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The certainty of change : a research into the interactions of the decoration on the western walls of the cult chapels of the mastabas at Giza during the Old Kingdom

Roeten, L.H.

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Chapter III

The methods employed in the research project

All interactions between (sub)themes can be traced back to either associations or dissociations. Therefore it is important to develop criteria, with which such an association or dissociation can be reliably determined, described and quantified. The methods employed in the research project have been developed to do that.

1. The frequency of occurrence (FO) of the (sub)themes, and its derivative FO/chronological period is defined.
2. The chronological development of the (sub)themes on the western wall and on the parts of the false door is described by means of chronological orderings and/or diagrams.
3. The co-occurrence of (sub)themes on the western wall is given as “co-occurrence percentage” (CP), a criterion which can also be expressed as CP/(chronological) period. A derivative of the CP value of a (sub)theme is the CPSD value pertaining to it (see table “Technical terms and abbreviations”). This CPSD value expresses the degree of association or dissociation between (sub)themes.
4. For every (sub)theme the percentage of occurrence on the same section of the western wall (SWS) is determined. An interaction between two (sub)themes is thus defined by a combination of a CP and a SWS value. The SWS value cannot be applied to the (sub)themes on the false door.
5. In order to determine whether the CP/SWS combination of an interaction indicates an association or a dissociation, the CP/SWS combination is linked with the +/- sign of the CPSD value adhering to it and placed in a CP/SWS diagram. In this diagram areas of + sign (association) and areas of – sign (dissociation) preponderance are determined. An interaction can thus be interpreted as an association or as a dissociation by way of its location in the CP/SWS diagram.
6. The cultic character of (sub)themes is determined employing the various methods previously mentioned and starting from the predetermined cultic character of the prime (sub)themes (see “Technical terms and abbreviations”).
7. Once these cultic characters have been determined, the various chronological developments and interactions can be discussed and a working hypothesis can be developed.

All tombs, (sub)themes, tables, chronological orderings, diagrams, etc. introduced as part of the development of the methods for the research project at hand are totally fictitious and have *no connection* with the tombs and (sub)themes forming the base of the research project in the following chapters.

I. Introduction.

Although statistics is useful in controlling large quantities of archaeological data and drawing conclusions from them, the conclusions reached in this research project have been drawn from results obtained by employing arithmetical methods. The methods described in this chapter, although basically statistical, are *not* interpreted as such.

II. Methods.

II.1.Frequency of occurrence.

II.1.1. The “frequency of occurrence” (FO) of the (sub)themes.

Both the false door and the remaining surface of the western wall of a cult chapel (the latter further referred to as “western wall”, unless otherwise stated), included in one of the catalogues of tombs, can either be complete or incomplete.

On an architecturally *and* decoratively completely finished *and* preserved western wall the presence, or absence, of a (sub)theme is unambiguous in the sense that it was *intentionally* chosen or not from the repertoire of available (sub)themes. However, a western wall may be completely architecturally preserved and yet be incomplete in decoration, indicating that its decoration

(sub)theme	1	2	3	4	5	6	7	8	
tomb									no. (sub)themes /tomb
A	x	-	-	x	-	-	x	-	3
B	x	o	o	x	x	o	x	o	4
C	x	x	o	x	x	-	-	-	4
D	o	o	o	x	x	o	o	o	2
E	-	x	-	x	-	-	x	-	3
F	x	x	-	x	x	x	-	-	5
G	x	x	o	o	o	o	o	o	2
H	-	x	-	x	x	x	-	-	4
I	o	o	o	x	x	o	o	o	2
J	x	x	-	x	-	x	-	-	4
K	x	x	x	o	x	o	o	x	5
L	-	-	x	x	-	x	-	-	3
M	x	o	x	o	o	x	o	o	3
N	x	-	x	-	-	x	-	x	4
O	x	o	x	o	o	o	o	o	2
number of "x" and "-"	13	10	10	11	12	9	9	9	
number of "x"	10	7	5	10	7	6	3	2	
FO (%) (= ("x" . 100) / ("x" + "-"))	77	70	50	91	58	67	33	22	

Figure III.1: Table of the FO values calculated from the presence/absence of (sub)themes.

x = present on the complete or incomplete western wall

- = not present on the complete western wall

o = not present on the incomplete western wall

remained unfinished. Another possibility is that the western wall has been partially destroyed. Therefore, the reason for the absence of a (sub)theme on the western wall can be the following:

1. The (sub)theme has never been placed on the wall, as on an unfinished western wall.
2. The (sub)theme has been lost, as on a finished western wall that has been (partially) destroyed.

In both cases, there is no certainty as to which of the following categories apply to the (sub)theme:

1. It was planned, but never placed there because the wall was never finished.
2. It was never chosen by the tomb owner.
3. It was originally placed on the western wall, but subsequently lost due to the destruction of a section of the wall (however, in some cases it is possible to create a reliable reconstruction of the missing section of the wall, in which case the western wall is considered to be complete).¹

The following methods have been applied to the surface of the western wall that is not taken up by (a) false door(s). In practice some of the methods can be employed for the elements of the false door(s) too.

