

The Mensural Scoring-up Tool

Martha E. Thomae, Julie E. Cumming, and Ichiro Fujinaga

Schulich School of Music, McGill University

Digital Libraries for Musicology (DLfM)

The Hague, November 09, 2019

Superius

L'autre d'antan l'autrier passa
percha. Dunt regard forque a melan q' me mist en
larriere l'uy. tant maluaie brassin me baissa
Kartel fuchon me frassa
Que de ses gaupes me rassa
Mais par dieu elle fist son don
l'autre d'antan l'autrier passa.

Tenor

L'autre d'antan l'autrier passa
sant me t'percha dunt regard forque a melan.
qui me mist en larriere l'uy tant maluaie
brassin l'autre d'antan l'autrier passa.

Beinecke Rare Book and
Manuscript Library,
Yale University
Mellon Chansonnier (MS 91),
25v-26r

Contratenor

L'autre d'antan
l'autre d'antan

Scoring up

The image displays a musical score for three voices: Superius, Tenor, and Contratenor. The score is presented in two systems. The first system shows the beginning of the piece, with the Superius part starting on a high note and the Tenor and Contratenor parts starting on lower notes. The second system shows the continuation of the piece, with the Superius part moving to a lower register and the Tenor and Contratenor parts moving to higher registers. The notes are represented by diamond shapes, and the stems are vertical lines. The background is divided into three horizontal bands: light blue for Superius, light pink for Tenor, and light green for Contratenor.

Mensural Notation

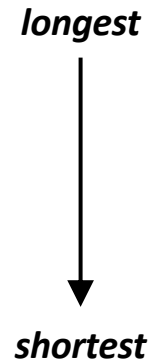
(An Introduction)



Beinecke Rare Book and Manuscript Library, Yale University
Mellon Chansonnier (MS 91), 25v-26r

Mensural Notation

- There is a clear hierarchy in the note duration



Notes		Values			
Name	Shape	Perfect			Imperfect
Maxima	☐	☐	☐	☐	☐
Long	☐	◊	◊	◊	◊
Breve	◊	⋮	⋮	⋮	⋮
Semibreve	◊	⋮	⋮	⋮	⋮



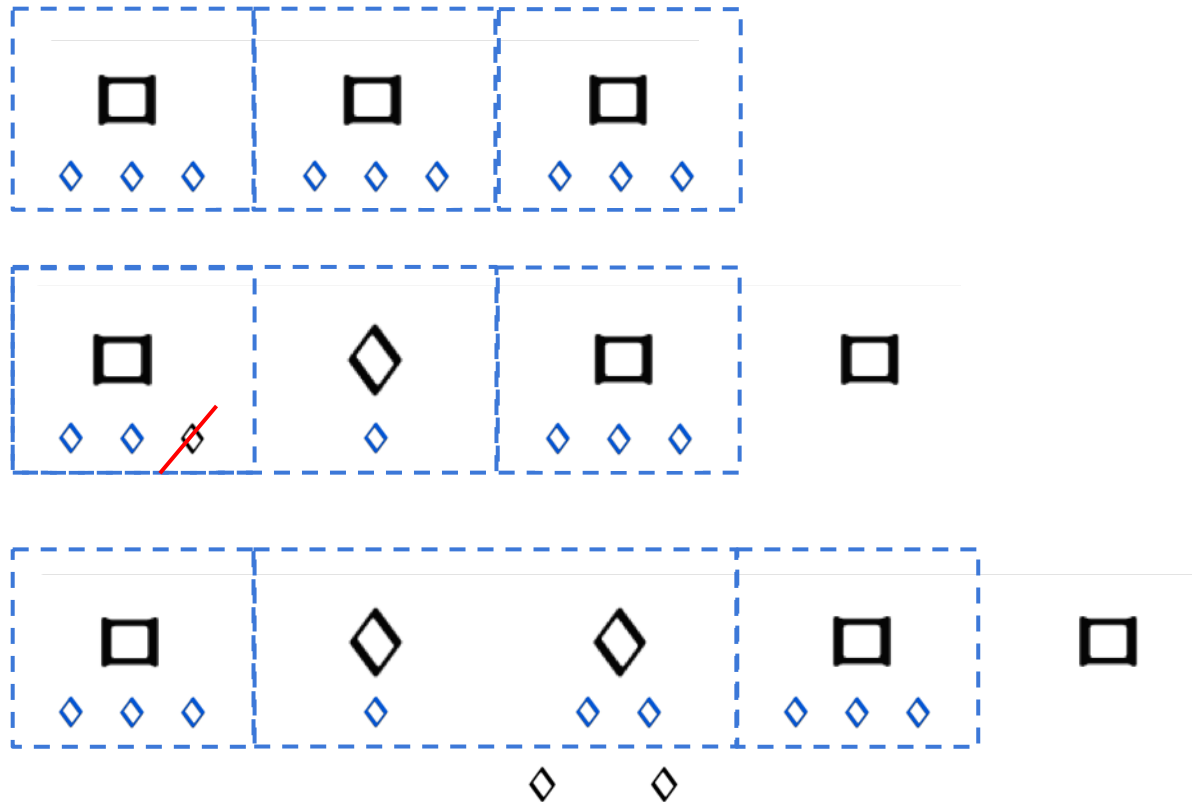
Mensuration

Establishes the relation between the note values (“perfect” or “imperfect”)

In perfect mensurations, the duration of the individual note symbols is not absolute, but rather **depends on context**

Examples of Context Changing the Note's Duration

Mensuration: Breve = 3 → Breves are perfect by default



*Principles of
Imperfection
and Alteration*

Imperfection
Perfect → Imperfect

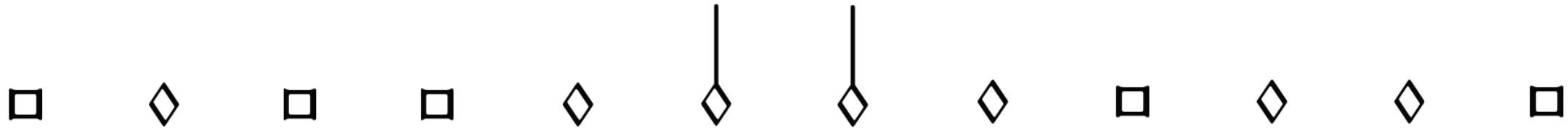
Alteration

Franco of Cologne
Ars Cantus Mensurabilis (ca. 1280)

