

Automatic Scoring up of Parts in Mensural Notation

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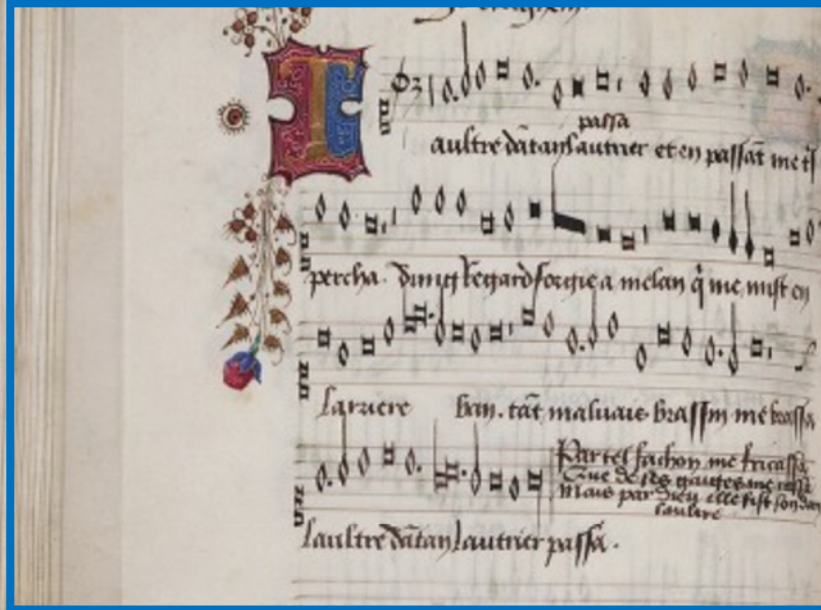
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Medieval and Renaissance Music Conference

Maynooth, 06 July 2018

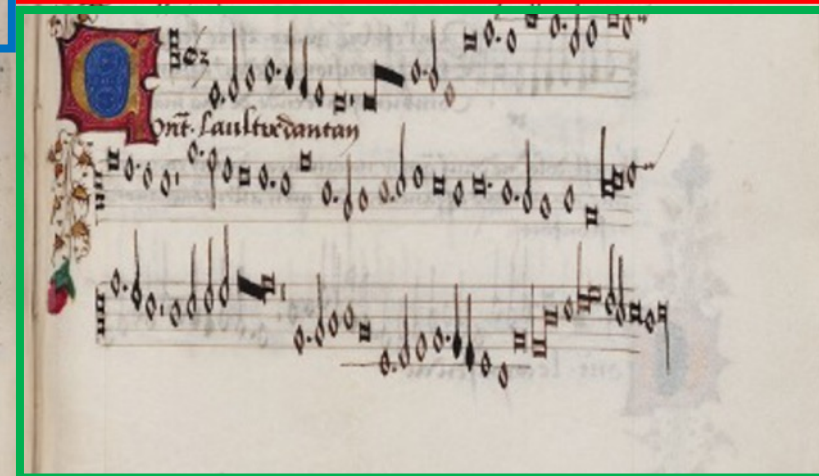
Superius



Tenor



Contratenor



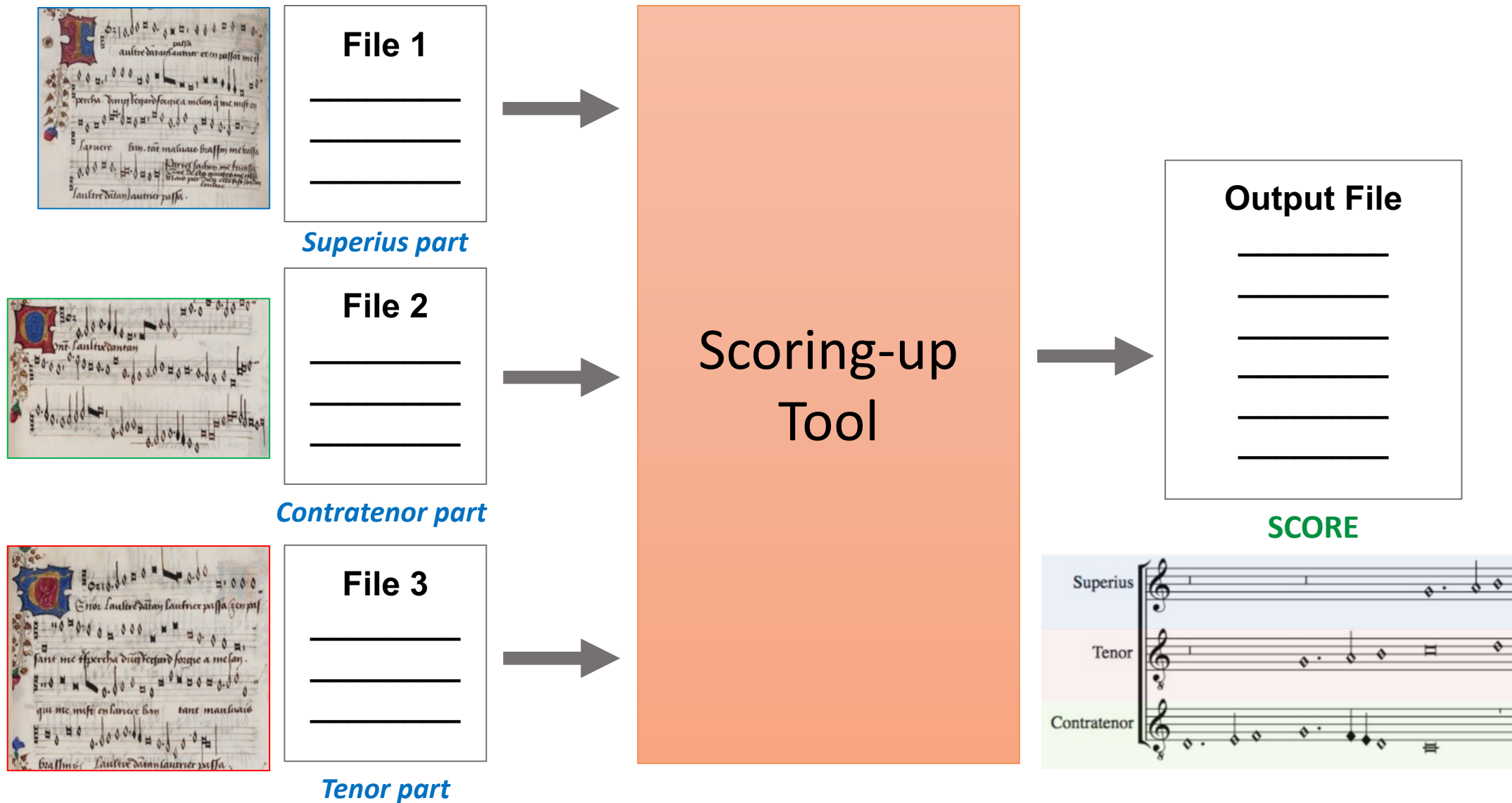
Beinecke Rare Book & Manuscript Library

Mellon Chansonier (MS 91), 25v-26r

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 initial entries of the voices, with the Superius part starting on a high note and the Tenor and Contratenor parts following. The second system shows the continuation of the music, with the voices moving in parallel motion. The notation includes treble clefs, a key signature of one sharp (F#), and a time signature of 8/8. The background of the score is divided into three horizontal bands: light blue for Superius, light red for Tenor, and light green for Contratenor. The notes are represented by diamond shapes, and the rests are indicated by vertical lines.