In the table in figure III.1 the western walls of 15 (fictitious) tombs, designated A to O, and chronologically ordered,² have been examined for the certain/uncertain absence or presence of a set of (fictitious) (sub)themes, numbered 1 through 8.³

It is necessary to distinguish between certainty and uncertainty in the presence or absence of a (sub)theme. In the table in figure III.1 “x” indicates certainty in presence and “-“ the same certainty in absence. The uncertainty in presence or absence is marked as “o”.

In this table it is evident that the western walls of tombs B, D, G, I, K, M and O are incomplete. In tomb C the presence/absence of (sub)theme 3 is uncertain, but the absence of (sub)themes 6, 7 and 8 could be established with certainty.

The reason(s) for the incompleteness of the (sub)themes (either unfinished or partially destroyed) is not given in the table, because this criterion is not important for the research project at hand.

In the table in figure III.1 the number of (sub)themes placed on the western wall of a tomb has been determined, this criterion can be interpreted as a measure of the “popularity” of decorating this wall.⁴ In order to determine this “popularity” only complete walls can be taken into account (tombs A, E, F, H, J, L, N, marked in grey).

II.1.2. The “popularity” of (sub)themes.

If the mean value of the popularity of (sub)themes in tombs with a complete western wall is calculated, the result over the whole period is 4,⁵ but more information can be obtained from a diagram that shows the chronological development of popularity in employment of decoration on the western wall of the cult chapel.

¹ Cf. on this also Van Walsem, *Iconography*, 44 - 6 and 60 - 1.

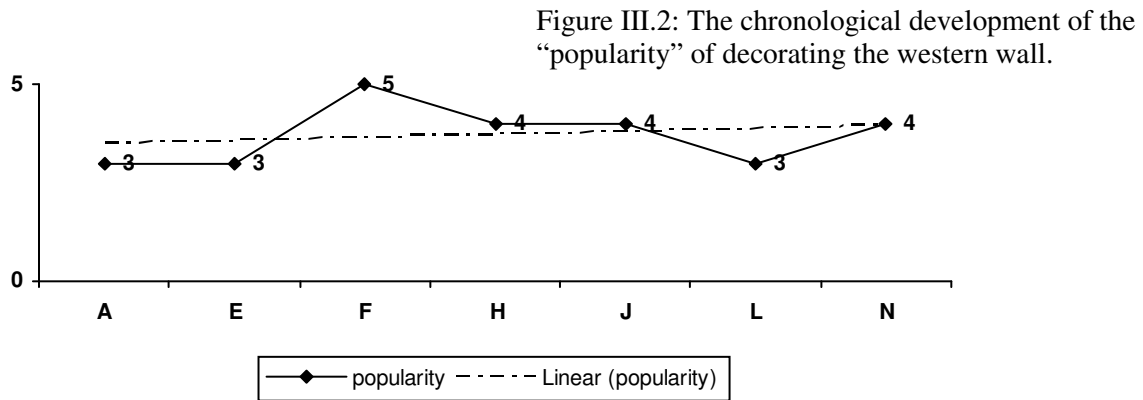
² The order is in a vertical direction from the oldest tomb at the top to the most recent one at the bottom.

³ When and where necessary the methods are explained employing these fictitious (sub)themes.

⁴ This can show whether a chronological development took place in the number of (sub)themes chosen on the western wall.

⁵ This is calculated by adding the number of (sub)themes of the tombs with complete western walls as given in figure III.1 (26) and dividing the sum by 7 (the number of tombs with a complete western wall). The resulting 3.71, and because of the uncertainty inherent in the catalogues this is rounded up to 4.

Because in figure III.1 the order of the tombs is chronological, the diagram of figure III.2 shows a kind of chronological development of popularity. The development over the whole period does not differ much from a horizontal line.⁶



II.1.3. The determination of the FO/period of the (sub)themes on the western wall.

Although in the table in figure III.1 the tombs have been ordered chronologically, no division into chronological periods has been made.

The FO values calculated in figure III.1 are a measure for the employment (or “popularity”) of the (sub)themes over the whole of the Old Kingdom, but they give little information about its chronological development. In order to determine this, a chronological division is introduced into the table (see figure III.3). In each period the FO values of all the (sub)themes are calculated (this is called the FO/period).