The Scoring-up Tool

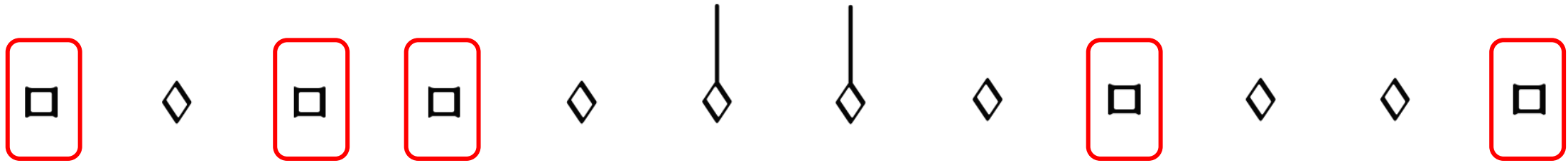
Algorithm

Mensuration: Breve = 3 → Breves are perfect by default



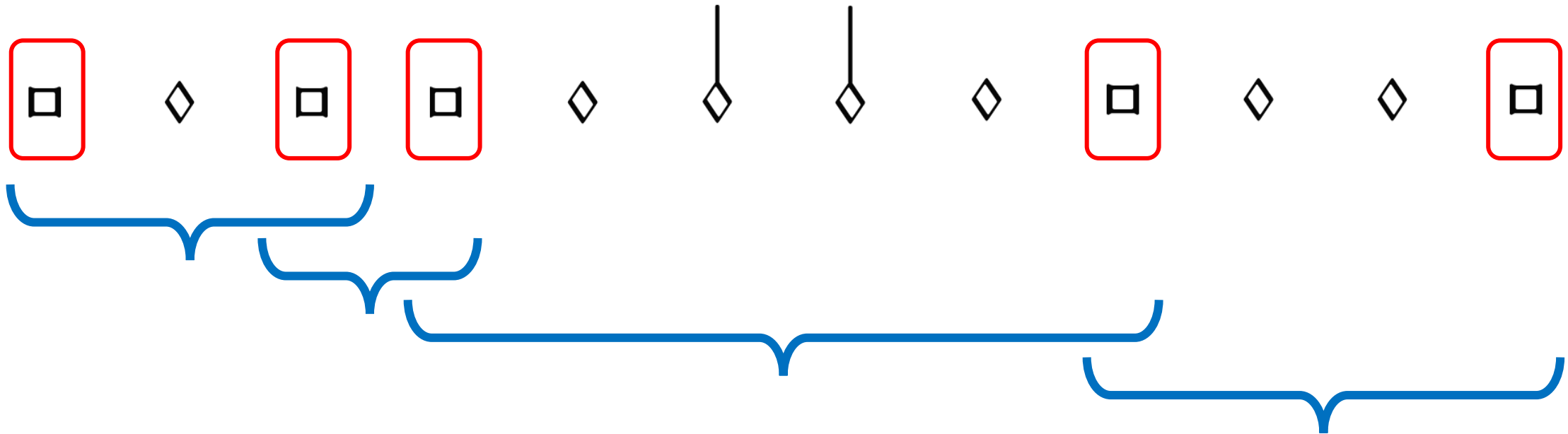
Algorithm

Mensuration: Breve = 3 → Breves are perfect by default

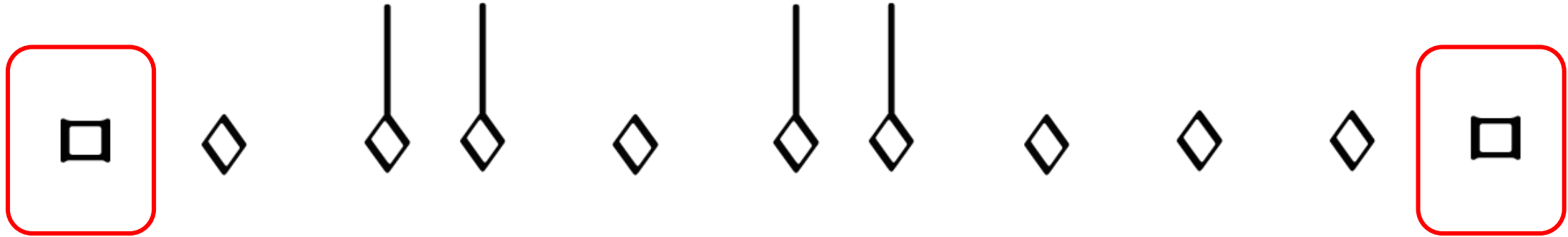


Algorithm

Mensuration: Breve = 3 → Breves are perfect by default

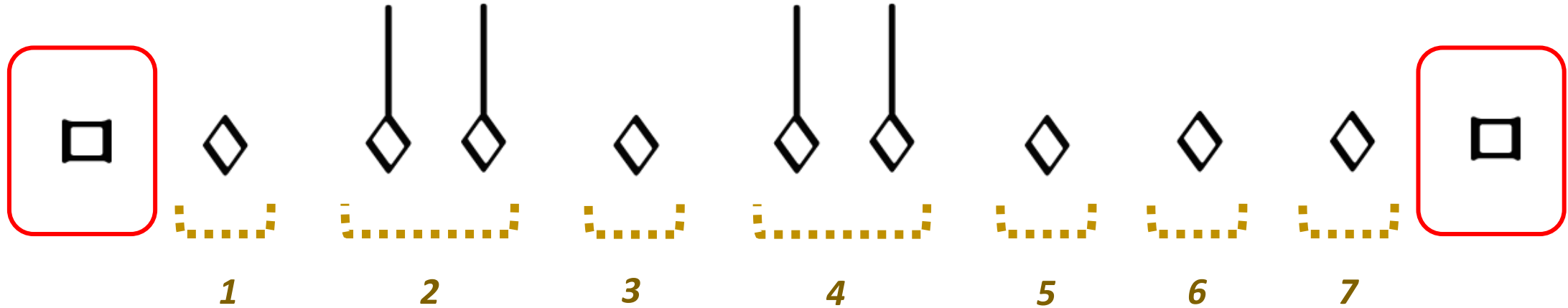


Example: (sequence bounded by breves)



