Exploring Musical Style in the Anonymous and Doubtfully Attributed Mass Movements of the Coimbra Manuscripts:
A Statistical Approach

María Elena Cuenca
Universidad de Salamanca, Spain

Cory McKay

Marianopolis College, Canada

Polyphonic repertoires in Portugal

- Rees, Owen (1994-5), Lisbon, Biblioteca Nacional, CIC Ms 60: the Repertories and their Context, *Revista Portuguesa de Musicologia* 4-5, 53-93.

- _____ (1995), *Polyphony in Portugal* c. 1530-c. 1620: *Sources from the Monastery of Santa Cruz, Coimbra.* New York & London: Garland.

- _____ (2004), Relaciones musicales entre España y Portugal, in John Griffiths & Javier Suárez-Pajares (eds), *Políticas y prácticas musicales en el mundo de Felipe II, Música Hispana, Textos, Estudios* 8. Madrid: Instituto Complutense de Ciencias Musicales, 455-487.

- d'Alvarenga, João Pedro (2010), 'Some Notes on the Reception of Josquin and of Northern Idioms in Portuguese Music and Culture', *Journal of the Alamire Foundation* 2 (1), 69-89.

Polyphonic repertoires in Portugal

- d'Alvarenga, João Pedro (2012), 'A Neglected Anonymous Requiem Mass of the Early (Sixteenth Century and its Possible Context', *Musica Disciplina* 57, 155-189.

- ____ (forthcoming), 'On the Transmission of Iberian Polyphonic Music in the Early Decades of the 16th Century: Some Philological Issues Revisited'.

- Nelson, Bernadette (2004-5), 'The Leiria Fragments: Vestiges of Fifteenth-Century Northern Polyphony in Portugal', *Revista Portuguesa de Musicologia* 14-15, 79-100.

- ____ (2015), 'Morales's Magnificats and Some Anonymous Settings in Portuguese Sources: Questions of Style and Authorship', *Revista Portuguesa de Musicologia*, NS 2/2, 193-214.

jMIR

Polyphonic repertoires in Portugal

- Ferreira, Manuel Pedro (2005), '*L'homme armé* no Cancioneiro de Resende', *Revista da Facultade de Ciências Sociais e Humanas* 16, 259-268.

- Knighton, Tess (ed.) (2012), *Gonçalo de Baena, Arte para tanger*. Lisbon: Ediçoes Colibri, CESEM.

- ____ (ed.) (2017), *Companion to Music in the Age of the Catholic Monarchs*. Leiden / Boston: Brill, 205-241.

- *The Anatomy of Late 15th- and Early 16th-Century Iberian Polyphonic Music* project at the Lisbon Nova University and CESEM (FCT-funded project, PTDC/CPC-MMU/0314/2014, led by João Pedro d'Alvarenga).

Objective

- To provide insights on whether there was circulation of foreign repertoire or not, and on the possible prevalence of Franco-Dutch repertoires in the manuscripts copied in Coimbra.

  - To present an initial analysis of the anonymous and doubtfully attributed masses and loose movements.

  - To discuss a statistical analysis of these works using the jSymbolic software.

Number and percentages of masses and works of Franco-Flemish, Iberian or unknown origin

Sources	No. of masses	No. of Franco-Flemish works	No. of Iberian works	No. of anonymous works
P-Cug MM 2 [c.1530-1535]?	12/12 = 100%	11/12 = 91%	0/12 = 0%	1/12 = 1,5% (only one mass movement)
P-Cug MM 6 [c.1540-c.1555]	1/22 = 4,5%	0/22 = 0%	4/22 = 18,1%	18/22 = 81,8%
P-Cug MM 7 Mid-16th century	1/24 = 4,1%	0/24 = 0%	0/24 = 0%	24/24 = 100%
P-Cug MM 9 [c.1545-c.1550]	6/40 = 15%	5/40 = 12,5% ?	7/40 = 17,5%	28/40 = 70%
P-Cug MM 12 [c.1540-c.1550]	8/64 = 12,5%	3/64 = 4,6%	30/64 = 46,8%	31/64 = 48,4%
P-Cug MM 32 Mid- 16th century (c.1540-c.1555) and late 16th century	0/74 = 0%	7/74 = 9,4%	21/74 = 28,3%	46/74 = 62,1%

Janequin's *Missa La Bataille* (Agnus Dei III, bb. 66-71) in Moderne's *Liber decem missarum* (1532)

Janequin's *Missa La Bataille* (Gloria bb. 34-38) in Moderne's *Liber decem missarum* (1532) (above) and in *P-Cug* MM. 9, 68v-76r

Berchem's *Missa da morte et fortuna* (Kyrie, bb. 1-6)

Elaborated cadence at the end of Kyrie in *Missa* no. 3 (bb. 55-58)