⁶ The chronological development determined here would not be very reliable, because every point is based on one tomb. A more reliable result is obtained by taking the popularity per chronological period. The horizontal tendency of the diagram is shown by the dotted line called “linear” (for considerations about the meaning of the term “linear”: see appendix III.3).

period	(sub)theme	1	2	3	4	5	6	7	8
	tomb								
IV	A	x	-	-	x	-	-	x	-
	B	x	o	o	x	x	o	x	o
	C	x	x	o	x	x	-	-	-
	number of "x" + "-"	3	2	1	3	3	2	3	2
	number of "x"	3	1	0	3	2	0	2	0
	FO (%) (= ("x" . 100) / ("x" + "-"))	100	50	0	100	67	0	67	0
V.E	D	o	o	o	x	x	o	o	o
	E	-	x	-	x	-	-	x	-
	F	x	x	-	x	x	x	-	-
	number of "x" + "-"	2	2	2	3	3	2	2	2
	number of "x"	1	2	0	3	2	1	1	0
	FO (%) (= ("x" . 100) / ("x" + "-"))	50	100	0	100	67	50	50	0
V.M	G	x	x	o	o	o	o	o	o
	H	-	x	-	x	x	x	-	-
	I	o	o	o	x	x	o	o	o
	number of "x" + "-"	2	2	1	2	2	1	1	1
	number of "x"	1	2	0	2	2	1	0	0
	FO (%) (= ("x" . 100) / ("x" + "-"))	50	100	0	100	100	100	0	0
V.L	J	x	x	-	x	-	x	-	-
	K	x	x	x	o	x	o	o	x
	L	-	-	x	x	-	x	-	-
	number of "x" + "-"	3	3	3	2	3	2	2	3
	number of "x"	2	2	2	2	1	2	0	1
	FO (%) (= ("x" . 100) / ("x" + "-"))	67	67	67	100	33	100	0	33
VI	M	x	o	x	o	o	x	o	o
	N	x	-	x	-	-	x	-	x
	O	x	o	x	o	o	o	o	o
	number of "x" + "-"	3	1	3	1	1	2	1	1
	number of "x"	3	0	3	0	0	2	0	1
	FO (%) (= ("x" . 100) / ("x" + "-"))	100	0	100	0	0	100	0	100

Figure III.3:
FO values per
period.

With the results inferred from the table in figure III.3, it is possible to make a diagram of the chronological development of the FO/period for each (sub)theme. Examples of these are given in figures III.4 – III.6.

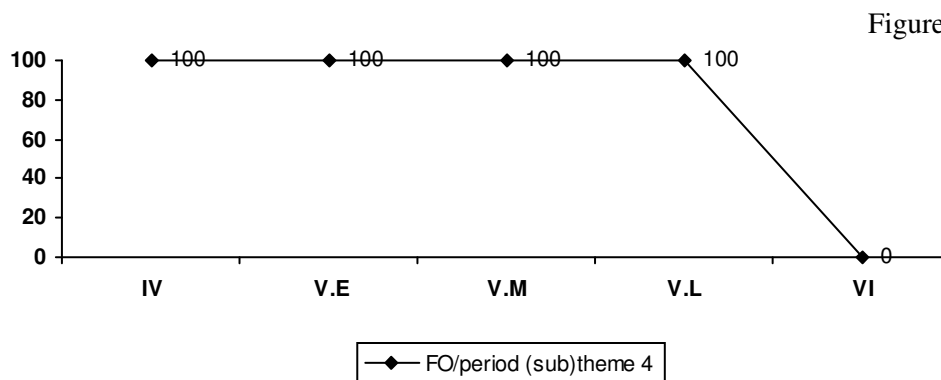


Figure III.5

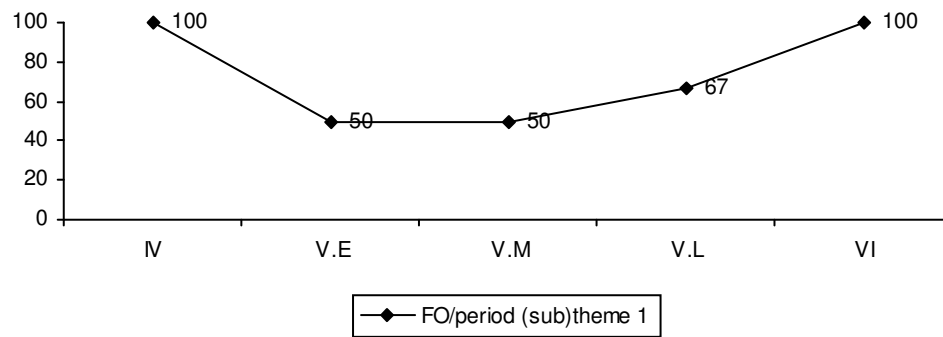
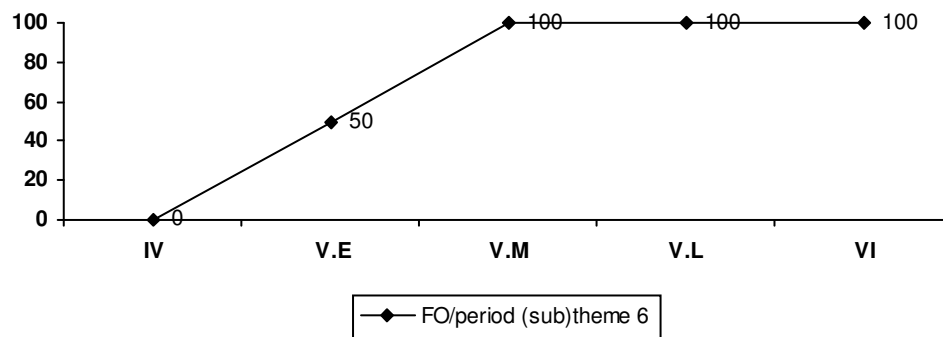


Figure III.6



Figures III.4, 5 and 6: Examples of FO/period curves, derived from figure III.3.