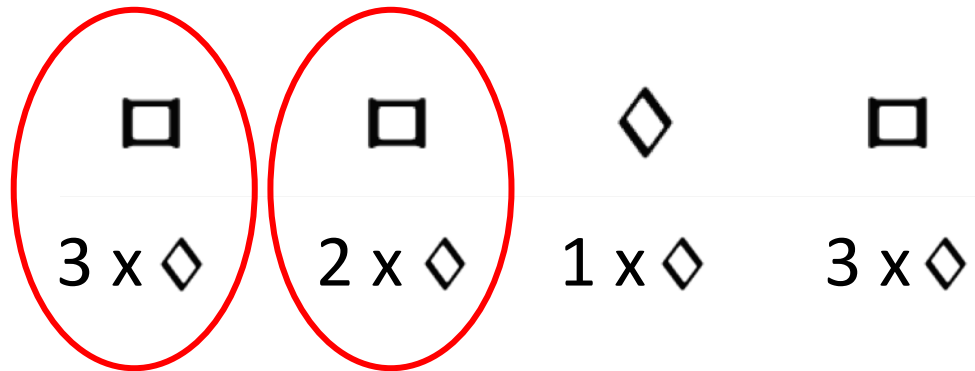
Scoring-up Tool



Mensural Notation 101

Mensural Notation

- There is a clear hierarchy in the note duration



longest

↓

shortest

Notes		Values	
Name	Shape	Perfect	Imperfect
Maxima	⏏	q q q	q q
Long	q	□ □ □	□ □
Breve	□	◇ ◇ ◇	◇ ◇
Semibreve	◇	⏏ ⏏ ⏏	⏏ ⏏

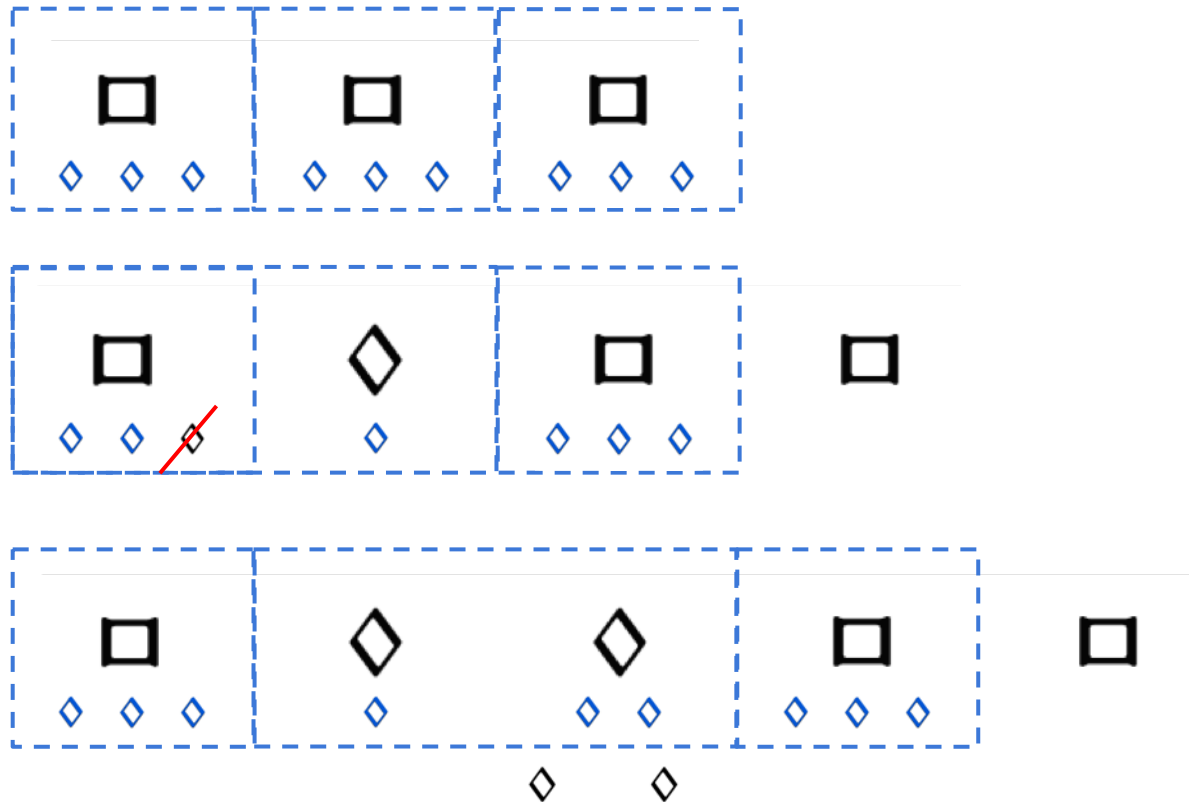
Mensuration

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

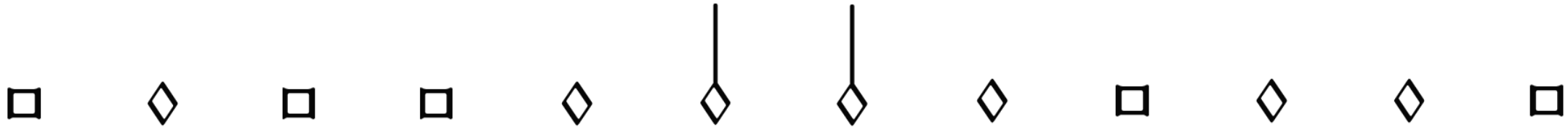
Franco of Cologne

Ars Cantus Mensurabilis (ca. 1280)

