Computer Applications to Byzantine Chant: A Relational Database for the Koinonika of the Asmatikon[*]

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1. Introduction and Motivations

The peculiarities of the Greek and Palaeoslavonic communion chants of the asmatikon repertory and the pioneering avenues for the encoding of Byzantine notation, which were opened up by the Copenhagen code, developed by Nanna Schiødt and Bjarner Svejgård since 1971[1], have been the elements which gave to me the idea to design a relational database containing the textual and neumatic data of the two mentioned repertories.

The present paper focuses on the database project and provides a description of the criteria I have used for the encoding and storing of the original data – up to fifteen neumatic rows. This comes at the end of a research which has been based on the tabulation of all the available sources of the Byzantine and Palaeoslavonic koinonika repertories[2]. Whereas the tabulation of all the extant MSS is workable in the standard format of a paper edition, the sheer quantity of neumatic and melodic data to be compared and handled demands different solutions.

The project's goal is to enable connection and retrieval of a very large amount of musical information, encoded with due regard for both the nature of the neumatic material and the analytical purposes for which the code can be used.

2. Data and Sources: The Communion Chants Repertories

Equivalent to the Western communion, the koinonikon is a chant of the Byzantine Divine Liturgy. The earliest Byzantine melodies, expressed in round notation, are transmitted in the asmatika, choir-books containing the melismatic chanted texts of the cathedral rite of Constantinople. The repertory of the koinonika of the asmatikon consists of over sixty melodies and twenty-six texts, preserved in eleven manuscripts, datable from the 12th-13th to the 14th centuries, from Southern Italy (CITTÀ DEL VATICANO, Biblioteca Apostolica Vaticana, Borg. gr. 19 and Vat. gr. 1606; GROTTAFERRATA, Biblioteca della Badia Greca, Γ.γ.I, Γ.γ.V, Γ.γ.VI, Γ.γ.VII, Ε.α.XIII and Ε.β.I; MESSINA, Biblioteca Regionale Universitaria, Fondo

[*] I wish to thank Professor Christian Troelsgård for encouraging this project in its initial stages. Reviewing the preliminary description he made important suggestions as regards the treatment of texts.

[1] Nanna Schiødt, "A Computer-Aided Analysis of Thirty-five Byzantine Hymns", *Studies in Eastern Chant*, ed. Miloš Velimirović (London, 1971), vol. 2, pp. 129-154.

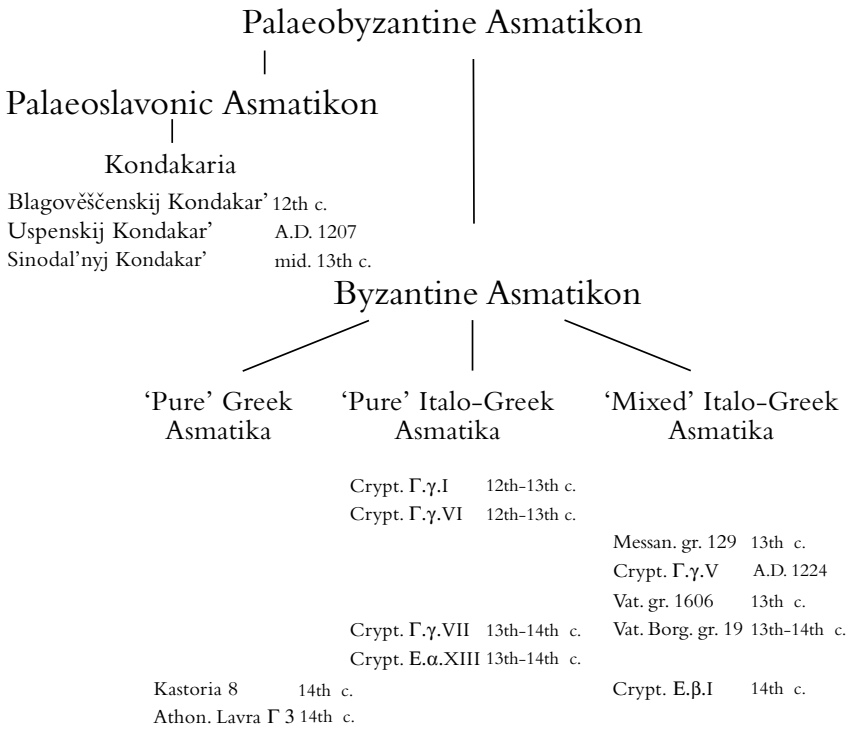
[2] The most significant studies in this area present only a selection of the round notation and/or kondakarian versions. Cf. Dimitri Conomos, *The Late Byzantine and Slavonic Communion Cycle: Liturgy and Music* (Dumbarton Oaks, 1985); Simon Harris, "The Communion-Chants in 13th Century Byzantine Musical MSS", *Studies in Eastern Chant*, ed. Miloš Velimirović (London, 1971), vol. 2, pp. 51-67 and *The Communion-Chants of the Thirteenth-Century Byzantine Asmatikon*, ed. Simon Harris (Amsterdam, 1999).

S. Salvatore, gr. 129)[3] and Greece (ΑΘΩΣ, Μονὴ Μεγίστης Λαύρας, Γ 3 and ΚΑΣΤΟΡΙΑ, Βιβλιοθήκη τῆς Μητροπόλεως, 8).

Two cycles are used to transmit the communion chants: the cycle of the oktoechos and the cycle of the liturgical year that follows the major feasts in the ecclesiastical calendar, with fixed and movable feasts combined in a single order. Several koinonika in the latter group are provided with more than one setting but with no fixed oktoechal scheme.

The majority of the texts are from the Psalter, but there are two non scriptural texts (for Holy Thursday and Easter); in all but these two cases the koinonika conclude with the alleluia refrain which frequently surpasses in length and elaboration the moderately melismatic choral settings of the scriptural texts.

Figure 1. Slavonic and Byzantine MSS transmitting the koinonika repertories



L Γ 3	ΑΘΩΣ, Μονὴ Μεγίστης Λαύρας, Γ 3	
C Γ.γ.I	GROTTAFERRATA, Biblioteca della Badia Greca,	Γ.γ.I
C Γ.γ.V		Γ.γ.V
C Γ.γ.VI		Γ.γ.VI
C Γ.γ.VII		Γ.γ.VII
C E.α.XIII		E.α.XIII
C E.β.I		E.β.I
K 8	ΚΑΣΤΟΡΙΑ, Βιβλιοθήκη τῆς Μητροπόλεως, 8	
M 129	MESSINA, Biblioteca Regionale Universitaria, Fondo S. Salvatore, gr. 129	
SK	MOSKVA, Gosudarstvennyi Istoričeskij Muzei (GIM), Sin. Tip. 777 (Sinodal'nyj Kondakar')	
UK	MOSKVA, Gosudarstvennyi Istoričeskij Muzei (GIM), Usp. 9 (Uspenskij Kondakar')	
BK	SANKT-PETERBURG, Rossijskaja Nacional'naia Biblioteka, Saltykov Shchedrin, Q.n.I. 32 (Blagověščenskij Kondakar')	
B 19	VATICANO, CITTÀ DEL, Biblioteca Apostolica Vaticana,	Borg. gr. 19
V 1606		Vat. gr. 1606