II.2. Chronological orderings.

In this research project chronological orderings are not of the utmost importance. They are only employed in order to determine whether a chronological development takes place (see appendix III.4).

III. The co-occurrences between (sub)themes.⁷

III.1. The co-occurrences between (sub)themes on the wall sections of the cult chapel.

In a compilation of (sub)themes it is possible to determine which (sub)themes are placed together on the wall or a section of it. For this the term “co-occurrence” is adopted. There are two possible forms of co-occurrence on a wall:

1. The two (sub)themes are placed on the western wall and it is of no importance whether or not they are together on the same section of the wall.
2. Because a wall can be divided into “wall sections” (see chapter VI, section I), two (sub)themes may not only be placed together on the western wall, they may even be placed together on the same wall section (see figure III.7 below).

⁷ For this being “together” of (sub)themes another term might be “coincidence”, but this term implies a more random conjunction, and the design of the decoration on the walls of the chapel certainly is not the result of a random action.

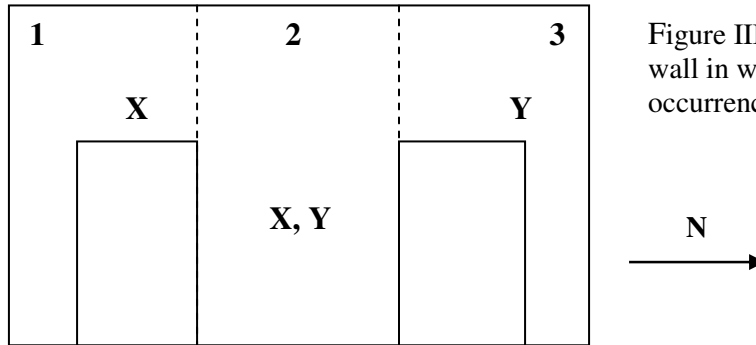


Figure III.7: The division of the western wall in wall sections and possible co-occurrences of (sub)themes X and Y.

In figure III.7 two (sub)themes X and Y are placed either on different wall sections, here wall sections 1 and 3 or on the same wall section, here wall section 2.

III.1.1. The determination of co-occurrences between (sub)themes and the calculation of the Co-occurrence Percentage (CP).

The co-occurrence of (sub)themes can be determined either in a chronological ordering or in a table, an example of the latter is the determination of the number of co-occurrences between (sub)themes 1 and 7 in figure III.1.

(Sub)theme 1 is placed on the wall 10 times and (sub)theme 7 only 3 times. The conclusion is that the theoretical maximum number of co-occurrences between (sub)themes 1 and 7 is three. In tombs A and B both (sub)themes are placed together on the western wall, which is 67% of the maximum number of co-occurrences.⁸ For this value the term “co-occurrence percentage” (CP) is used. The result is a CP of 67% (for considerations concerning the degree of uncertainty of these values, see section III of appendix III.3 of this chapter).

A CP value can be determined for the interaction between each couple of (sub)themes, provided that they overlap in time (since there is no overlap in time between (sub)theme 7 and (sub)themes 3, 6 and 8, no CP value can be determined).

III.1.2. How to determine association or dissociation between (sub)themes from their CP values.

The (sub)themes 1 through 8 are, both horizontally and vertically, arranged in an increasing order of their FO values (see figure III.1),⁹ and for every interaction the CP value is determined in the chronological ordering of figure app.III.4.4.¹⁰

⁸ In order to stress the fact that the percentages calculated in this research project have a relatively high degree of uncertainty they are always given without decimals unless otherwise stated. The percentages are calculated up to one decimal point and after that rounded up/down according to the rule that the number of an integer X and with a decimal y (e.g. 9.4) is rounded off to X if $1 \leq y \leq 4$ (e.g. 9.4 becomes 9) and to X+1 if $5 \leq y \leq 9$ (e.g. 9.5 becomes 10).

⁹ The decision to employ this type of ordering is based on the consideration that two (sub)themes have a higher change of being placed together on the same wall if each of them has a relatively high FO value. This means that in a table as depicted in figure III.8 there is a tendency to have higher CP values in its lower right-hand corner than in its upper left-hand corner.

¹⁰ If two (sub)themes have no overlap in time, their lack of interaction is given as “---“, if there is an overlap in time, but they have no co-occurrences then the value “0” is given.

(sub)theme		8	7	3	5	6	2	1	4
	FO value	22	33	50	58	67	70	77	91
8	22	-	---	100	50	50	50	100	0
7	33		-	---	33	---	33	67	100
3	50			-	20	60	20	80	20
5	58				-	33	57	57	86
6	67					-	50	67	67
2	70						-	71	71
1	77							-	50
4	91								-

Figure III.8: The CP values of the (sub)theme interactions in figure app.III.4.4.

All the CP values that can be determined are compiled in figure III.8. In such a table every interaction occurs twice, consequently half of the table is left empty.