The Scoring-up Tool

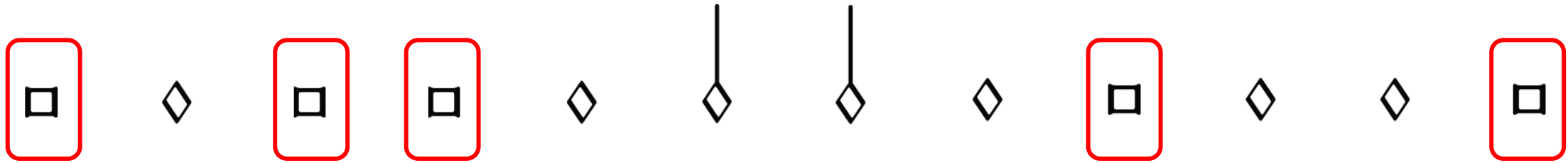
Algorithm

Mensuration: Breve = 3 \rightarrow Breves are perfect by default



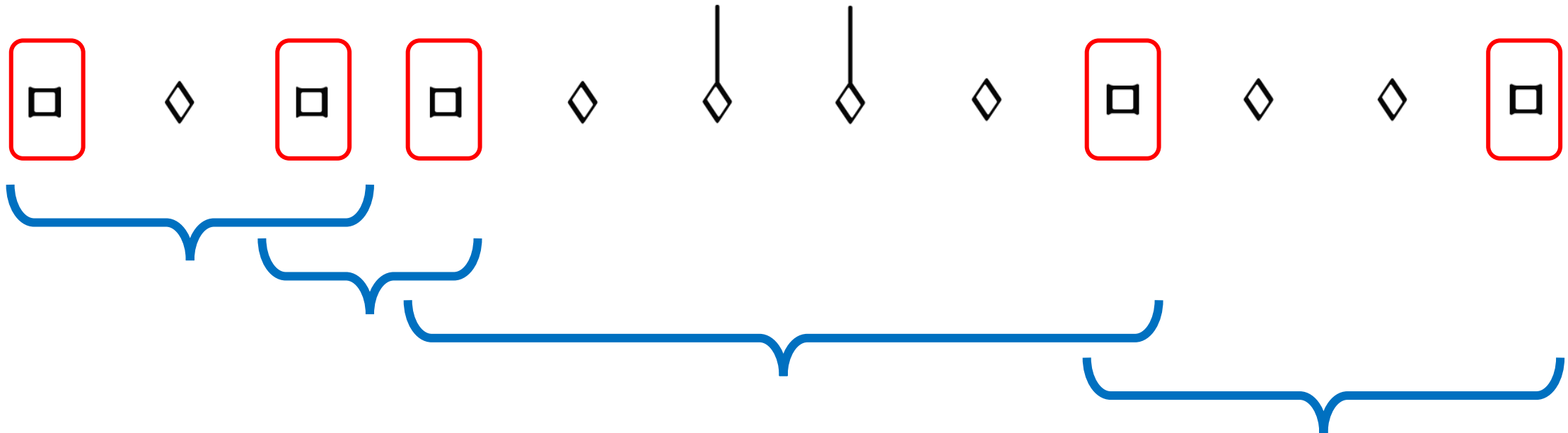
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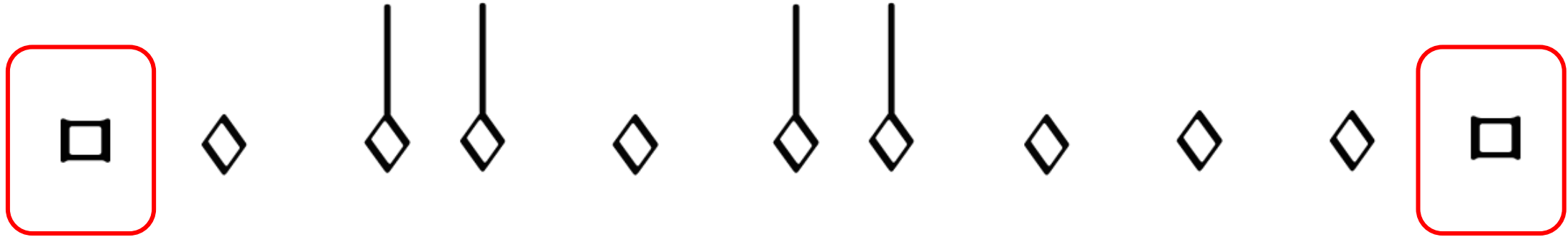


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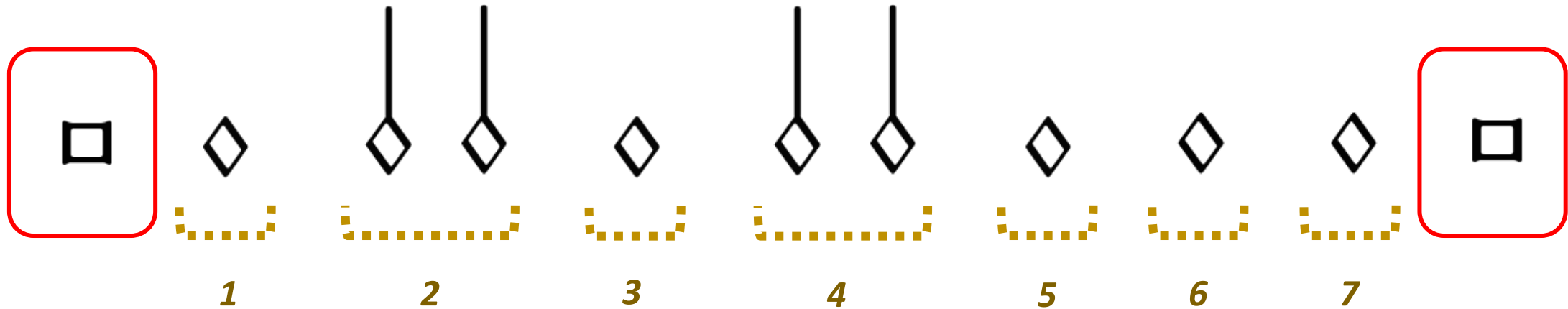


Example: (sequence bounded by breves)



Example in *perfect tempus and minor prolatio*

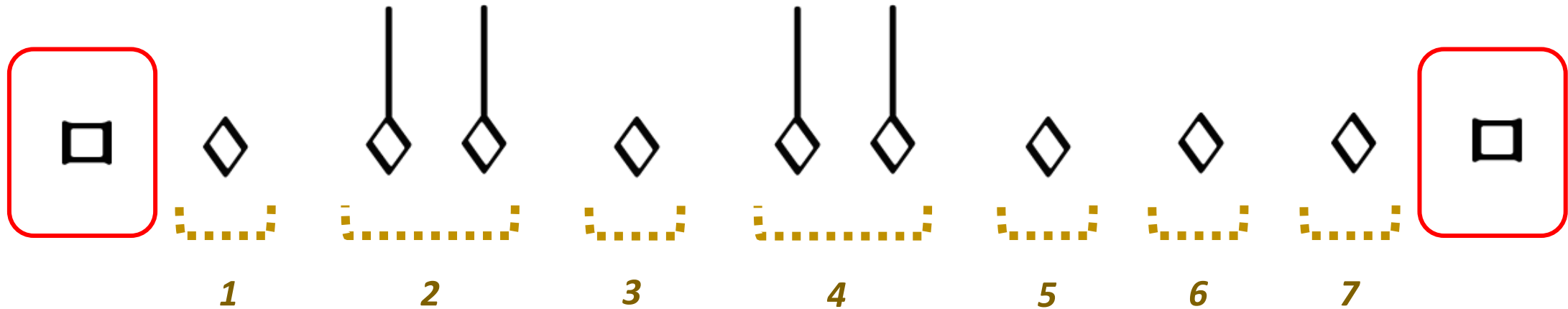
Example: (sequence bounded by breves)



7 semibreves

Example in *perfect tempus and minor prolatio*

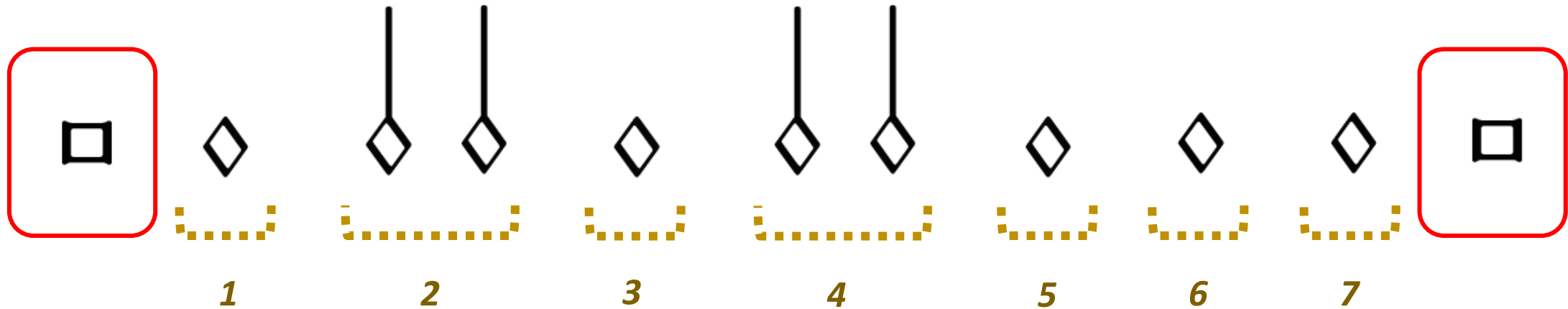
Example: (sequence bounded by breves)