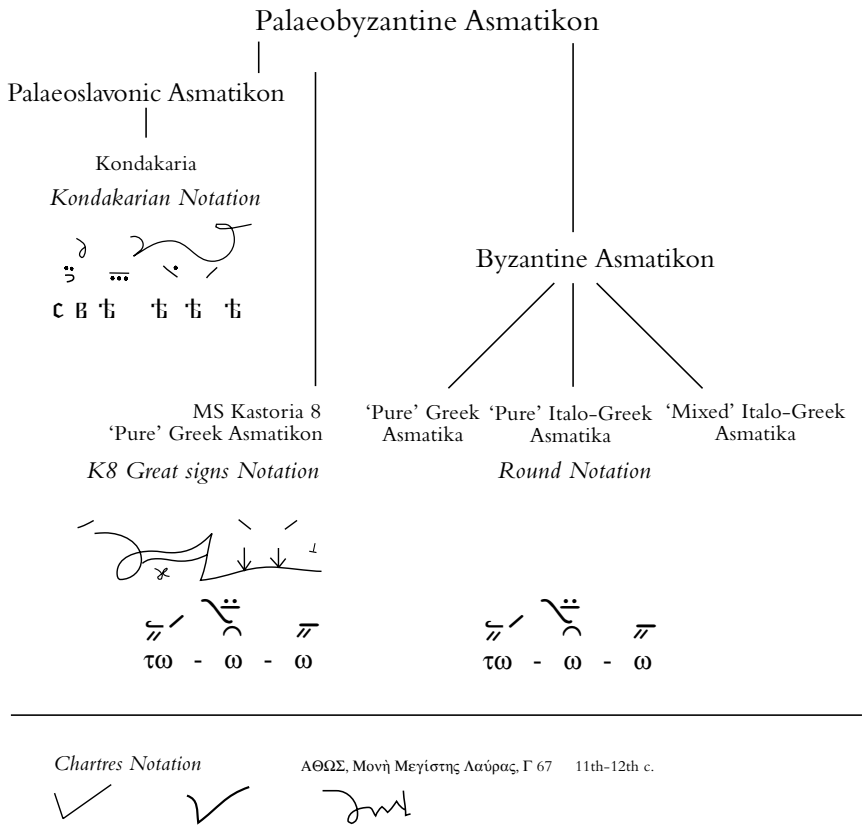
[3] Vat. Borg. gr. 19, Vat. gr. 1606, Crypt. Γ.γ.V, Crypt. E.β.I and Messan. gr. 129 combine the content of the Asmatikon with the repertory of the Psaltikon, the soloist's book. Cf. Oliver Strunk, "S. Salvatore di Messina and the Musical Tradition of Magna Graecia", *Essays on Music in the Byzantine World*, ed. Kenneth Levy (New York, 1977), pp. 45-54.

The tabulation of all the round notation versions, as I have produced in the traditional edition on paper[4], points to a substantially uniform tradition, with the unique exception of Borg. gr. 19. However, within this substantially uniform tradition, there are occurrences of small neumatic variants among the different versions, as well as modal ambiguities and melodic transpositions of chant sections. There are also differences in the number and disposition of the medial cadences.

The case of this repertory is, however, more complex and it is an oversimplification to consider only the Middle Byzantine notational system. Among the Greek asmatika, manuscript Kastoria 8 stands out because its notation is expressed in great 'stenographic' signs placed over the standard round notation version. It most likely recalls archaic adiastematic notational systems such as, the Palaeobyzantine Chartres notation and the kondakarian notation of the Palaeoslavonic asmatikon.

The Slavonic counterpart of the koinonika is transmitted in three kondakaria dating from the 12th to the 13th centuries: SANKT-PETERBURG, Rossijskaja Nacional'naia Biblioteka, Saltykov Shchedrin, Q.n.I. 32 (Blagověščenskij Kondakar'), MOSKVA, Gosudarstvennyi Istoričeskij Muzei (GIM), Sin. Tip. 777 (Sinodal'nyj Kondakar') and Usp. 9 (Uspenskij Kondakar')[5].

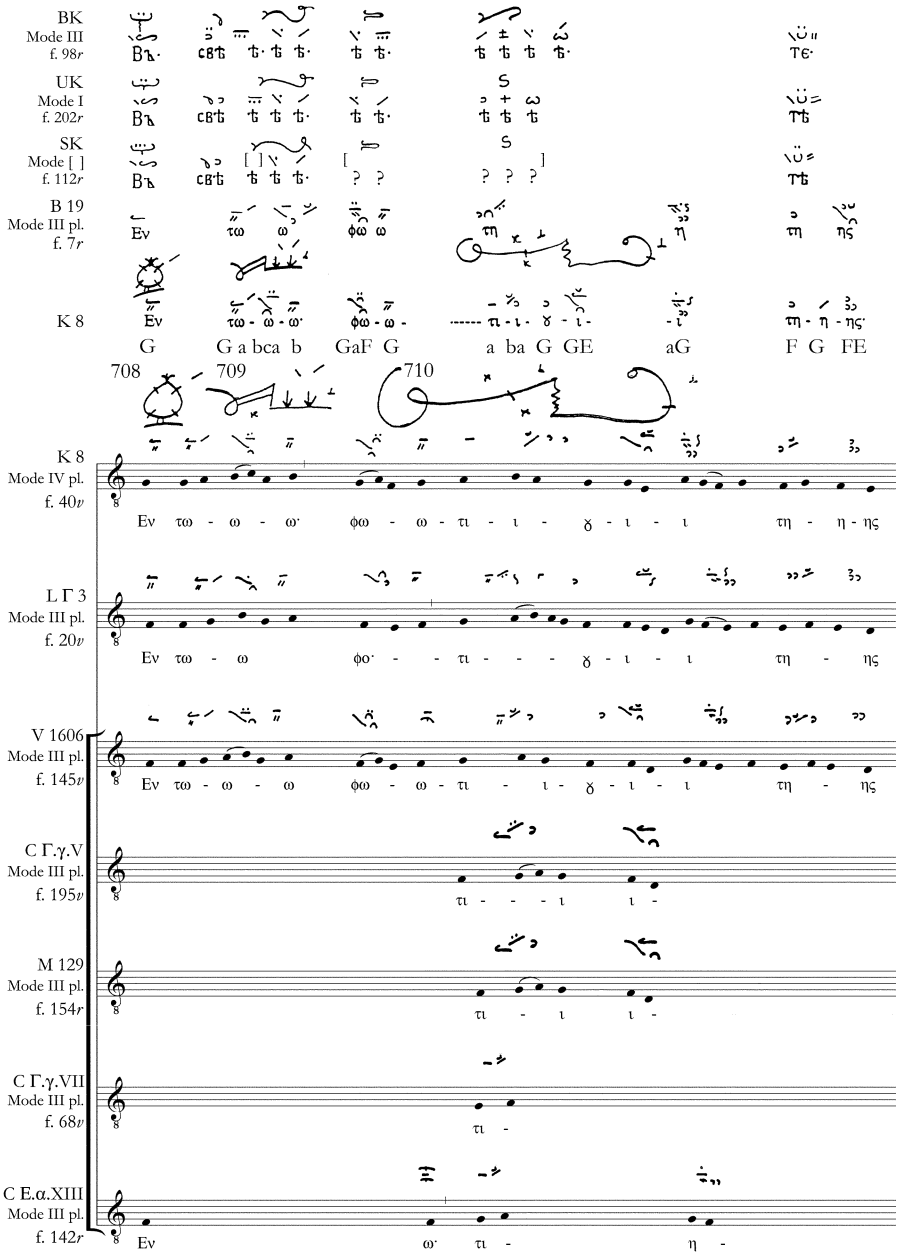
Figure 2. The notational systems employed in the koinonika repertories