It is possible that two (sub)themes rarely coincide on the western wall, although they completely overlap in time. In this case the CP value will be lower than expected from the FO values on the interacting (sub)themes. Consequently, if both (sub)themes have a high FO value, the low CP value of their interaction will be embedded in an area where the CP values normally are high. An example is the low CP value of the interaction of (sub)themes 2 and 3 (CP value = 20%) which is embedded in a field of higher CP values. This is a situation that indicates a possible dissociation between the (sub)themes.

It is also possible that a positive interaction (an association) exists between two (sub)themes, in this case the CP value will be higher than expected, and if this positive interaction is between two (sub)themes with low FO values, the higher CP value will be embedded in a surrounding field of lower CP values. An example is the interaction between (sub)themes 4 and 5 (CP value = 86%).

III.1.3. The determination of the degree of difference between a CP value and its surrounding.

For the determination of the degree of difference of a CP value with its surrounding CP values, a central value surrounded by a field of 8 CP values is taken as a standard.

20	30	25
35	50	25
20	20	30

Figure III.9: A hypothetical CP value diagram with a central value higher than the surrounding field.

There are several methods to calculate and represent the degree of difference CPSD between the central value and its surrounding field,¹¹ but all of them have the disadvantage that the graduated scales at both sides of the midpoint (the point that indicates a difference of zero between the central value and the surrounding field) are not identical and in most cases do not have opposite signs (see appendix III.1).

As a measure of the difference between the central value and the values of the field in which it is embedded, a calculation method giving equal scales with opposite signs at both sides of the midpoint is introduced (appendix III.2).

¹¹ For the term “CPSD”: see the table “technical terms and abbreviations”.

Apart from the type of surrounding field as in figure III.9, also other types of surrounding fields are possible, all of them derived from the standard field (figure III.10). The following types of surrounding fields are also acceptable for the calculation of CPSD values.

20	30	25
35	50	25
	20	30

20	30	25
	50	25
		30

	30	25
	50	25
	20	30

Figure III.10: Other types of CP value diagrams derived from the diagram in figure III.9.

Not just the value, but also the sign of the CPSD value is of importance. The sign can either be negative or positive. A positive CPSD value signifies an association between two (sub)themes, and a dissociation between two (sub)themes is indicated by a negative CPSD value. The value itself can be seen as an indication of the relative strength of the interaction.

The CPSD values cover a range running from a high positive value through zero to a high negative value and this means a range from a strong association through no interaction, to a strong dissociation between (sub)themes (figure III.11).

In this method adjectives like “strong” and “weak” in expressions like “strong association/dissociation” and “weak association/dissociation” can be employed in the text, but they have no mathematical or arithmetical meaning or significance, and distinctive ranges of CPSD values *cannot and will not* be attached to any of these designations, because the two terms are exclusively employed in a comparative context.

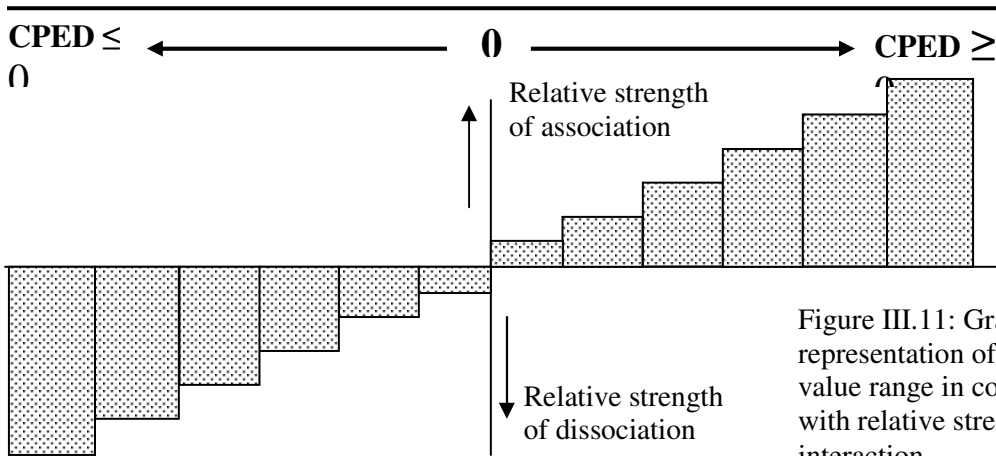


Figure III.11: Graphic representation of CPED value range in connection with relative strength of the interaction.

In the table in figure III.8 two interactions marked in grey have been selected as examples of a possible association and dissociation between (sub)themes. Of the two interactions the CPSD value is calculated in the way given in appendix III.2.

---	33	67
60	20	80
33	57	57

CPSD = - 1.2¹²

80	20
57	86
67	67

CPSD = 1.1

Figure III.12: Examples of CP value fields with positive and negative CPED values.

¹² The “---“ has *not* been included in the count, consequently the total number of values is 8.

The sign of the thus calculated CPSD values can serve as an indication of a possible association or dissociation for these interactions.