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	-

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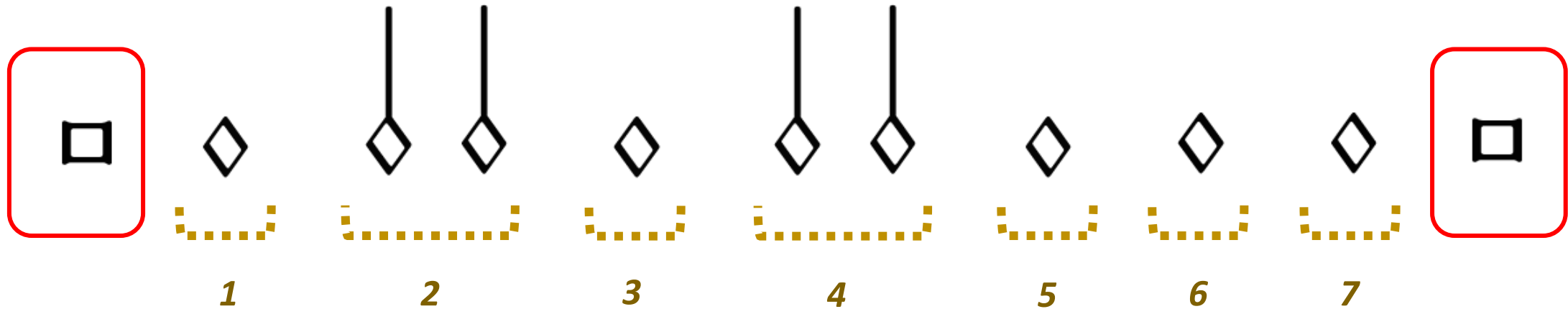
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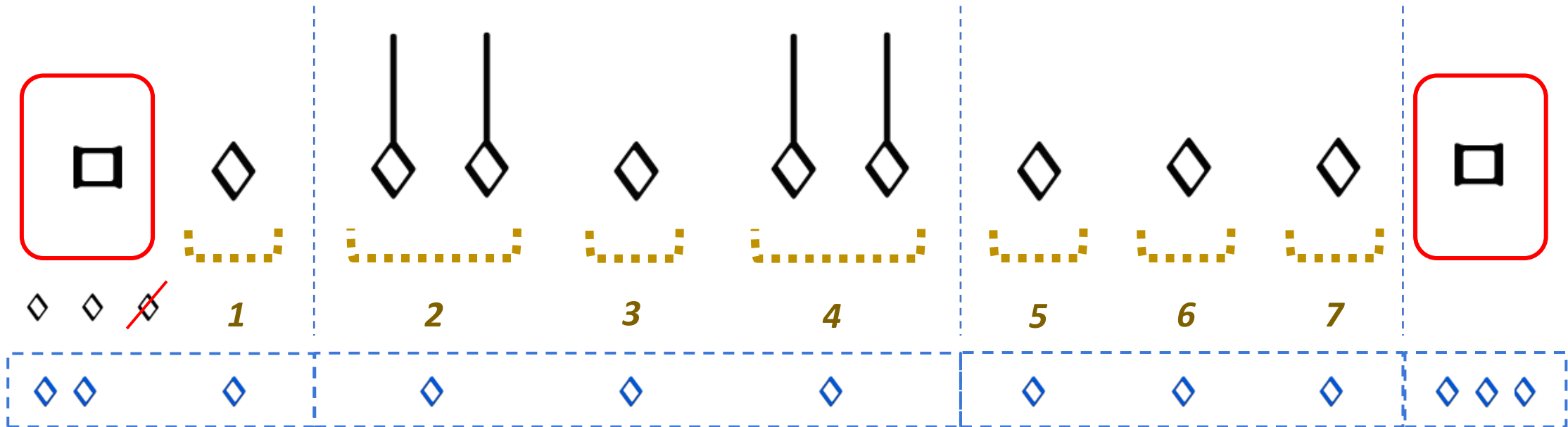
Example: (sequence bounded by breves)



7 semibreves = Two groups of 3 semibreves + 1

Example in *perfect tempus and minor prolatio*

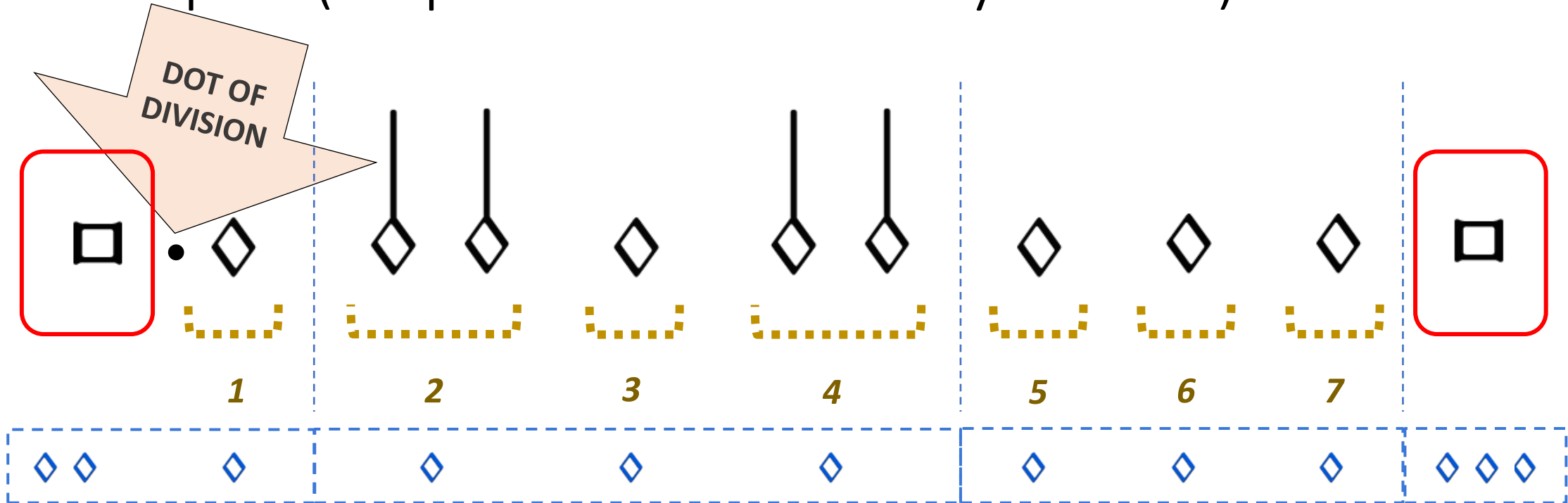
Example: (sequence bounded by breves)



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Example in *perfect tempus and minor prolatio*