[4] Cf. the *incipit* of the Koinonikon for the Liturgy of the Transfiguration of the Lord (Example 1) on p. 4 and Annalisa Doneda, *I Koinonikà dell'Anno Liturgico nel Ms Kastoria 8*, [typewritten dissertation, University of Pavia, 1993-94]; *eadem*, "Hyperstases in MS Kastoria 8 and the Kondakarian Notation: Relationships and Interchangeability", in *Palaeobyzantine Notations II. Acta of the Congress Held at Hernen Castle (The Netherlands) in October 199*6, ed. C. Troelsgaard and G. Wolfram, A.A. Bredius Foundation (Hernen, 1999), pp. 23-36.

Example 1.

Koinonikon for the Liturgy of the Transfiguration of the Lord



The kondakarian notation consists of two combined rows of neumes. The lower row presents little signs of intervallic and rhythmic value; the upper one shows 'stenographic signs', which were first called hypostases (MdO)[6] and subsequently (UNK)[7] hyperstases by Constantin Floros. The neumes can be arranged in sets in which the signs remain independent, or else they can be combined to create a new complex sign. Moreover, a few elementary signs can be rotated in different positions. The kondakarian notational system is highly complex: the hyperstases may be a form of stenographical rendering of the melodic formulas, but their definitive meaning depends on the related little signs. The combination of neumes probably allowed to represent details of the melodic line but, as far as we can understand, it creates possible variables in the deciphering of melodic and formulaic meaning.

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[5] Floros, *Universale Neumenkunde*, vol. 2, pp. 265-272.
[6] Floros, "Die Entzifferung... ".

The kondakaria transmit a communion repertory which is clearly linked to the koinonika of the Byzantine asmatikon as regards modal, melodic and textual elements. “We have a Slavic Communion cycle apparently borrowed, as far as text and liturgy are concerned, from the Constantinopolitan usage of about 1100. [...] Where the *kontakia* were disappointing, the Communions provide the musical link with Greek models that one might almost expect in these circumstances. The parallels are not limited to the mode or overall form, but extend to the fabric of the melodies. In this moderately ornate style the formulas tend to stand out, and when it appears that corresponding formulas are more or less systematically applied to corresponding words and phrases it seems clear enough that these Slavic communions descend from a Greek Asmatikon archetype.”[8].

The peculiar notation found in manuscript Kastoria 8 proves the existence of a ‘lost’ Palaeobyzantine version of the chants and confirms the validity of the criteria for deciphering the kondakarian notation worked out by Floros even before the discovery of the manuscript[9].

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The ultimate objective of the koinonika database is the complete long-term storage of the data of Byzantine and Paleoslavonic repertories, connecting text, punctuation, signatures, neumations, pitches and intervals for each chant, on the basis of the Copenhagen code. This is done in such a way as to make data accessible for a variety of uses, thus enabling one to search for string-, pitch-, or interval-combinations within the Middle Byzantine tradition. The database will also facilitate the comparison of different notational systems, such as kondakarian and Kastoria 8 notations, which can be presented in graphic or encoded formats.

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[7] Floros, *Universale Neumenkunde*, vol. 1, p. 44. ‘Hyperstases’ indicate the physical position above the row of small ‘intervallic’ signs.

[8] Kenneth Levy, *The Byzantine Communion-Cycle and its Slavic Counterpart*, Actes du XIIe Congrès International d'Études Byzantines, Ochride 1961 (Belgrade, 1963), vol. 2, pp. 571-574: 572. An exhaustive bibliography regarding the history and the deciphering of the kondakarian notation is available in Constantin Floros, “Die Entzifferung der Kondakarien-Notation”, *Musik des Ostens*, 3 (1965), pp. 7-71 and 4 (1967), pp. 12-44 and *idem*, *Universale Neumenkunde* (Kassel, 1970), vol. II, pp. 265-272; in Gregory Myers’ facsimile edition of Lavrsky Kondakar’ *The Lavrsky Troitsky Kondakar*, compiled by Gregory Myers, Monumenta Slavico-Byzantina et Mediaevalia Europensia, 4 (Sofia, 1994); as well as in his PhD thesis: *The Asmatic Troparia, Katavasiai, and Hypakoai “Cycles” in their Paleoslavonic Recensions; A Study in Comparative Paleography*, University of British Columbia, 1994 (microfiche).

[9] Cf. Floros, *Universale Neumenkunde*, vol. 2, pp. 265-272 and Doneda, “Hyperstases...”, pp. 23-24.

3. The Koinonika Database Development Processes

After having described the peculiarities of the data, I shall briefly outline the main phases involved with the development of the application.

The application design was broken down into two sub-areas: database design and program design. The database design involves understanding and breaking apart the data that are going to be entered and extracted from the application; it aims to perform all design decisions in a structured way.

Program design breaks apart the application into different processes and defines how the application is going to work.

Three distinct subphases describe the process of database design: conceptual design, logical design and physical design.

- The objective of the conceptual design is to produce a high-level, DBMS-independent schema[10], starting from requirement specifications.
- The logical design describes how the application parts will function with each other and how the database will interact.
- The physical design describes the physical technologies, databases, and implementations of visual components that the application will use.

Database design can be introduced using abstraction mechanism, the mental processes through which designers concentrate upon the properties of data that describe the reality. The most diffused model that handles abstraction mechanism model is that proposed by Chen in 1976[11], called the *Entity-Relationship model*, which depicts the relationships between data entities in a graphical form.

The E-R diagram in **Figure 3** represents the conceptual model of the koinonika database.