Example in *perfect tempus and minor prolatio*

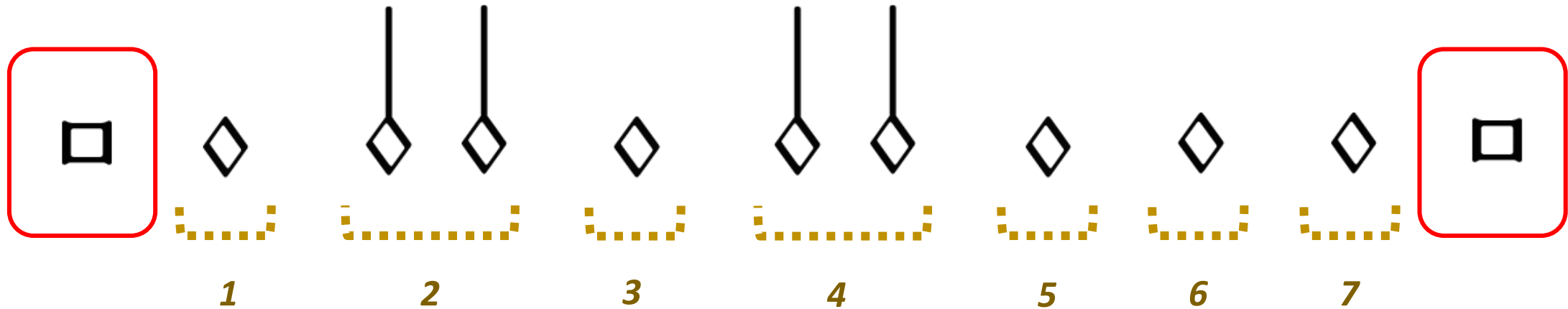
Example: (sequence bounded by breves)



7 semibreves

Example in *perfect tempus and minor prolatio*

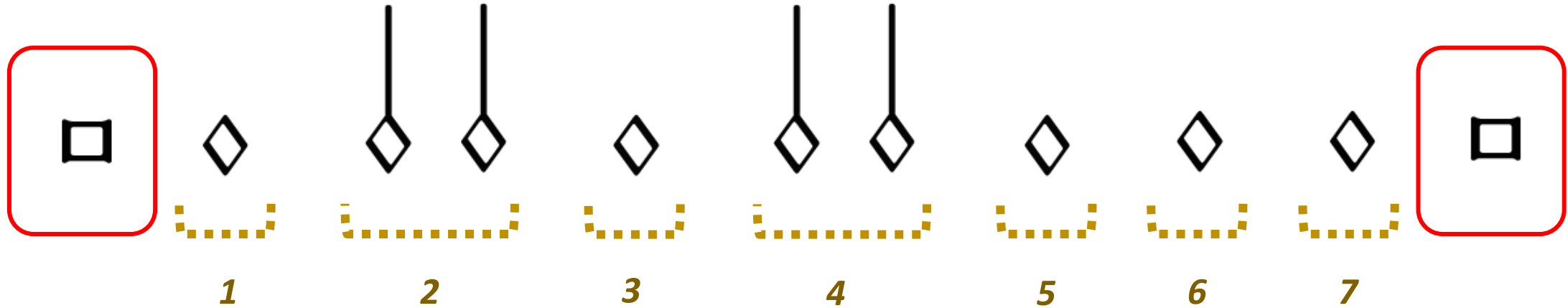
Example: (sequence bounded by breves)



7 semibreves = Two groups of 3 semibreves + 1

Example in *perfect tempus and minor prolatio*

Example: (sequence bounded by breves)



7 semibreves

=

Two groups of 3 semibreves

+

1

Example in *perfect tempus and minor prolatio*

Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$	-	Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$	-	Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

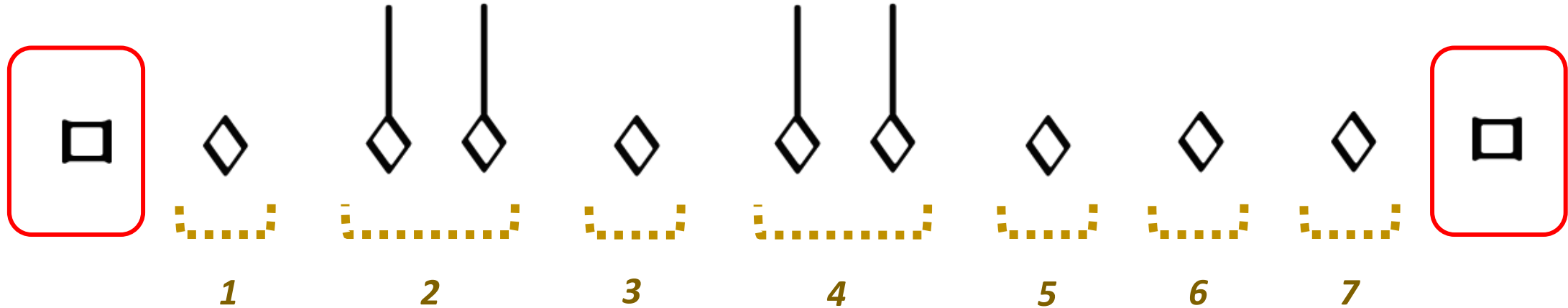
Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$	-	Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$	-	Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$	-	Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

Number N of semibreves between the boundaries	Number P of perfect groups of semibreves	General Interpretation	Alternative Interpretation
$N = 3P + 1$	$P \geq 0$	Imperfection (by following)	Imperfection (by preceding)
$N = 3P + 2$	$P = 0$	Alteration	Imperfection (by following) & Imperfection (by preceding)
	$P > 0$	Imperfection (by following) & Imperfection (by preceding)	Alteration
$N = 3P$	$P = 0$	-	-
	$P = 1$		Imperfection (by following) & Alteration
	$P > 1$	Imperfection (by following) & Alteration	-

Example: (sequence bounded by breves)