IV. Co-occurrences of (sub)themes in relation to their location on the wall.

IV.1. The placement of the (sub)themes on the different wall sections.

As already pointed out, two (sub)themes can be placed together on the same wall section or on different wall sections. The placement of the (sub)themes can be introduced into the chronological ordering of figure app.III.4.4 (also see figure III.13).¹³

In the chronological ordering of figure III.13 there are in total 68 placements (33 single placements, 16 double combinations and 1 triple combination).¹⁴ The following data can be obtained from this chronological ordering:

	(sub)theme	7	4	2	5	1	6	8	3
period	tomb								
IV	A	1	2			2			
	B	1	2		2	2			
	C		2	3	2	1			
V.E	D		3		2				
	E	2	2	3					
	F		1.2	3	1	2	1.2		
V.M	G			2		1.2			
	H		1.3	2	2.3		1.2		
	I		2		1.2				
V.L	J		2	2		1.2	1		
	K			2	1.2	2		1.3	1.3
	L		2				2		2
VI	M					1.2	1.2		2
	N					1.3	1.2.3	1	1.2
	O					2			1.2
total placements ¹⁵	68	3	12	7	10	14	11	3	8
combinations ¹⁶									
single	33	3	8	7	4	6	2	1	2
double	16		2		3	4	3	1	3
triple	1						1		

Figure III.13: The placement of the (sub)themes on the wall sections (the numbers 1, 2 and 3 indicate the wall sections as given in figure III.7), (squares marked in grey are the midpoints of the use life of the (sub)themes).

¹³ These placements are based on a western wall with two false doors (type A) and are totally arbitrary.

¹⁴ A single placement means that the (sub)theme is placed on one wall section only, a double placement signifies that it is placed on two wall sections, etc.. Multiple placements are called “combinations”.

¹⁵ In calculating the total placement, a multiple placement is counted as the number of placements it contains (e.g. (sub)theme 5 contains 4 single and 3 double placements, which totals to 10 placements).

¹⁶ A combination is the placement of a (sub)theme on more than one section of the same wall.

1. A possible chronological development of the employment of combinations.
2. A preference for placing (sub)themes on certain wall sections, and a possible chronological development for the various (sub)themes.
3. The co-occurrence of (sub)themes (CP values) on the western wall as a whole and on the same wall sections.

IV.1.1. The co-occurrences between (sub)themes in relation to the wall sections.

Although not necessary for determining the CP values of the interactions, the (sub)themes are placed in increasing order.¹⁷ In this case it is done by counting the total number of placements per (sub)theme and ordering them according to an increasing number of placements.¹⁸

(sub)theme		8	7	2	3	5	6	4	1
	no. placements	3	3	7	8	10	11	12	14
8	3	-	---	67	167	133	100	0	133
7	3		-	33	---	33	---	100	67
2	7			-	29	86	71	100	100
3	8				-	50	100	13	125
5	10					-	60	110	50
6	11						-	82	109
4	12							-	58
1	14								-

Figure III.14: The CP values of placement interactions.

For the ordering the number of placements per (sub)theme is taken from figure III.13 (line “total placements”) and the order of (sub)themes is: 8-7-2-3-5-6-4-1.¹⁹

This order is transferred to the table of figure III.14, and the number of co-occurrences between the (sub)themes is determined in the chronological ordering of figure III.13. Two of these CP values (marked in grey in figure III.14) show a notable difference with their respective surrounding fields.

The number of co-occurrences involving multiple placements, as is the case between (sub)themes 3 and 8 in figure III.13, is determined in the following way:

¹⁷ Although ordering is not strictly necessary, it is done because if a table of CP values is ordered in this way, it is possible to detect interactions which deviate strongly from their surrounding field. The ordering is obligatory if CPSD values are to be calculated from the CP values.

¹⁸ Although in figure III.8 the FO value has been employed as a criterion for the ordering of the (sub)themes, the number of placements must be employed here, because the significance of the choice of wall section has to be incorporated into the determination of the CP values.

¹⁹ The order 7-8-2-3-5-6-4-1 is also possible, but in this case the result is identical.

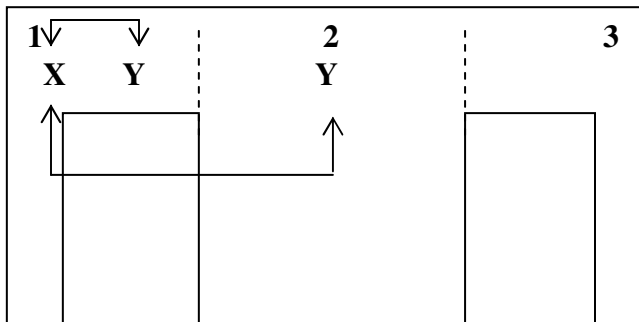


Figure III.15: The determination of the number of co-occurrences on more than one wall section.