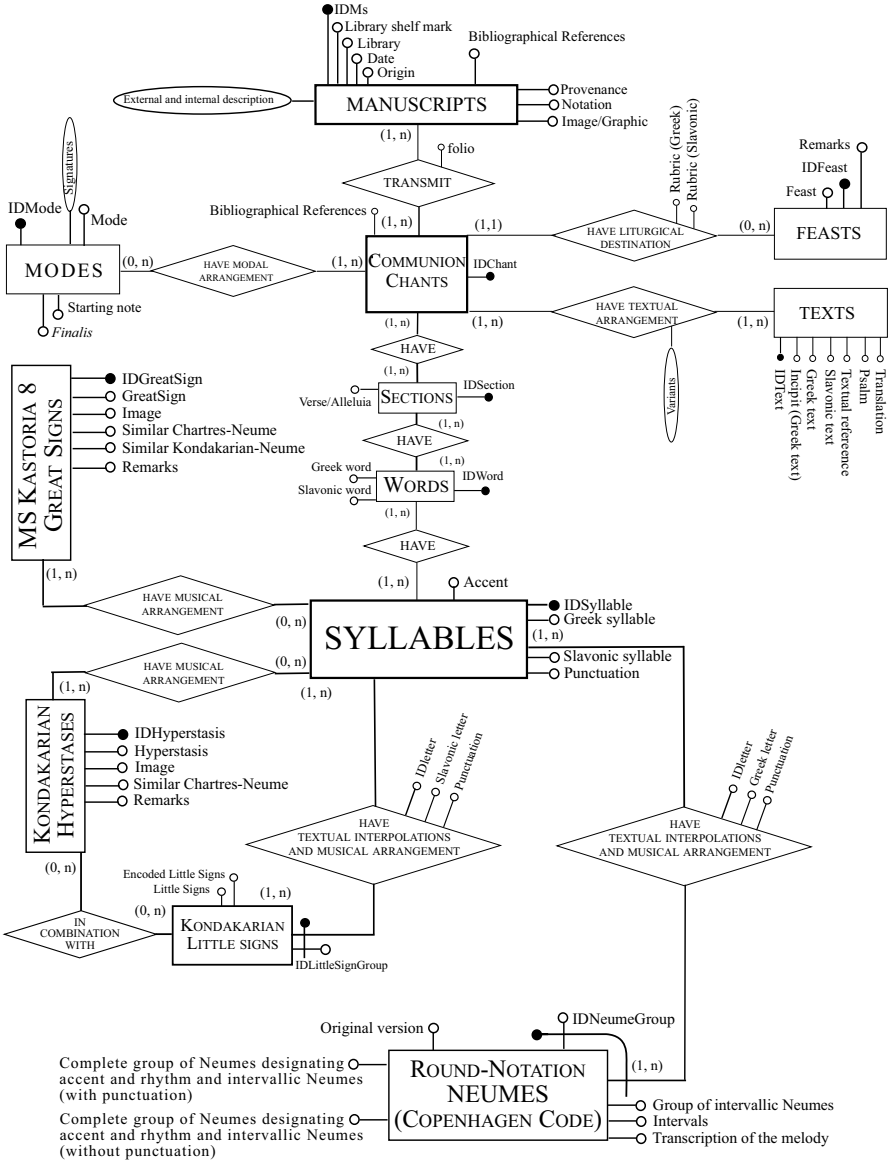
The basic elements of an E-R diagram are entity sets and relationships between these sets. Relationships are shown as diamonds and entity sets are shown as rectangles. The entity sets are MANUSCRIPTS, FEASTS, TEXTS, MODES, COMMUNION CHANTS, SECTIONS, WORDS, SYLLABLES and NEUMES of the Notational Systems involved (ROUND NOTATION neumes, encoded according to the Copenhagen code, KONDAKARIAN HYPERSTASES with related LITTLE SIGNS and KASTORIA 8 GREAT SIGNS).

Diamonds express relationships such as *transmits*, *has many*, *has one*, *has zero or one*, *represents*, and so on.

[10] DBMS = Database Management System

[11] Cf. Peter P. Chen, "The Entity-Relationship Model: Toward A Unified View of Data", *ACM Transactions on Database Systems* 1/1 (1976), pp. 9-36 and Paolo Atzeni - Stefano Ceri - Stefano Paraboschi - Riccardo Torlone, *Basi di dati: concetti, linguaggi e architetture* (Milano 1999).

Figure 3. The Entity-Relationship diagram of the koinonika database



In the koinonika database:

- MANUSCRIPTS transmit TEXTS, and each TEXT can have many musical settings for various different liturgical destinations.
- Musical settings are related to the BYZANTINE and SLAVONIC MODAL SYSTEMS.
- Each COMMUNION CHANT combines the elements listed above.
- The vast majority of the chants consist of two SECTIONS: verse and alleluia.
- Each SECTION can be subdivided (verses and/or hemistichs and/or words).
- Each WORD can be subdivided into single syllables, where accented syllables will be highlighted.
- For each SYLLABLE, the entities ROUND NOTATION NEUMES, KASTORIA 8 GREAT SIGNS, and KONDAKARIAN HYPERSTASES store the appropriate neumatic, rhythmic, intervallic, and melodic data.

Once the entities and their relationships were defined,

- key attributes for each entity were established;
- each entity was completed with all the attributes;
- all entities were normalized;
- it was ensured that all events and operations were supported by the model.

The next step in the database design was converting this model into a logical model.

- The logical model of the koinonika database is relational. Following the fundamental steps of database design and development the E-R diagram was translated into the relational model.

In the last step the physical model described how Microsoft Access 2000® manages physical data storage.

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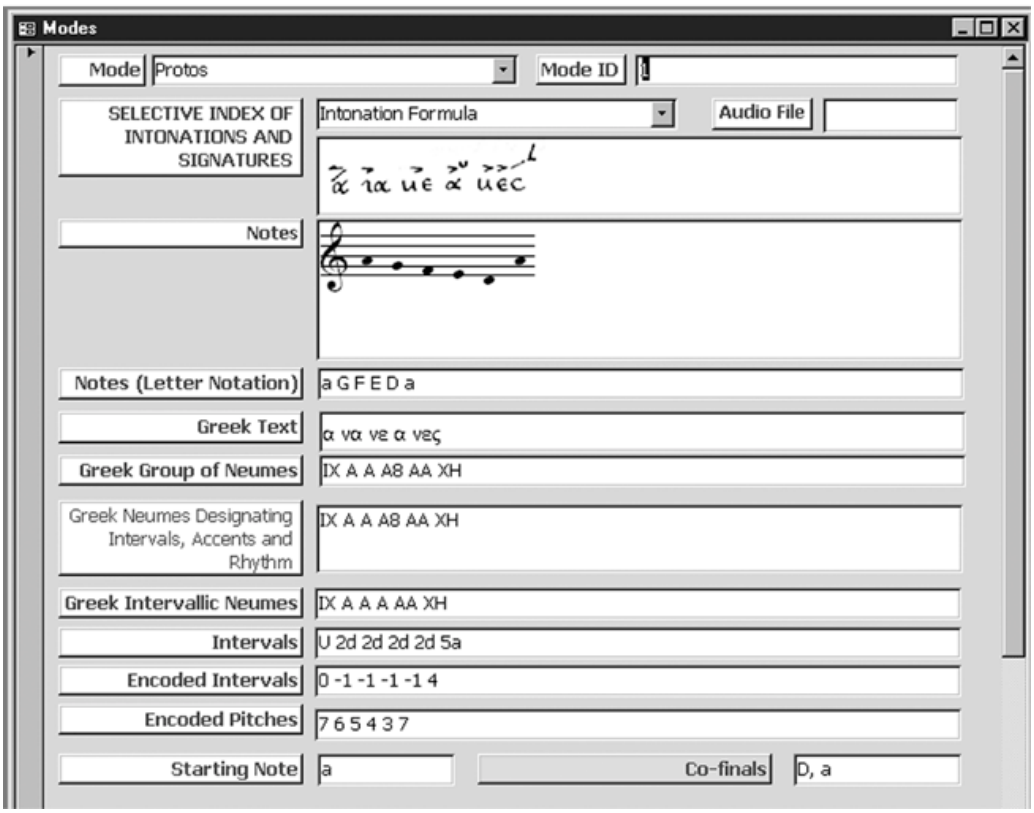
Now, for the sake of brevity, I shall point out only the most important entities and relationships of the diagram (cf. **Figure 3**). Moreover, using snapshots to make the procedure of data storage more comprehensible, I shall show several significant tables and forms of the koinonika database file that I implemented with Microsoft Access 2000® and Visual Basic®. At present the database contains only a selection of textual, neumatic and melodic data of the repertoire.