7 semibreves

=

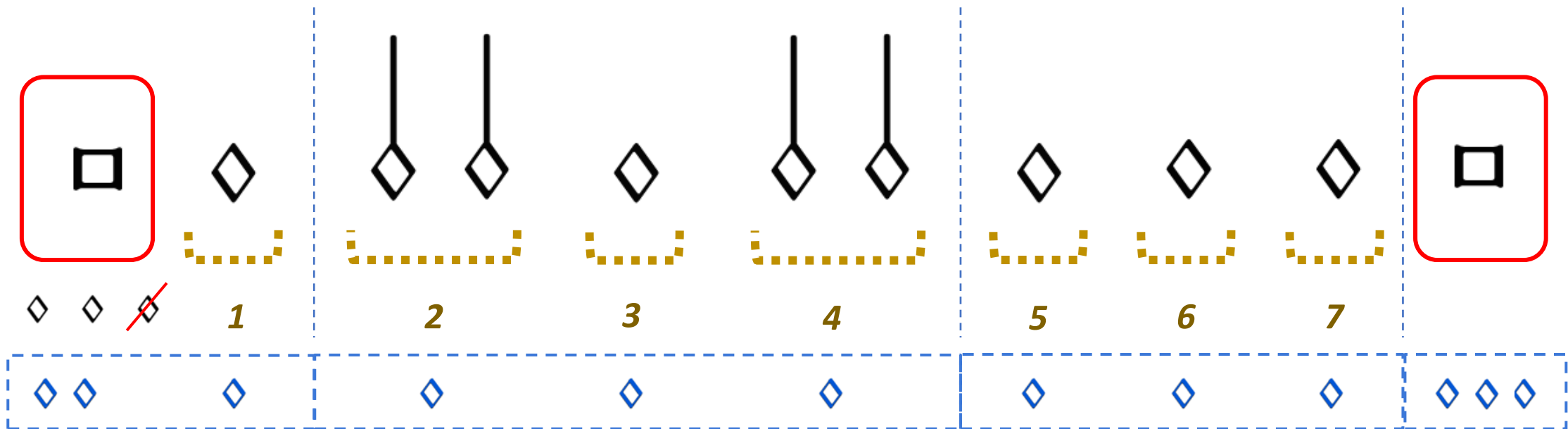
Two groups of 3 semibreves

+

1

Example in *perfect tempus and minor prolatio*

Example: (sequence bounded by breves)



7 semibreves

=

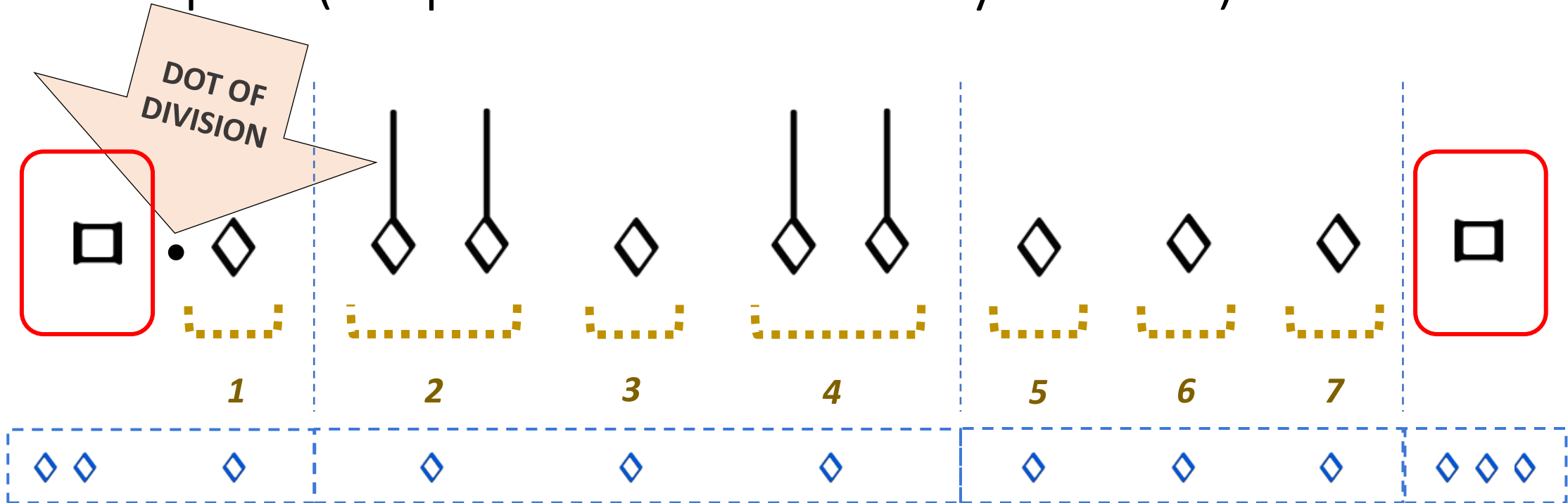
Two groups of 3 semibreves

+

1

Example in *perfect tempus and minor prolatio*

Example: (sequence bounded by breves)



7 semibreves

=

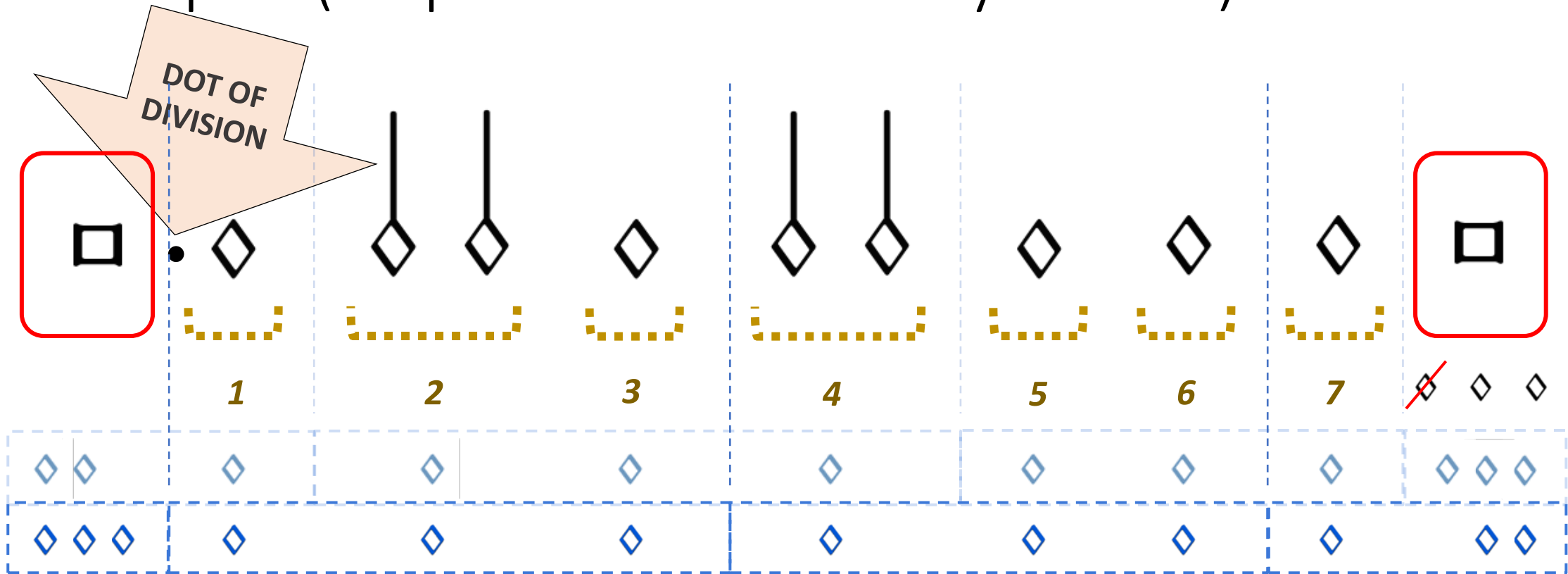
Two groups of 3 semibreves

+

1

Example in *perfect tempus and minor prolatio*

Example: (sequence bounded by breves)