Prolonged cadence in Bruxel's Sanctus from his mass (no. 17 in Table 2) (bb. 50-55)

Parallel 4ths in Bruxel's Gloria (no. 17 in the handout) (bb. 86-92)

Beginning of Sanctus in Verdelot's *Missa Philomena* (above) and Mass no. 19 (below)

'Et incarnatus' from Credo no. 5 in *P-Cug* MM 12, ff. 80v

Agnus Dei no. 8 (above) and Tordesillas's Agnus Dei from *Missa Sine nomine* in *E-Tz* 2-3 (below)

Elaborated cadence at the end of Kyrie no. 9

Elaborated cadence at the end of Kyrie in *Missa* no. 3 (bb. 55-58)

Ink corrosion in P-Cug MM 12, ff. 95v-96r (mass no. 12 in handout)

Quantitative experiments

- We also performed a series of quantitative experiments using features, statistical analysis and machine learning

- Computational approaches and expert theoretical and historical analyses can complement each other extremely well
  - Many opportunities for joint future research of this kind in a wide range of early music domains

What are "features"?

- A feature is a piece of statistical information that characterizes some aspect of a piece of music using a simple, consistent measurement
  - Each feature is represented as one or more simple numerical values
- Features can reveal meaningful patterns in music at a macro sense

A basic sample feature: *Range*

- Range: Difference in semitones between the highest and lowest pitches

- Value of this feature for this music: 7
  - G - C = 7 semitones

- In practice, of course, we want many features, not just one

jSymbolic

- The jSymbolic software (McKay et al. 2018) can be used to automatically extract features from digital scores
- It extracts 1497 separate values (version 2.2) measuring:
  - Pitch statistics
  - Melody / horizontal intervals
  - Chords / vertical intervals
  - Texture
  - Rhythm
  - Instrumentation
  - Dynamics
- Other jSymbolic research published at MedRen:
  - Composer attribution (McKay et al. 2017)
  - Origins of the madrigal (Cumming & McKay 2018)
  - Database search and annotation (McKay et al. 2019)

Our dataset: 603 MIDI files

Dataset	Mass Movements	Motets
Coimbra	38	0
Franco-Flemish	245	151
Iberian	78	91

- All are 15th or early 16th century works
- Secure Franco-Flemish composers (*from the Josquin Research Project*):
  - Alexander Agricola, Antoine Busnois, Loyset Compère, Josquin des Prez, Jacob Obrecht, Johannes Ockeghem, Marbrianus de Orto, Pierre de la Rue
- Secure Iberian composers (*from the Anatomy of Late 15th- and Early 16th-Century Iberian Polyphonic Music* project):
  - Alonso de Alba, Juan de Anchieta, Pedro de Escobar, Alonso Mondejar, Francisco de Peñalosa, Antonio de Ribera, Rivafrecha, Sanabria, Tordesillas, Juan de Urrede, Vasco Pires, Juan Illario, a few anonymous works

Experiment 1: Cross-validation

- **Research questions:**
  - ☐ How well are the secure Franco-Flemish and Iberian groups separated from one another stylistically?
  - ☐ Are these stylistic differences evident in both masses and motets?
  - ☐ Are the Coimbra mass movements statistically distinguishable from the Franco-Flemish and Iberian groups?
- **Methodology:**
  - ☐ Used machine learning to train classifiers to automatically distinguish between the different groups, based on the extracted jSymbolic features
  - ☐ Tested masses and motets separately, as well as together

Experiment 1: Classification accuracies

Music Being Compared	Average Classification Accuracy
FF and Ib, masses and motets	93.6%
FF and Ib, only motets	91.7%
FF and Ib, only masses	95.4%
FF, Ib and Coimbra, only masses	89.5%
FF, Ib and Coimbra, masses and motets	90.4%

- Rows 1 to 3 indicate that:
  - The Franco-Flemish and Iberian works are well-separated stylistically
  - This is true for both motets and masses, but mass movements are especially easily distinguishable (95.4%)

Experiment 1: Classification accuracies

Music Being Compared	Average Classification Accuracy
FF and Ib masses and motets	93.6%
FF and Ib only motets	91.7%
FF and Ib only masses	95.4%
FF, Ib and Coimbra only masses	89.5%
FF, Ib and Coimbra masses and motets	90.4%

- Rows 4 and 5 suggest that:
  - The Coimbra mass movements are also well-separated from the Franco-Flemish and Iberian music . . . or are they?
  - Actually, we need to look at the confusion matrices to verify
    - The Coimbra mass movements only represent 6.3% of the dataset
    - Their particular performance can thus be obscured