- Entity MANUSCRIPTS stores a number of identificatory features pertaining to each codex, such as library shelf mark, library, date, origin, provenance, notations, external description, internal description, bibliographical references and image/graphics, when available.

Figure 4. Entity MODES stores data related to Byzantine and Slavonic modes: pitches, signatures and/or intonation formulas, encoded according to the Copenhagen code (cf. Figure 5)[12] and ".wav" files. The Copenhagen code uses *alphabetic code symbols* for intervallic neumes and *numeric code symbols* for neumes designating accent and rhythm. Additional symbols are: *comma,* to separate neumes and groups of neumes, *underscore* in combination with Dyo Kentemata, *space* to separate neumes and groups of neumes.

Figure 4. Entity Modes



[12] See Schiødt, "Computer-Aided Analysis", pp. 131 and 135.

Figure 5. The Copenhagen Code

CODE SYMBOLS

Intervallic Neumes

Neume	*Name of Neume*	*Code Symbol*
	Ison	I
	Oligon	O
	Oxeia	X
	Petaste	P
	Kouphisma	U
	Kentema	K
	Hypsele	H
	Apostrophos	A
	Elaphron	E
	Hyporrhoë	R (r)
	Chamele	C
	Dyo Kentemata	D

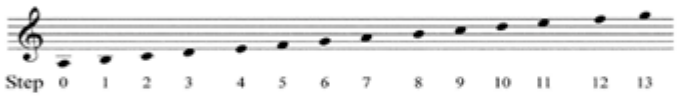
Neumes Designating Accent and Rhythm

Neume	*Name of Neume*	*Code Symbol*
	Bareia	1
	Piasma	2
	Xeron Klasma	3
	Kylisma	4
	Apoderma	5
	Diple	6
	Kratema	7
	Tzakisma	8
	Gorgon	9

Additional Symbols

:	End of Hymn
_	Used in Combination with D
,	Separates Neumes and Groups of Neumes
space	Separates Neumes and Groups of Neumes

Sequence of Notes Used



Upward Intervals

0	+1	+2	+3	+4	+5	+6	+7
I	O	K	KO	OH	HP	HOX	HKO
IP	P	OP	KP	PH	HX		
IX	X	OX	KX	XH			
IU	U	OK		KOP			
r	D	XK					
		PK					

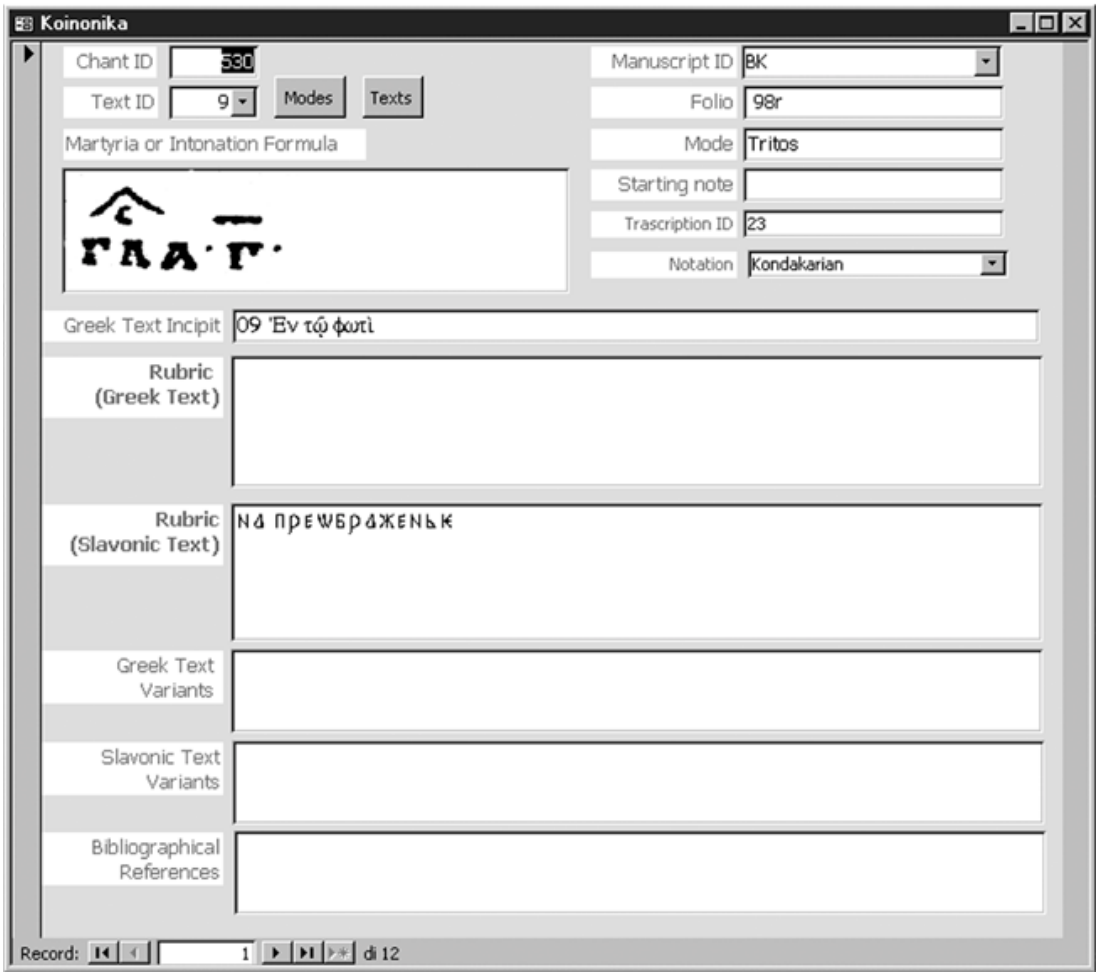
Downward Intervals

-1	-2	-3	-4
A	E	EA	AC
AA	R	EAA	AAC
AP	EP		
	AE		
	AAE		

- Entity FEASTS stores data related to the feasts of the liturgical year.
- Entity TEXTS stores the incipit of each Greek text, the whole Greek and Slavonic texts, an Italian translation and the relevant scriptural references.