7 semibreves

=

Two groups of 3 semibreves

+

1

Example in *perfect tempus and minor prolatio*

Scoring-up Tool

- Deals with the context-dependent nature of mensural notation
 - By implementing the “principles of imperfection and alteration”
- Deals with other non-context-related features:
 - Dots of augmentation
 - Coloration

Scoring-up Tool

- Deals with the context-dependent nature of mensural notation
 - By implementing the “principles of imperfection and alteration”

- Deals with other non-context-related features:

- Dots of augmentation



When?
Distinguish between “dots of division”
and “dots of augmentation”

- Coloration



Scoring-up Tool

- Deals with the context-dependent nature of mensural notation
 - By implementing the “principles of imperfection and alteration”

- Deals with other non-context-related features:

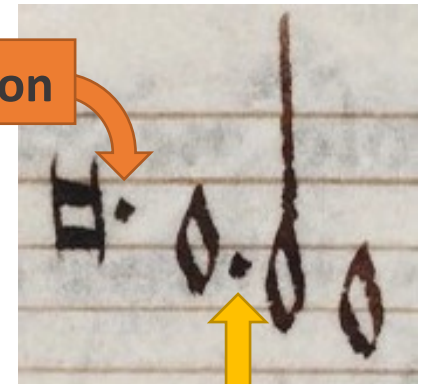
- Dots of augmentation



When?
Distinguish between “dots of division”
and “dots of augmentation”

- Coloration

division



augmentation

Scoring-up Tool

- Deals with the context-dependent nature of mensural notation
 - By implementing the “principles of imperfection and alteration”
- Deals with other non-context-related features:

- Dots of augmentation →

When?
Distinguish between “dots of division”
and “dots of augmentation”

- Coloration →

When does coloration affect the note value?

Scoring-up Tool

- Pitch
- Note shape



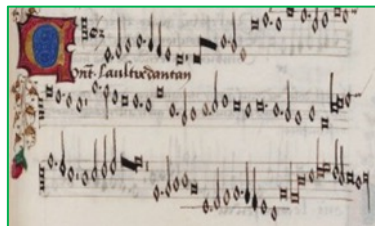
**Mensural
MEI file**

Superius part



**Mensural
MEI file**

Tenor part



**Mensural
MEI file**

Contratenor part

Mensural Scoring-up Tool

1. Determine note duration based on contextual and non-contextual cues
2. Merge all files together

**Mensural
MEI file**

SCORE

Verovio

Superius
Tenor
Contratenor

Data used for the Experiment

Pieces from the XIV and XV Centuries

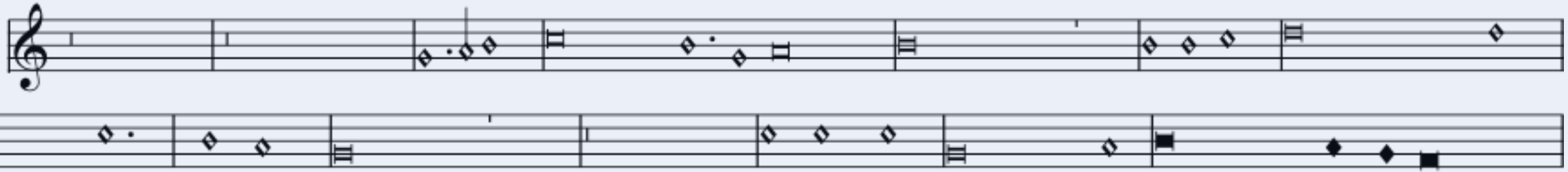
Century	Project	Format	Composers and Sources	Number of Pieces
XIV	Measuring Polyphony Project (Karen Desmond http://measuringpolyphony.org)	Mensural MEI	Vitry, Machaut, Anonymous (Ivrea Codex)	8
XV	Josquin Research Project (Jesse Rodin, Craig Sapp, Clare Bokulich)	Modern transcriptions converted into Mensural MEI using: <i>SibMEI + Mensural MEI Translator</i>	Du Fay and Ockeghem (GB-Ob, Dijon, Mellon, Laborde, Wolfenbüttel)	Du Fay: 5 Ockeghem: 5

Results

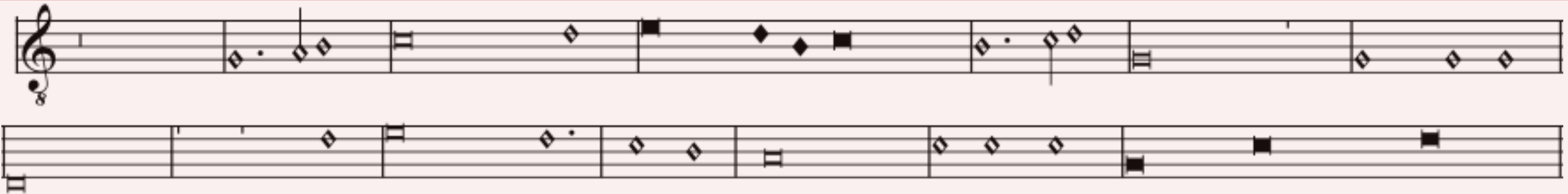
- Accuracy: 98%
 - Only 55 mislabeled notes out of 2866 notes of **ambiguous duration**
- Most common source of error: absence of the dot of division

Example: Three Separate Parts

Superius



Tenor



Contratenor



In Quasi-Score Format – Without Scoring-up Tool (notes are not aligned)

The image displays a musical score in Quasi-Score Format, consisting of two systems of three staves each. The top system is labeled 'Superius', 'Tenor', and 'Contratenor' on the left. Each staff begins with a treble clef and a common time signature. The notes are represented by diamond-shaped symbols, and the stems are vertical lines. The notes are not aligned across the staves, indicating that the parts are not synchronized. The bottom system continues the notation for the three parts, maintaining the same diamond-shaped notes and vertical stems. The overall layout is clean and minimalist, focusing on the rhythmic and melodic structure of the music without traditional musical notation like beams or accidentals.