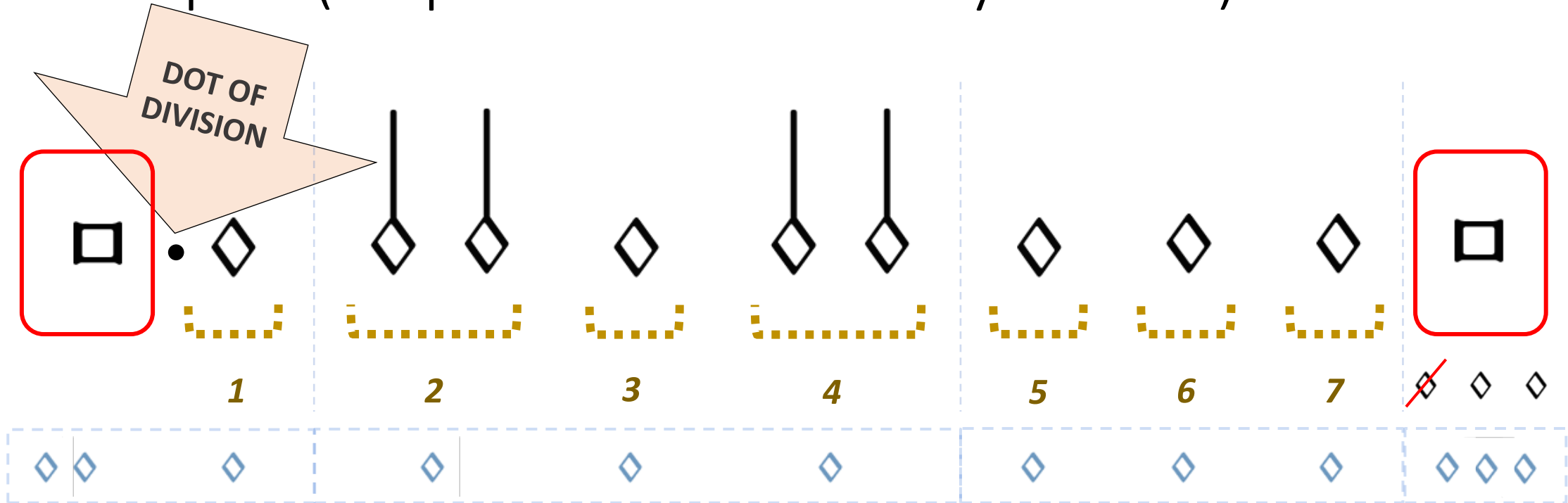
Example: (sequence bounded by breves)



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Example in *perfect tempus and minor prolatio*

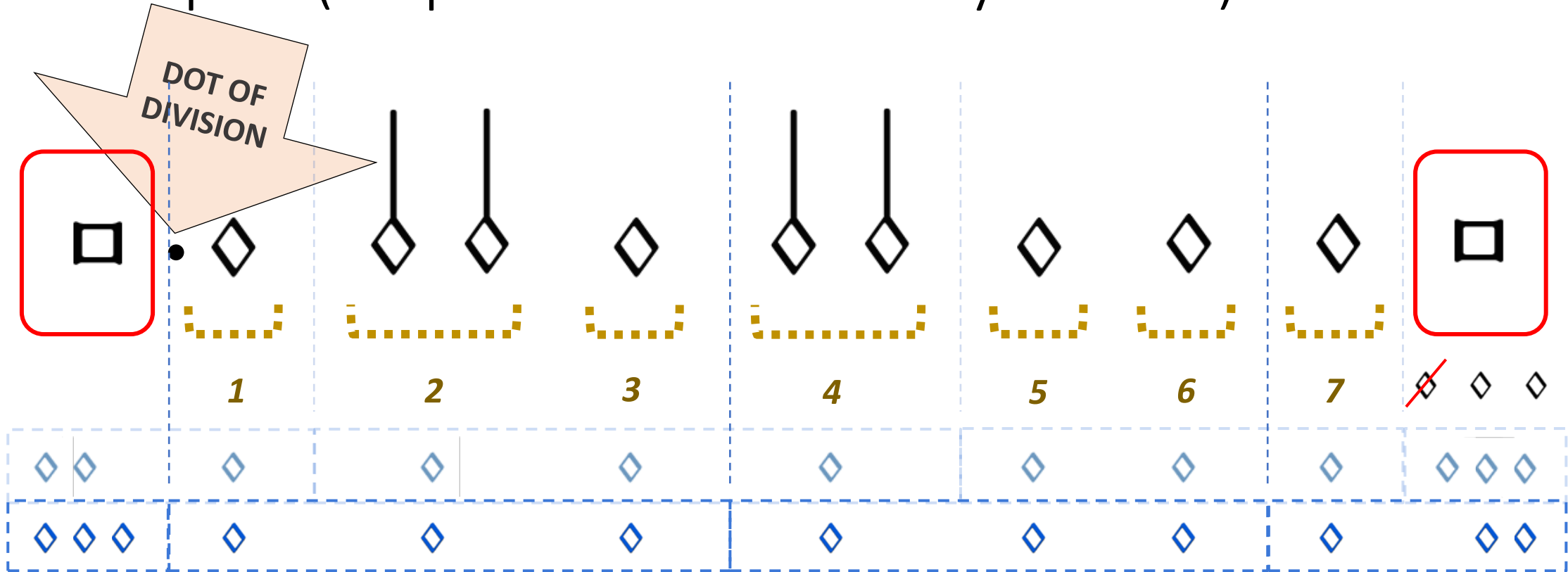
Example: (sequence bounded by breves)



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Example in *perfect tempus and minor prolatio*

Example: (sequence bounded by breves)



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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 →

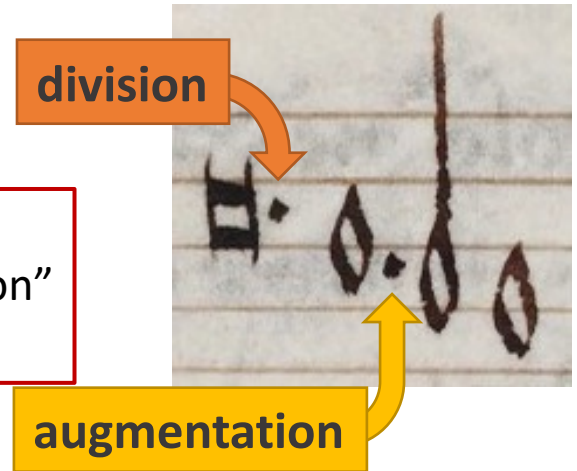
When?
Distinguish between “dots of division”
and “dots of augmentation”
 - Coloration



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Scoring-up Tool

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When?