In figure III.15 two (sub)themes X and Y are placed on the western wall. (Sub)theme X is placed on wall section 1 (notation: 1) and (sub)theme Y is placed on wall sections 1 and 2 (notation: 1.2). Between the (sub)themes two co-occurrences are possible (in figure III.15 given as \leftrightarrow):

X – Y = 1.1 (a co-occurrence on the same wall section)

X – Y = 1.2 (a co-occurrence on different wall sections)

In the table in figure III.16 the number of co-occurrences between other possible placement combinations is given.

(sub)theme X	(sub)theme Y	no. co-oc. ²⁰	co-occurrences						
1	1.3	2	1.1	1.3					
1	1.2	2	1.1	1.2					
2	1.3	2	1.2	2.3					
3	1.2	2	1.3	2.3					
1.3	1.3	3	1.1	3.3	1.3				
1.3	2.3	4	1.2	1.3	2.3	3.3			
1	1.2.3	3	1.1	1.2	1.3				
1.3	1.2.3	5	1.1	1.2	1.3	2.3	3.3		
1.2.3	1.2.3	6	1.1	2.2	3.3	1.2	1.3	2.3	

Figure III.16: (Theoretical) number of co-occurrences involving combinations.

One of the results of this method is that the calculation of the CP value can give rise to percentages over 100%. An example of this is the interaction between (sub)themes 4 and 5:

The number of placements for (sub)theme 4 is 12 and for (sub)theme 5 it is 10 (see figure III.13). This means that, in the case of single placements, the maximum number of co-occurrences would be 10. In figure III.17 the co-occurrences between the two (sub)themes are given:²¹

The result is a total of 11 co-occurrences. Consequently the CP value is $11/10 \times 100\% = 110\%$ (marked in grey in figure III.14).

²⁰ The abbreviation “co-oc.” stands for “co-occurrence”.

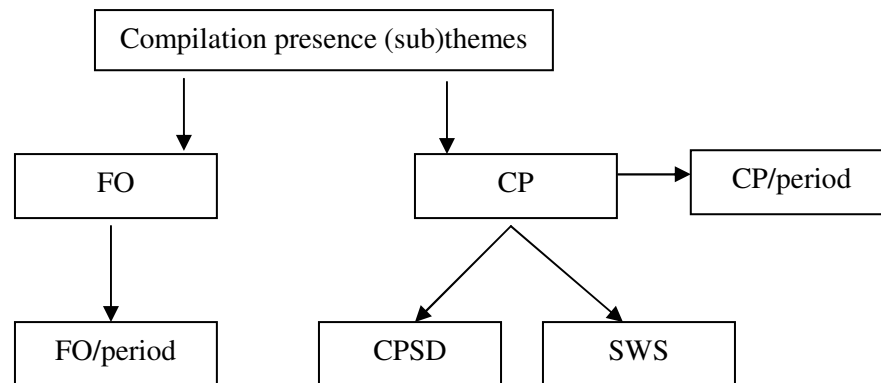
²¹ A, B etc. indicate the tomb, and 1-1, 2-3 etc. the interactions between (sub)themes on the various wall sections.

tomb	interaction	tomb	interaction	tomb	interaction	tomb	interaction
B	2 - 2	F	1 - 1	H	1 - 2	I	1 - 2
C	2 - 2		1 - 2		1 - 3		2 - 2
D	2 - 3				2 - 3		
					3 - 3		

Figure III.17: The possible co-occurrences between (sub)themes 4 and 5.

Of these 11 co-occurrences 5 are on the same wall section (1 for tombs B,C and I on wall section 2, 1 for tomb F on wall section 1 and 1 for tomb H on wall section 3). Of 11 co-occurrences 5 are on the Same Wall Section (SWS) and this gives a SWS value of $5 \times 100/11 = 45\%$.²² As with the FO value, the CP value of an interaction can not only be determined over the whole Old Kingdom, it can also be determined per period, and so can the SWS value belonging to it.

So far the methods developed for this research project has been:



1. The FO value of a (sub)theme only gives information about its “popularity” throughout the whole period (here the Old Kingdom). The FO/period gives information about the possible chronological development of this “popularity”.
2. The CP value indicates whether a association or an dissociation exists between two (sub)themes.
3. The CPSD value not only indicates the type of interaction (association/dissociation), but also its relative strength.
4. The interaction between two (sub)themes can be described by two values, the CP and the SWS value. The former shows their tendency to be together on the same wall, on which they can nevertheless be far apart. The latter describes their tendency to be close together on that wall (on the same wall section).

The information that can be drawn from the components of the method has a different degree of reliability.

²² SWS is the percentage of the co-occurrences between two (sub)themes that take place on the S(ame) W(all) S(ection).

1. When two (sub)themes both have a high FO value, the CP value of their interaction is not automatically high because an dissociation or a weak or non-existing overlap in time is possible.
2. A high CP value indicates a strong co-occurrence on the same wall, but no information is given about its being on the same wall section.
3. A high SWS value indicates a strong co-occurrence on the same wall section. This is the strongest possible indication of a close interaction.

The conclusion is that the percentage of co-occurrences situated on the same wall section (the SWS value) gives the most reliable information about the interaction between (sub)themes.