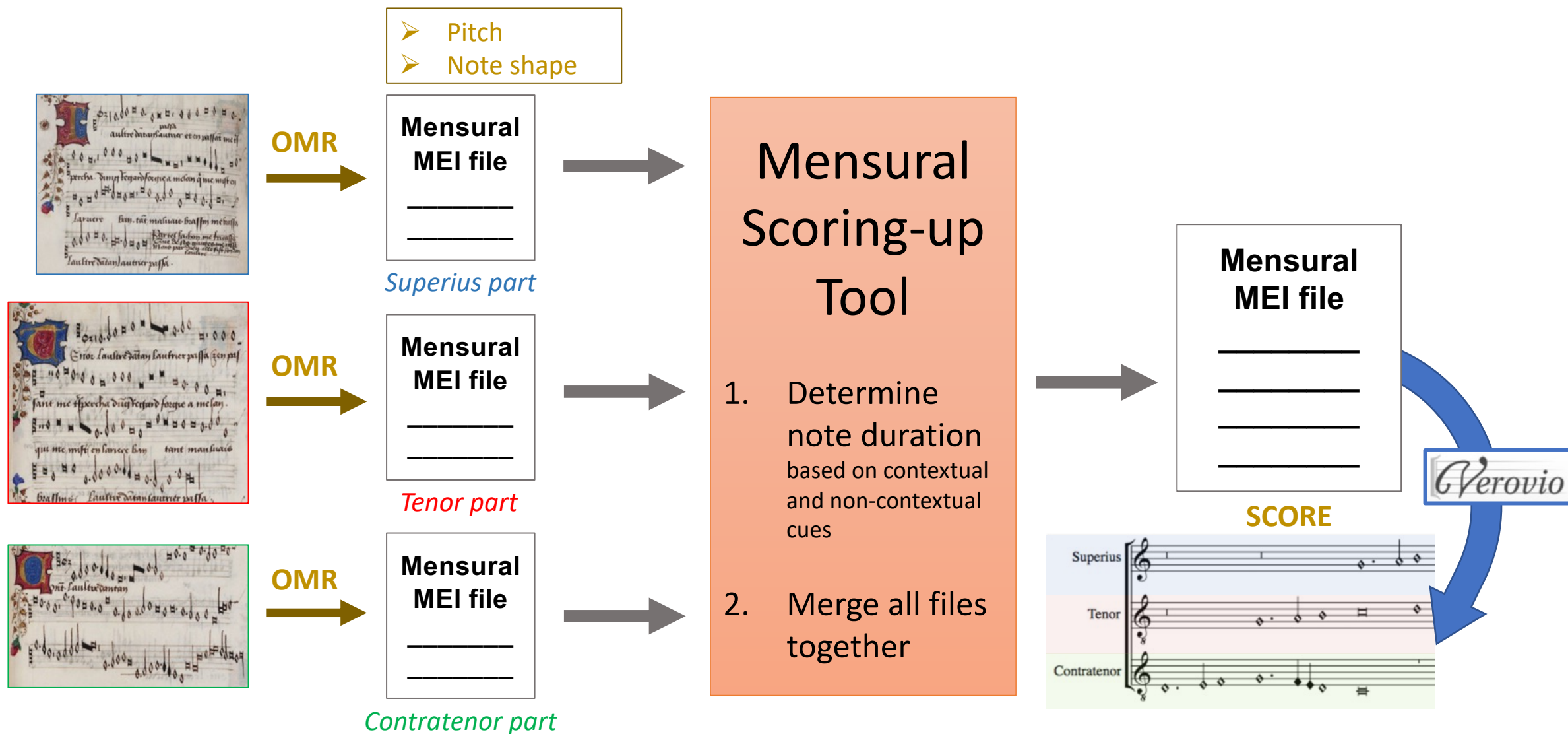
In Score Format – With Scoring-up Tool (modification values encoded)

The image displays a musical score in In Score Format, featuring three vocal parts: Superius, Tenor, and Contratenor. The score is presented in a system of seven staves. The top three staves are labeled 'Superius', 'Tenor', and 'Contratenor' on the left. Each staff begins with a treble clef and a common time signature. The music is written in a diamond-shaped notation style, with notes and rests represented by diamonds and vertical stems. Red vertical bar lines are placed at regular intervals across all staves, indicating measure boundaries. The score includes various musical symbols, such as Roman numerals (II, III) and diamond-shaped notes, which are likely encoded modification values. The bottom four staves continue the musical notation without labels, maintaining the same diamond-shaped notation and red bar lines. The overall layout is clean and professional, typical of a digital music score.

Conclusions

- The scoring-up tool presents the piece in score format
- Preserves the original note values
- Facilitates visualizing the vertical sonorities and studying the relation between the voices of a piece

Future Work



Thank you!

<https://github.com/elvis-project/scoring-up>

SIMSSA | Single Interface for Music
Score Searching and Analysis

Verovio

MUSIC ENCODING
MEI
INITIATIVE



Social Sciences and Humanities
Research Council of Canada

Conseil de recherches en
sciences humaines du Canada

Canada



McGill



Schulich School of Music
École de musique Schulich

DDMAL

DISTRIBUTED DIGITAL MUSIC
ARCHIVES & LIBRARIES LAB

CIR
MMT

Centre for Interdisciplinary Research
in Music Media and Technology

Fonds de recherche
Société et culture

Québec



Table 7: Type of errors in the scoring-up output.