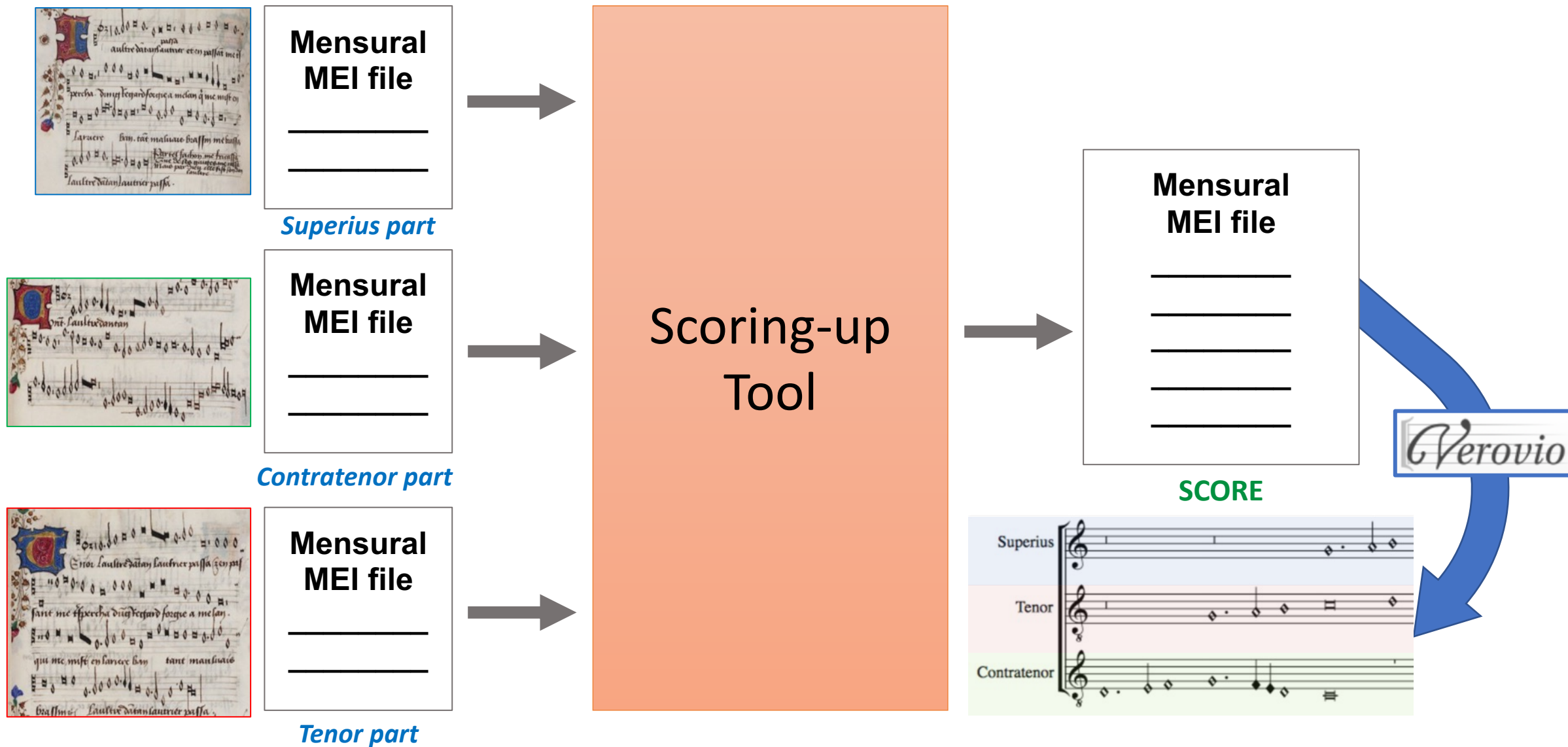
Distinguish between “dots of division”
and “dots of augmentation”

- Coloration



When does coloration affect the note value?

Scoring-up Tool



Data used for the Experiment

Pieces from the XIV and XV Centuries

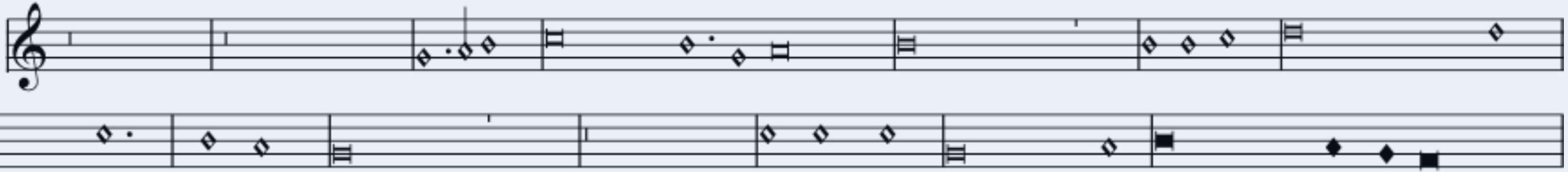
Century	Project	Format	Composers and Sources	Number of Pieces
XIV	Measuring Polyphony Project (Karen Desmond http://measuringpolyphony.org)	Mensural MEI	Vitry, Machaut, Anonymous (Ivrea Codex)	8
XV	Josquin Research Project (Jesse Rodin, Craig Sapp, Clare Bokulich)	Modern transcriptions converted into 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, organized into two systems. The first system contains three staves labeled 'Superius', 'Tenor', and 'Contratenor' on the left. Each staff begins with a treble clef and a common time signature 'C'. The notes are represented by diamond-shaped symbols, some with stems and flags, and are not aligned across the staves. The second system consists of three additional staves without labels, continuing the musical notation with similar diamond-shaped notes and stems. Vertical red lines are used as bar lines to divide the music into measures across all staves.

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

The image displays a musical score for three vocal parts: Superius, Tenor, and Contratenor. The score is written on three staves, each with a treble clef and a key signature of one flat (B-flat). The Superius part is the highest, followed by the Tenor, and then the Contratenor. The score is divided into measures by vertical red lines. The notation includes various note values (quarter, eighth, and sixteenth notes), rests, and accidentals (sharps and flats). The Tenor and Contratenor parts are marked with an '8' below the staff, indicating an octave shift. The score is presented in a clean, professional format, typical of a printed musical score.

Conclusions

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

Future work

Optical Music Recognition (OMR)

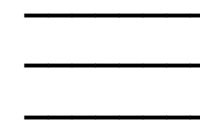
- Similar to Optical Character Recognition (OCR)