Figure 6. Entity KOINONIKA stores data relating to each musical setting (the total number adds up to 450). This procedure of data storage facilitates the subsequent comparison of the round notation neumatic versions because each koinonikon can be separately treated and analysed. The data are: folios, mode, rubric (Greek or Slavonic), references to Greek or Slavonic text and bibliography.

Figure 6. Entity Koinonika



- Entity SECTIONS stores the verse/alleluia subdivision of each koinonikon. A further subdivision is related to the textual structure of the verse and to the musical structure of the melismatic setting of the alleluia. At the present stage of the project, considering the formulaic peculiarity of the repertoire, the first subdivision is related to hemistichs and/or single words. Subroutines will allow the grouping of words and encoded neumes, pitches and intervals in single fields as continuous strings of signs, reconstructing the structure of the chants.

- Entity WORDS stores every word in either Greek or Slavonic for each koinonikon.
- Entity SYLLABLES stores syllables of each word, inclusive of accentuation and punctuation.

The method used in storing texts is crucial because it is the starting point for the process of linking musical data and for the subsequent procedure of data retrieval through specific queries. The basic unit for queries, notational comparison, and musical analysis is the syllable. Syllables are, however, further divided into letters, including vowel repetitions and interpolated asmatic letters, which are preserved in transcription just as they are found in the manuscripts.

Figure 7. INPUT form for ROUND NOTATION NEUMES LINKED TO LETTERS. Each encoded neume is linked to its syllable or letter of vocalization. Subroutines automatically translate the melodic values of the neumes to intervals and write down the related pitches, according to the Copenhagen code, expressed in numbers and letter notation.

Figure 7. Input form for round notation neumes linked to letters

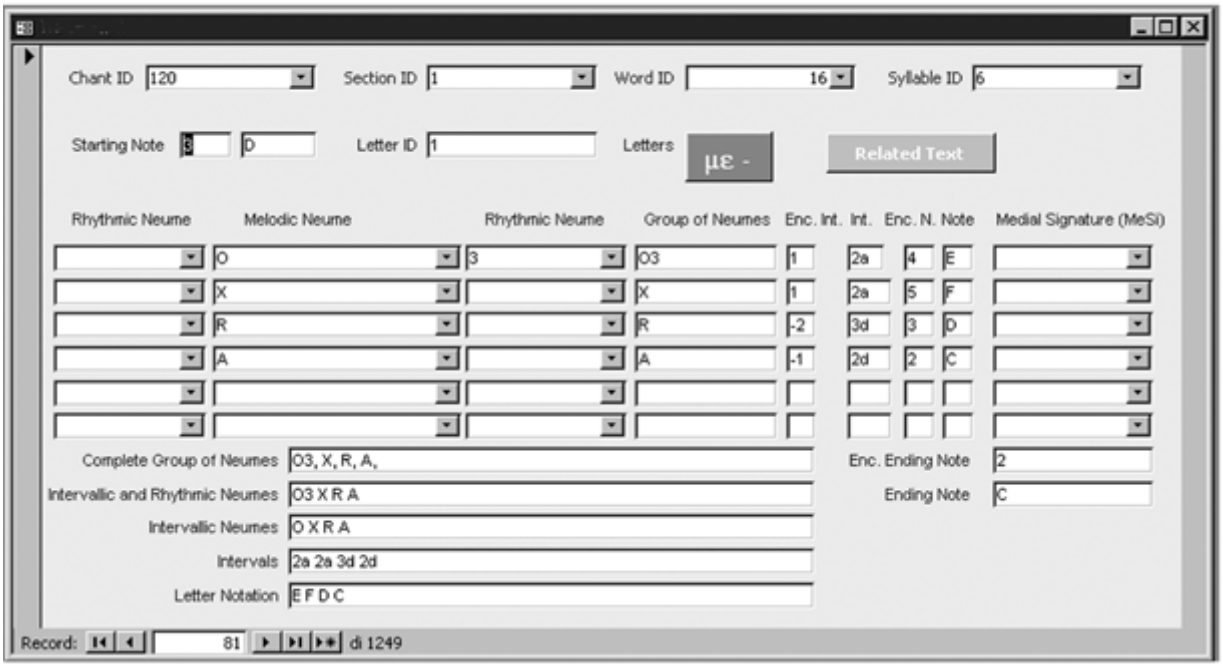


Figure 8. Table ROUND NOTATION NEUMES LINKED TO LETTERS. It stores complete groups of neumes for each Greek vowel or interpolated letter because the neumation of simple signs and rhythmical signs is recorded for detailed searches. A complete group of neumes contains neumes designating accent and rhythm and intervallic neumes. Other data stored in this table are the intervals and the transcription of the melody in letter notation. These multiple presentations of neumatic data make the search operations more flexible.

Figure 8. Table Round notation neumes linked to letters

Koinonikor	Sect	Word	Syll.	Letter	Greek Le	Group of Neu	Intervallic and Rhytl	Intervallic Ne	Intervals	Notes
274	1	14	4	3	i -	O6,	O6	O	2a	c
274	1	15	1	1	sou -	8IX, A,	8IX A	IX A	U 2d	c b
274	1	15	1	2	ε -	A,	A	A	2d	a
274	1	15	1	3	ou -	AA,	AA	AA	2d	G
274	1	15	1	4	ou -	1KO, E,	1KO E	KO E	4a 3d	c a
274	1	15	1	5	ou:	O, O6,	O O6	O O	2a 2a	b c
274	1	16	1	1	a -	CA, _D,	CA _D	CA _D	6d 2a	E F

Intervallic and Rhythmic Neu	Intervallic Neumes	Intervals	Notes
CA _D O OK P E17 A O6	CA _D O OK P E A O	6d 2a 2a 3a 2a 3d 2d 2a	E F G b c a G a

Intervallic and Rhythmic I	Intervallic Neumes	Intervals	Notes
CA _D O OK P E17 A O6	CA _D O OK P E A O EA _D	6d 2a 2a 3a 2a 3d 2d 2a	E F G b c a G a E F G c c
EA _D O6 KO 1I8 E 1KO	O KO I E KO E O E OK R O E	4d 2a 2a 4a U 3d 4a 3d	d b c a c a b G b c a G a G

274	1	16	1	2	ca -	O,	O	O	2a	G
274	1	16	1	3	ca -	OK, P,	OK P	OK P	3a 2a	b c
274	1	16	1	4	a -	E17, A, O6,	E17 A O6	E A O	3d 2d 2a	a G a
274	1	16	2	1	Ga -	EA, _D,	EA _D	EA _D	4d 2a	E F
274	1	16	3	3	Ili -:	O6,	O6	O	2a	G
274	1	16	4	1	a -	KO,	KO	KO	4a	c
274	1	16	5	1	sw -	1I8, E,	1I8 E	I E	U 3d	c a

Figure 9. Form KONDAKARIAN NEUMES (ENTITIES KONDAKARIAN HYPERSTASES AND KONDAKARIAN LITTLE SIGNS) stores the kondakarian hyperstases names, the hyperstases images, links to kondakarian little signs and to related syllables of the text. This allows the comparison of both Greek and Slavonic neumatic versions.