Types of Error		No. of errors	Mislabeled notes per instance	Total of mislabeled notes
Errors in the sources	Missing dot of division	8	2	16
		3	3	9
	Mistakenly colored note	1	1	1
	Incomplete hemiola group	1	2	2
Errors in the experiment	Dot of alteration	3	2	6
	Dot misplacement	1	1	1
	Last note's undetermined duration	7	1	7
	Semibreve rest lines	2	2	4
Transition to XVI c. mensural notation		5	2 in 4 instances	8
			1 in another	1

Absence of a dot of division

Discantus

Ha, For- -tu- -ne, n'as tu pas
&
Plus ne de- -si- -re que la

Tenor

Ha, For- -tu- -ne, n'as tu pas
&
Plus ne de- -si- -re que la

Contra

Ha, For- -tu- -ne, n'as tu pas
&
Plus ne de- -si- -re que la

Discantus

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

Tenor

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

Contra

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

Discantus

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

Tenor

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

Contra

Ha, For-tu-ne, n'as tu pas
&
Plus ne de-si-re que la

triplum

motetus

e qu a - li - xan - dre hot en sa vi - e

est tou - te la mieux par - ti - e

Detailed description: The image shows a musical score for two parts: 'triplum' and 'motetus'. Both parts are written on a single staff with a treble clef and a common time signature 'C'. The 'triplum' part has a red rectangular box highlighting the first six measures. The 'motetus' part has a dashed rectangular box highlighting the first six measures. The lyrics are written below the notes. The 'triplum' lyrics are 'e qu a - li - xan - dre hot en sa vi - e' and the 'motetus' lyrics are 'est tou - te la mieux par - ti - e'. The notes are diamond-shaped, and there are some square symbols above the notes in the first six measures of both parts.

triplum

est qu a - li - xan - dre hot en sa vi - e

est tou - te la mieux par - ti - e

triplum

est qu a - li - xan - dre hot en sa vi - e

est tou - te la mieux par - ti - e



Figure 4-6: Ground truth interpretation of Ock3009 (contra voice) as found in Dijon based on a modern transcription.



Figure 4-7: Incorrect interpretation from scoring-up tool of Ock3009 (contra voice) as found in Dijon.

Placement of the dot of division

The image displays a musical score for three voices: Cantus, Altus, and Tenor. Each part is written on a five-line staff with a treble clef and a key signature of one flat (B-flat). The Cantus part begins with a diamond-shaped note on the second line (F4), followed by a series of notes and rests. The Altus part begins with a diamond-shaped note on the second space (G4), followed by a series of notes and rests. A red rectangular box highlights a specific section of the Altus part, spanning the second and third measures. The Tenor part begins with a diamond-shaped note on the second space (G3), followed by a series of notes and rests. The score is presented in a clean, black-and-white format with diamond-shaped notes and square-shaped notes.

Figure 4-16: Ground truth interpretation of Duf16002 (altus) based on a modern transcription.

Last note

triplum
 nul - la fi - des pi - e - tas - que vi - ris - qui ca - stra se - cun - tur.

motetus
 tis ma - la per in - nu - me - ra dum ma gis op - ta - tis.

tenor

Figure 4-19: Interpretation from scoring-up tool of Iv001's ending. Even though the last note of all voices is reached at the same time, the tenor ends sooner than other voices given that the last notes are interpreted according to the mensuration (perfect modus in triplum and motetus, and imperfect modus in the tenor).

Missing information regarding
the staff-line in which a rest lies

Cantus

-ne, Ri- -ches- -se, hon- -nour,
 -ne; Ain- -si pour- -rez
 -ne; Tous vos de- -sirs

Contratenor

Cantus

-ne, Ri- -ches- -se, hon- -nour,
 -ne; Ain- -si pour- -rez
 -ne; Tous vos de- -sirs

Contratenor

Errors due to situations out of
the scope of the principles of
imperfection and alteration

Discantus

Tenor

Contra

per, ne vous ver- -ray
quiers vi- -vre heu- -re ne

per, ne vous ver- -ray je
quiers vi- -vre heu- -re ne de-

Discantus

Tenor

Contra

per, ne vous ver- -ray je
quiers vi- -vre heu- -re ne de-

per, ne vous ver- -ray je my-
quiers vi- -vre heu- -re ne de- my-

Other errors (sources)