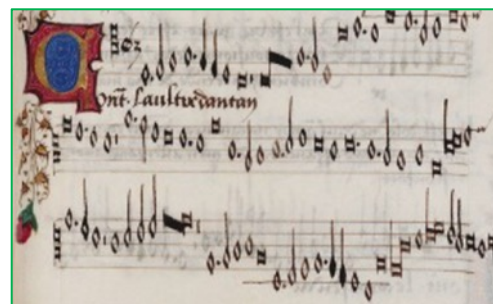
OMR



Mensural
MEI file



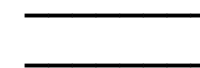
Superius part



OMR



Mensural
MEI file



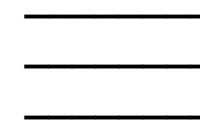
Contratenor part



OMR

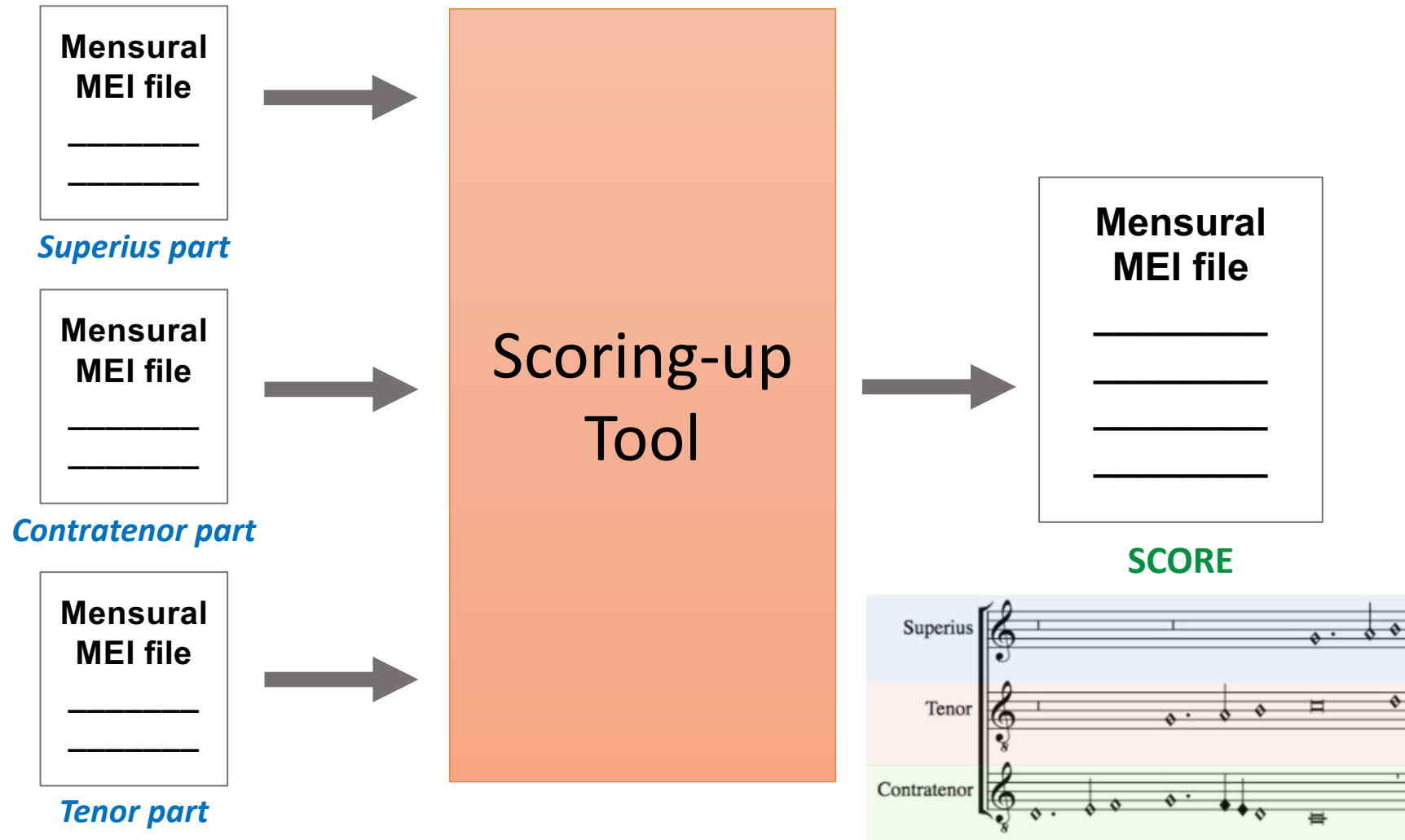


Mensural
MEI file

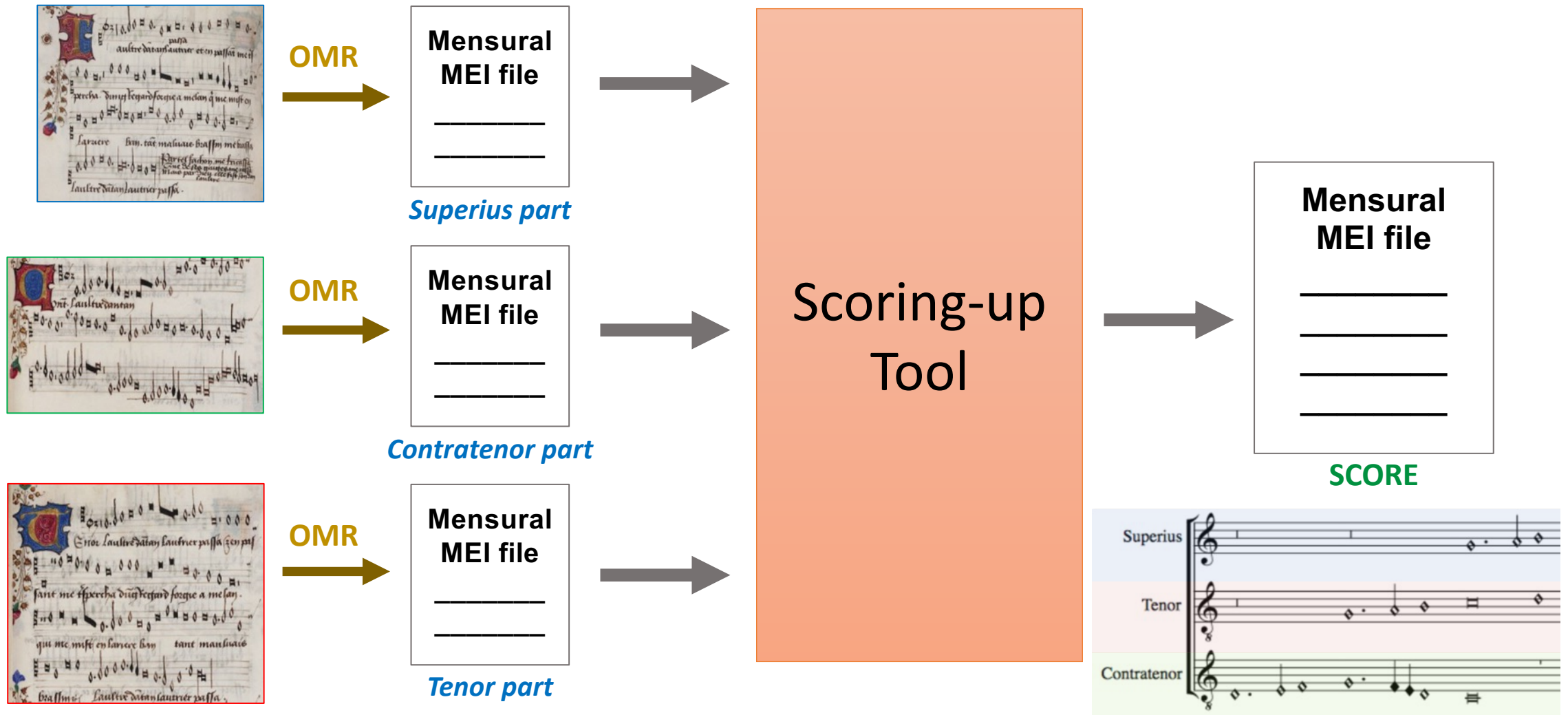


Tenor part

Future work



Future work



Thank you!

martha.thomaeelias@mail.mcgill.ca

<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



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Schulich School of Music
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Centre for Interdisciplinary Research
in Music Media and Technology

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Sources of Error

Types of Error		Instances	Mislabeled Notes
Errors in the sources	Absence of a dot of division	11	25
	Others	1	1
Errors in the experiment	Placement of the dot of division	4	7
	Last note	7	7
	Missing information regarding the staff-line in which a rest lies	2	4
	Others	1	2
Errors due to situations out of the scope of the principles of imperfection and alteration		5	9
			55

Absence of a dot of division

Discantus

Tenor

Contra

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

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

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

Discantus

Tenor

Contra

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

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

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Discantus

Tenor

Contra

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

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

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

musical score for two parts: triplum and motetus.

triplum

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

motetus

8 est tou - te la mieux par - ti - e

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 key signature of one flat (B-flat). The time signature is 8/8. The triplum part has a red box highlighting the first six measures. The motetus part has a dashed box highlighting the first six measures. The lyrics are written below the staves. The triplum lyrics are: e _____ qu a - li - xan - dre hot en sa vi - e. The motetus lyrics are: est tou - te la mieux par - ti - e.