Figure 9. Form Kondakarian neumes
(Entities Kondakarian hyperstases and
Kondakarian little signs)

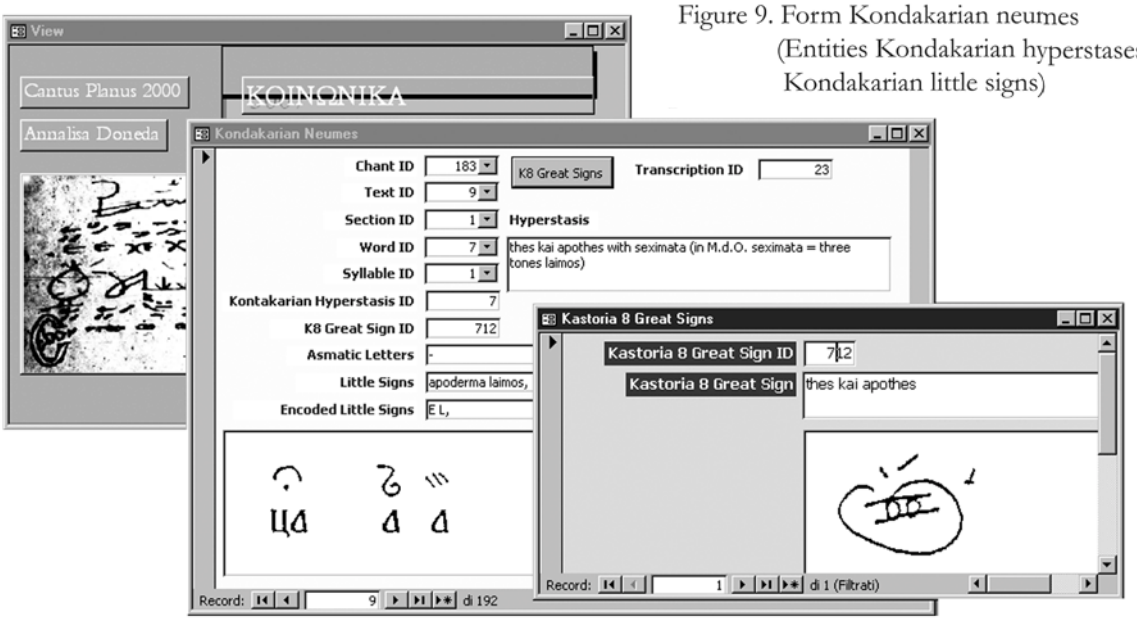
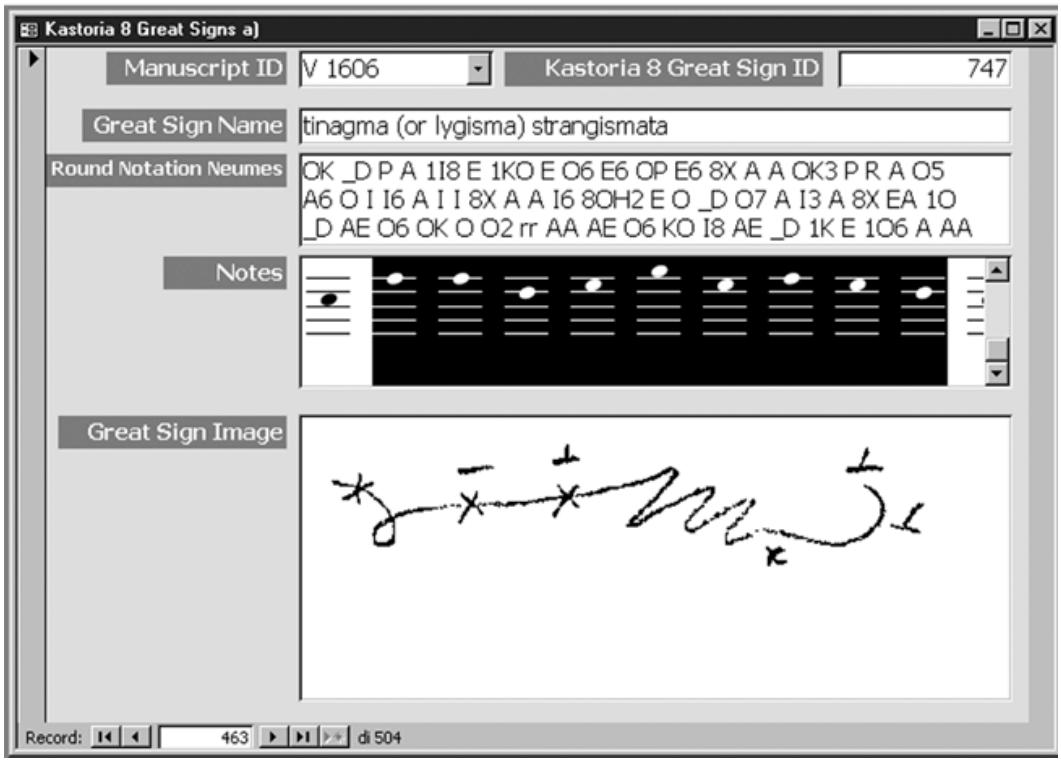


Figure 10. Entity KASTORIA 8 GREAT SIGNS stores the great sign name, the great sign image, links to the related syllables. Additional remarks are sometimes included.

Figure 10. Entity Kastoria 8 great signs



The data stored in the tables will be available for different purposes. The neumes are initially stored in connection with a single letter, but they can be grouped in connection with the related syllable (see **Figure 11**) or the related word. For each syllable all the neumatic versions expressed in Middle Byzantine, kondakarian and Kastoria 8 great signs notations can be listed. Moreover, to facilitate the display of melodic

formulas I have designed a font which automatically converts letter transcription to arrhythmical staff-notation (Cf. Figure 12).

