper RAT Limit
Range of Lower RAT Limit

Results

- Correlation test-retest
  - $r(120) = 0.46$, $p < .001$
- Lower threshold for the retest
  - $t(120) = 3.64$, $p < .001$



➔ **Threshold: *M* =27.45 cents (*SD* = 10.45)**

Results

Conditions	F	p
Melodic contour	1.09	0.30
Musical criteria	2.00	0.16
Error type	0.62	0.43
Melodic contour*Criteria	0.01	0.94
Melodic contour*Error type	0.19	0.66
Criteria*Error type	0.14	0.71
Melodic contour*Criteria*Error type	0.00	0.95

➔ **No effect of the condition on threshold**

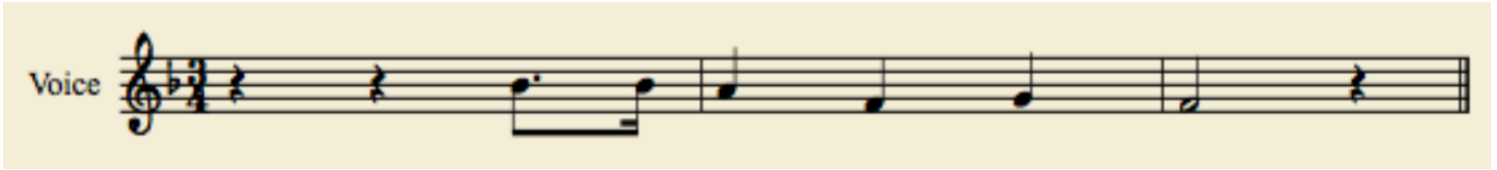
Discussion

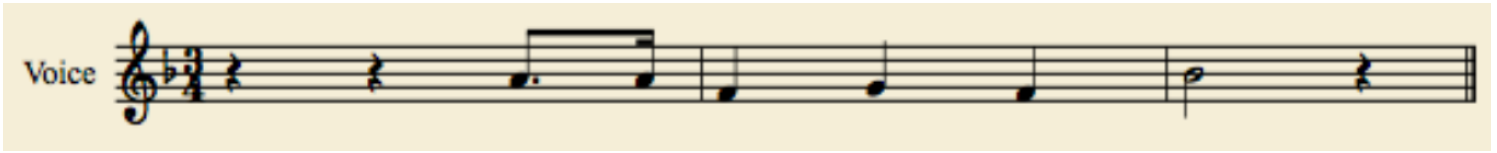
➔ Precise and stable melodic representations

- 27 cents
- Much smaller than 100 or 50 cents (Berkowska & Dalla Bella, 2009; Hutchins & Peretz; 2012 ; Hutchins, Roquet, & Peretz, 2012 Dalla Bella et al., 2007, 2009a, 2009b ; Pfordresher & al., 2007, 2009, 2010, 2014)

- Effect of training … to confirm
- Effect of familiarity ?
  - Same method applied to a familiar/non familiar melodies
    - Last sentence of "Happy birthday" and similar melody
  - Online questionnaire
    - 399 participants from 13 to 70 years old ($M = 29.81$)
    - $t(398) = 20.92$, $p < .001$

Discussion





➔ **Same "tolerance" for familiar/non familiar melodies**

➔ **Pertinent limit between in tune and out of tune**

- Next step: interval size, place of the error, cumulative errors
- To include in objective tools

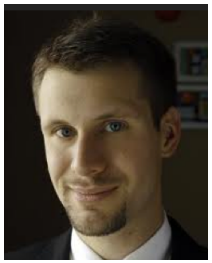
Conclusion

- Preference for computer-assisted method
- Preference for full melodies
- Ircam's tools seem adequate
- Alternatives
- Two musical criteria
- Small threshold (around 30 cents)

Conclusion

	Interval precision	Respect of tonal center	Modulations
Man 	75.74	100.5	4
Woman 	22.26	20	0









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FREEDOM TO RESEARCH

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June 2014

Université de Liège

Pitch analysis workshop

Thank you !

June 2014

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