triplum

8

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

motetus

8

est tou - te la mieux par - ti - e

triplum

8

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

motetus

8

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

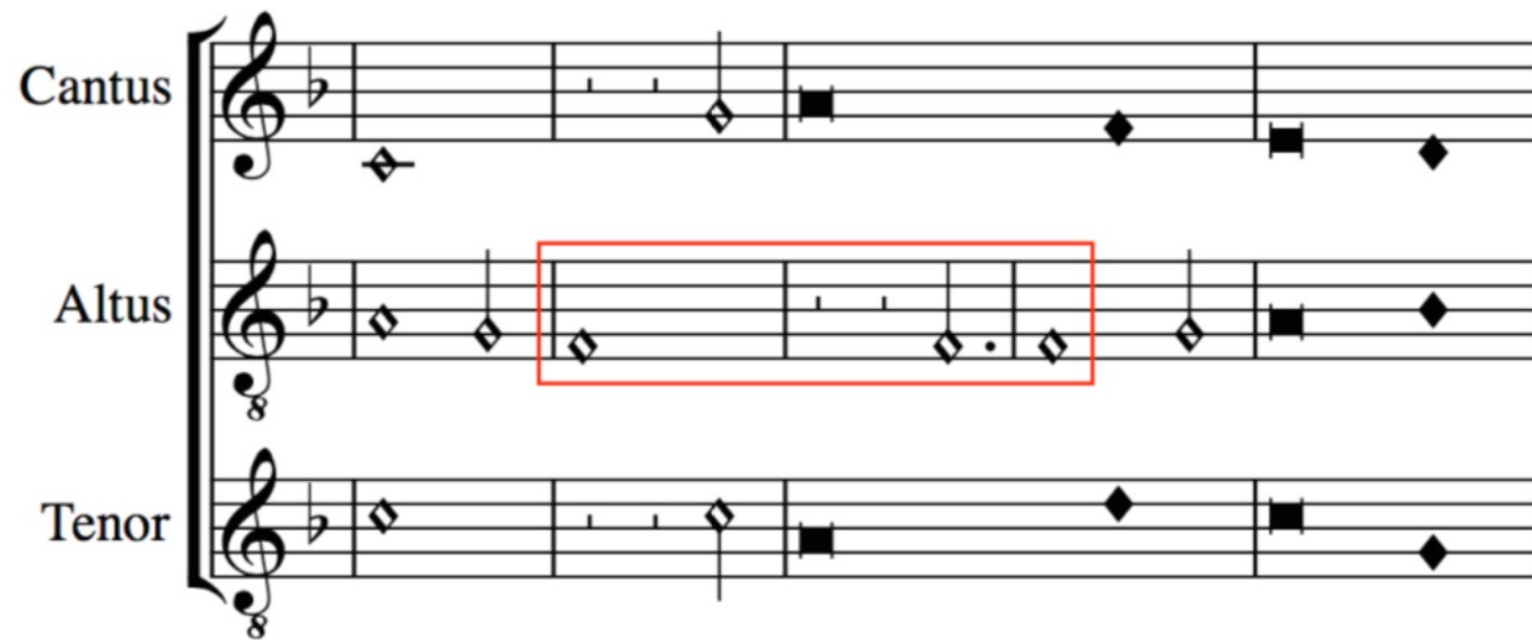


Figure 4-16: Ground truth interpretation of Duf16002 (altus) based on a modern transcription.

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

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

Cantus

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

Contratenor

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

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)

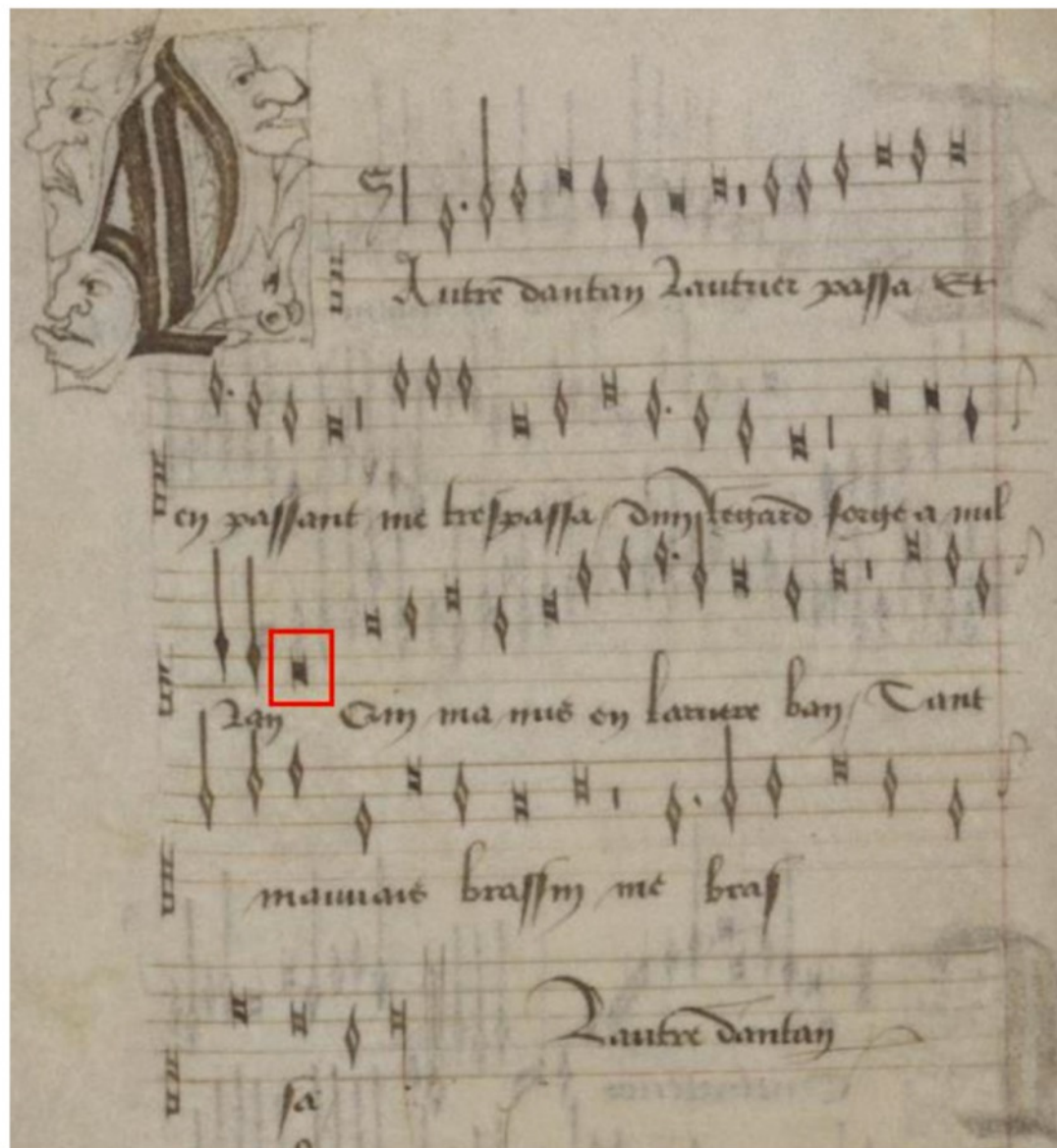


Figure 4-10: Tenor voice in Ock3009 according to Dijon.



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 modern transcription style, featuring a treble clef for the Discantus and Contra parts, and a bass clef for the Tenor part. The lyrics are written below the staves. The first measure of the score is highlighted with a dashed blue box, indicating a hemiola group coloration. The lyrics for the first measure 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 lyrics for the second measure are: "He-las, je suis con-tre mon vueil en vi-e, si n'est Mo-rir ne puis et tous-jours m'y con-vi-e, m'est bien".

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