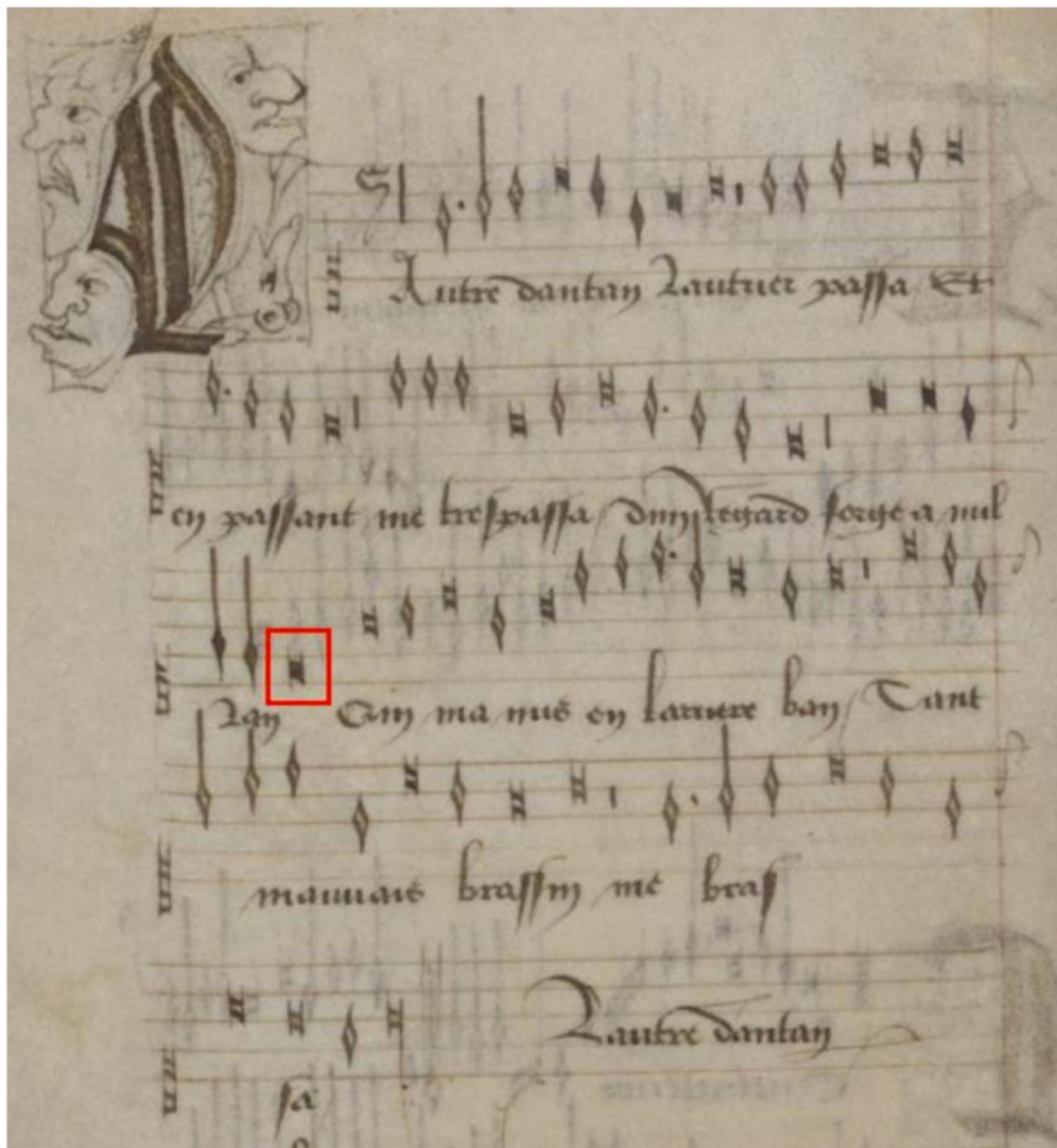


Figure 4-10: Tenor voice in Ock3009 according to Dijon.

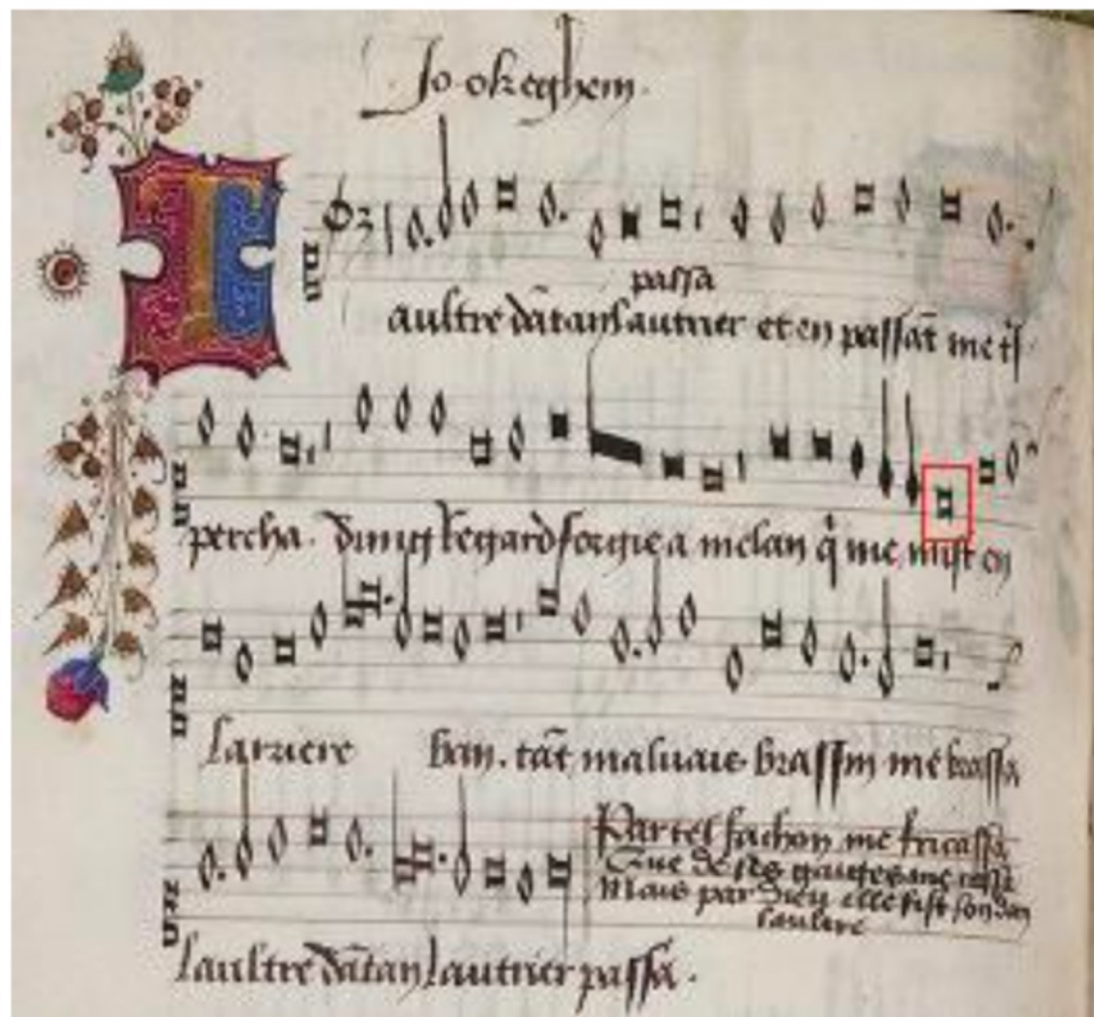


Figure 4-11: Tenor voice in Ock3009 according to Mellon.

Other errors (experiment)

Incompleteness of hemiola group coloration

The image displays a musical score for three voices: Discantus, Contra, and Tenor. The score is written in a single system with three staves. The lyrics are: "He-las, je suis con-tre mon vueil en vi-e, Et si n'est Mo-rir ne puis et tous-jours m'y con-vi-e, Et m'est bien". The first two measures of the score are highlighted with a dashed blue box, indicating a hemiola group. The lyrics for these two measures are: "He-las, je suis" (Discantus), "He-las, je suis" (Contra), and "He-las, je suis" (Tenor). The lyrics for the remaining measures are: "con-tre mon vueil en vi-e, Et si n'est" (Discantus), "con-tre mon vueil en vi-e, si n'est" (Contra), and "con-tre mon vueil en vi-e, Et si n'est" (Tenor). The lyrics for the final measure are: "Mo-rir ne puis et tous-jours m'y con-vi-e, Et m'est bien" (Discantus), "Mo-rir ne puis et tous-jours m'y con-vi-e, m'est bien" (Contra), and "Mo-rir ne puis et tous-jours m'y con-vi-e, Et m'est bien" (Tenor). The score uses a treble clef for the Discantus and Contra parts, and a bass clef for the Tenor part. The time signature is not explicitly shown, but the music is in a 3/4 time signature. The notes are marked with diamond symbols, and the lyrics are written below the notes.

Figure 4-18: Ground truth interpretation of Ock3016 based on a modern transcription.