Experiment 1: Confusion matrices

True Label	Classified as Coimbra	Classified as FranFlem	Classified as Iberian
Coimbra masses	27	0	11
FF masses	2	236	7
Iberian masses	8	10	60

True Label	Classified as Coimbra	Classified as FranFlem	Classified as Iberian
Coimbra masses & motets	27	1	10
FranFlem masses & motets	7	377	12
Iberian masses & motets	7	21	141

- **So, only some (a little under ¾) Coimbra mass movements are separable from the Franco-Flemish and Iberian music**
  - So there is something distinctive about them, but there is also overlap

Experiment 1: Confusion matrices

True Label	Classified as Coimbra	Classified as FranFlem	Classified as Iberian
Coimbra masses	**27**	0	**11**
FF masses	2	**236**	7
Iberian masses	8	10	**60**

True Label	Classified as Coimbra	Classified as FranFlem	Classified as Iberian
Coimbra masses & motets	**27**	**1**	**10**
FranFlem masses & motets	7	**377**	12
Iberian masses & motets	7	21	**141**

- For those that are "misclassified", they are almost always (95.4% of the time) classified as Iberian!
  - □ This suggests that at least some of them are closer in style to Iberian than Franco-Flemish music

Experiment 2: Classifying individual Coimbra mass movements

- **Research question:**
  - Are the individual Coimbra mass movements each more Iberian or Franco-Flemish in style?
- **Methodology:**
  - Trained two classification models on the secure Franco-Flemish and Iberian music (only)
    - One classifier was trained on both motets and mass movements
    - One classifier was trained on only mass movements
  - Used these trained models to classify each Coimbra mass movement separately
    - Each could only be classified only as Franco-Flemish or Iberian

Experiment 2: Results

Coimbra Mass Movement	Trained on Masses and Motets	Trained on Masses Only
2. Missa Salve Regina, Benedictus, P-Cug 12	Franco-Flemish	Iberian
3. Missa Kyrie P-Cug 12	Franco-Flemish	Iberian
3. Missa Sanctus P-Cug 12, f. 26v	Franco-Flemish	Iberian
4. Missa Sine nomine anónima, Kyrie P-Cug 12	Franco-Flemish	Franco-Flemish
16. Missa A Batalha. Janequin. Sanctus. P-Cug 9	Franco-Flemish	Iberian
18. Missa Da Morte e fortuna, Berchem, Kyrie P-Cug 9	Franco-Flemish	Iberian

- **6 / 38 (15.8%)** of the Coimbra mass movements were classified as Franco-Flemish by either of the 2 classifiers
  - □ Listed on the table above
- **97.3%** (all but one) were classified as Iberian by the model specialized in mass movements
  - □ Recall that all the Coimbra pieces are mass movements

Experiment 2: Results

Coimbra Mass Movement	Trained on Masses and Motets	Trained on Masses Only
2. Missa Salve Regina, Benedictus, P-Cug 12	Franco-Flemish	Iberian
3. Missa Kyrie P-Cug 12	Franco-Flemish	Iberian
3. Missa Sanctus P-Cug 12, f. 26v	Franco-Flemish	Iberian
4. Missa Sine nomine anónima, Kyrie P-Cug 12	Franco-Flemish	Franco-Flemish
16. Missa A Batalha. Janequin. Sanctus. P-Cug 9	Franco-Flemish	Iberian
18. Missa Da Morte e fortuna, Berchem, Kyrie P-Cug 9	Franco-Flemish	Iberian

- These results suggests that the Coimbra mass movements are, as a whole, more Iberian than Franco-Flemish in character

- Although results for individual mass movements should not be interpreted as perfectly authoritative, the overall pattern is clear and convincing

Closing comments (1/2)

■ The Coimbra manuscripts, and Portugal, were strongly influenced by international styles (and vice versa?):

☐ Spanish-style repertoires

☐ Northern-style masses

Closing comments (1/3)

- **Influences include:**
  - ☐ Foreign masses circulated in Portugal
  - ☐ Iberian composers influenced by Northern styles
- **The Coimbra works were adapted to the performative context of the Santa Cruz chapel**
  - ☐ A happened in the case of Janequin's mass

Closing comments (3/3)

- Franco-Flemish elements in the polyphony seem to have been received mostly through Spanish masses
  - Which were influenced by Burgundian and French composers
- This Spanish-influenced merged style was transmitted to Portugal through numerous anonymous and doubtfully attributed masses

Future research

- Learn more about the reception of French works by Janequin, Verdelot, or Richafort
  - And their influence on Iberian polyphony
- Extend this case study to other genres
  - e.g. motets, hymns, or anonymous lamentations in Portuguese manuscripts
  - Others are doing promising work already

Thanks for your attention!

- **E-mail:** elenacrod@usal.es
- **E-mail:** cory.mckay@mail.mcgill.ca