Figure 11. Forms neumes linked to syllables and neumes linked to words

Figure 11. Forms Neumes linked to syllables and Neumes linked to words

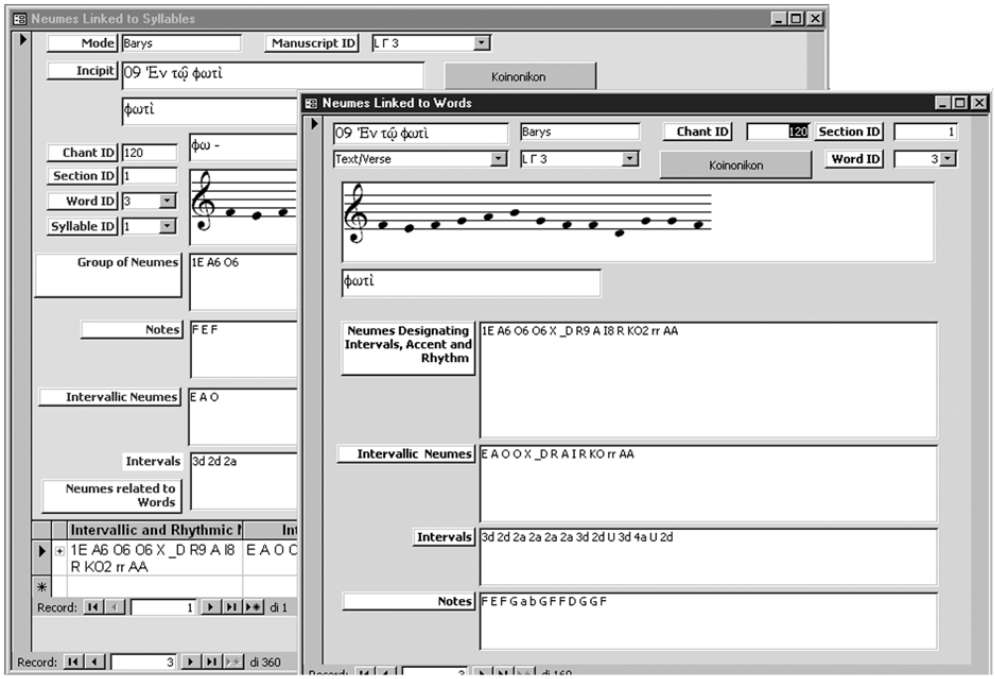
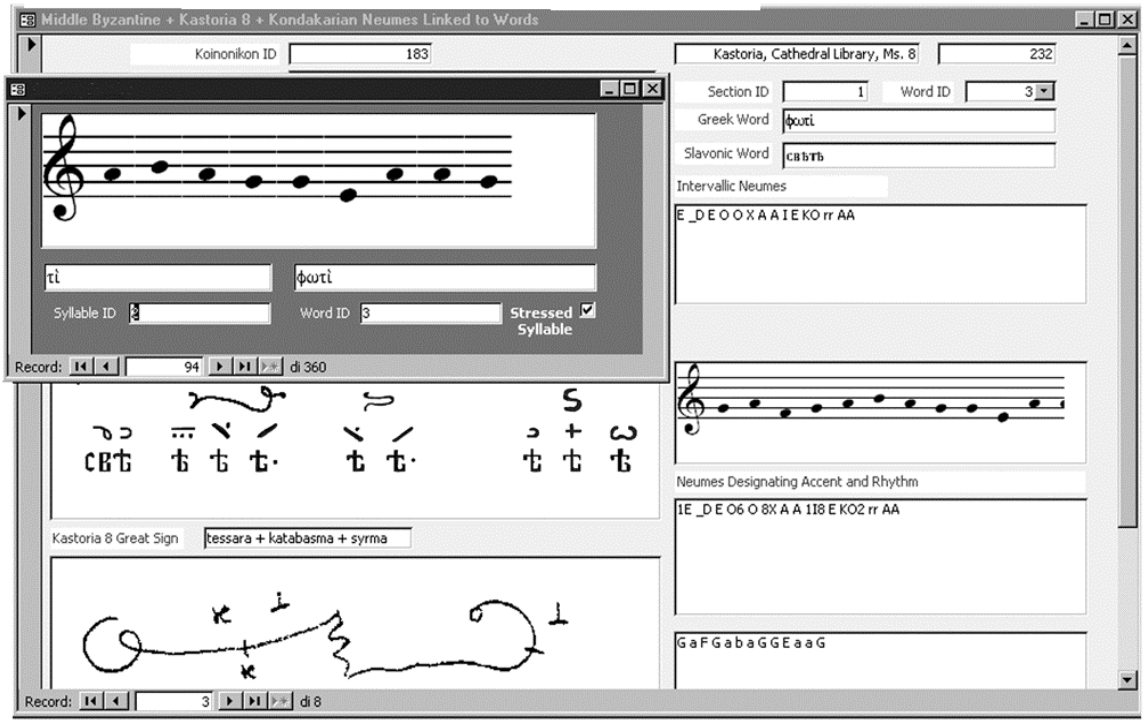


Figure 12. Synoptic view of encoded round notation neumes and related Kastoria 8 and kondakarian neumes



To analyse the data, query expressions using wildcard characters are permitted, so that the following types of searches are possible:

a. Sets of intervals connected with specific neumes and pitches.
b. Sets of intervals not connected with specific neumes but related to specific pitches.

c. Sets of pitches or sets of intervals not connected with specific neumes.
d. Sets of pitches connected with specific neumes and so on.
e. Sets of neumes for each accentuated syllable in the repertoire for specific modes and so on.
f. Sets of round notation neumes related to one specific kondakarian hyperstasis.
g. Sets of round notation neumes related to one specific Kastoria 8 great sign.

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In conclusion, the idea for this type of project was prompted by consideration of the difficulties experienced in handling the Byzantine musical data and by the interesting results produced with a simpler version of the database I implemented some years ago with the specific aim of comparing the Kastoria 8 Round notation neumes and the Great signs. The automatic handling of data has produced evidence for unexpected relations between the notational systems[13]:

- Sometimes the Kastoria 8 great signs seemed not even to represent the formulae written in the inferior rows: they appear to be linked rather to the neumations which can be found in one or more of the other sources I had collated.
- Comparison of numerous round notation sources revealed divergences suggesting the existence of various links between the formulas present in the Greek and Slavonic traditions. This seems preferable to assuming the existence of a distinct South Italian tradition different from the Greek one.
- Comparison of Borg. gr. 19 with the Slavonic versions shed new light on its anomalous features, highlighting the peculiarities of this MS within the Byzantine musical tradition: the anomalous Middle Byzantine tradition of codex Borg. gr. 19, in comparison with the Slavonic versions, seemed to be reinforced.

Several aspects of the logical and physical design of this ‘new’ database and the criteria for an effective storage and retrieval of data must still be verified. I am aware of the necessity to design a ‘user-friendly’ input form to enter the neumes: a possible solution would be to create a specific neumatic font to cover the Copenhagen code with a mask. The production of a graphic interface, however, involves radical changes in the code's ‘dictionary’ to represent neume groups and positions. However, in my opinion, the development of computer applications of this type may provide an important research tool in the treatment of complex notational combinations and I welcome proposals and suggestions for adapting or simplifying the mechanisms described in this project, especially for extending the storage of musical data to different repertories of Byzantine chant.

[13] For a detailed description see Doneda, “Hyperstases in MS Kastoria 8”, pp. 23-36.