An interaction with a low SWS value indicates that the (sub)themes have an dissociation on the same wall section, and it can be caused by:

1. a reluctance to place the two (sub)themes on the same wall section based on cultic or other symbolic considerations.
2. the practical consideration that the two (sub)themes are too large to be placed together on the same wall section. This can be one of the reasons why the interactions of prime (sub)themes have low SWS values.²³

In figure III.14 the interaction between (sub)themes 3 and 4 has a low CP value (13%), which is (partly?) caused by the fact that they have a small overlap in time. They coincide once on wall section 2 (figure III.13), but the SWS value of the interaction is high, namely 100%.

In figure III.14 the interaction between (sub)themes 4 and 5 has a CP of 110% and a SWS value of 45%, the latter indicating that the association is caused by the fact that frequently the (sub)themes are placed together on the western wall, but without a very strong preference to placing them on the same wall section.

IV.1.2. The CP and SWS values of the interactions.

The CP and SWS values are determined for all the interactions in the chronological ordering in figure III.13, and compiled in the table of figure III.18 (below).

The CP and SWS values are graphically displayed in a diagram with the SWS value on the X-axis and the CP value on the Y-axis (figure III.19).

Some general conclusions may be drawn about the cloud of CP/SWS points in the diagram in figure III.19.²⁴

1. The clustering of the cloud of points leads to the conclusion that a high SWS value is not coupled to an extremely low CP value, because the points with high SWS values are situated high on the CP-axis.
2. Points with a low CP value are always coupled to a low SWS value. This indicates that two (sub)themes with an interaction with a low CP value, if placed together on the western wall, are preferably not positioned on the same wall section.

²³ For the term “prime (sub)theme” see table “Technical terms and abbreviations”.

²⁴ The diagram in figure III.19 has been made with a Microsoft Excel calculation matrix.

(sub)theme	1	2	3	4	5	6	7	8
1	-	CP = 100 SWS = 43	CP = 125 SWS = 30	CP = 58 SWS = 57	CP = 50 SWS = 40	CP = 109 SWS = 50	CP = 67 SWS = 0	CP = 133 SWS = 25
2		-	CP = 29 SWS = 0	CP = 100 SWS = 14	CP = 86 SWS = 33	CP = 71 SWS = 20	CP = 33 SWS = 0	CP = 67 SWS = 0
3			-	CP = 13 SWS = 100	CP = 50 SWS = 25	CP = 100 SWS = 50	---	CP = 167 SWS = 60
4				-	CP = 110 SWS = 45	CP = 82 SWS = 44	CP = 100 SWS = 33	CP = 0 SWS = 0
5					-	CP = 60 SWS = 33	CP = 33 SWS = 0	CP = 133 SWS = 25
6						-	---	CP = 100 SWS = 33
7							-	---
8								-

Figure III.18: The CP and SWS values of the interactions (all values are percentages).

Yet, this type of diagram does not make it possible that the designation association or dissociation of an interaction between two (sub)themes can be reliably based on its CP and SWS values. The introduction of the CPSD value of the interaction makes it possible to find a solution (this is discussed in part V.1.2. of this chapter).

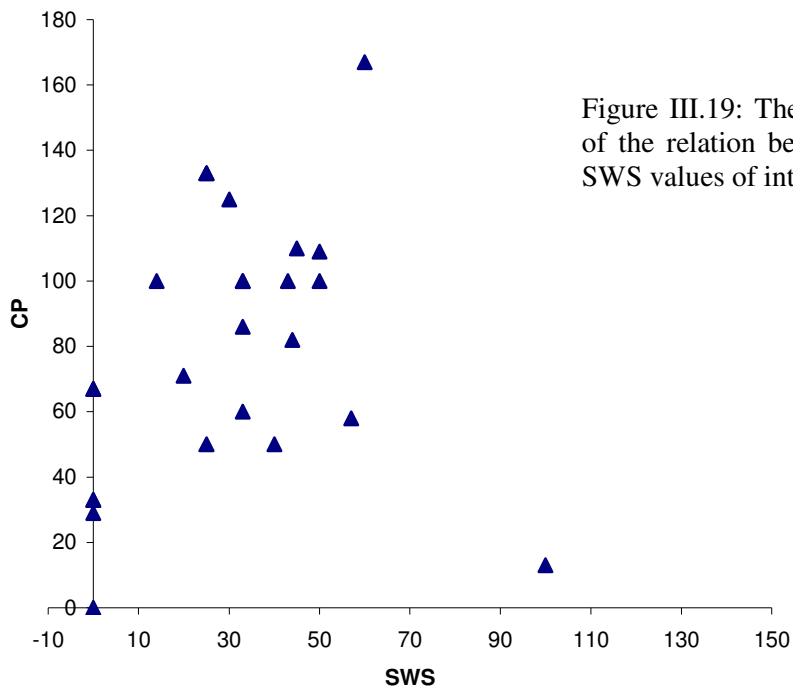


Figure III.19: The graphical display of the relation between the CP and SWS values of interactions.

V. The cultic character of (sub)themes.

V.1. The determination of the cultic character of (sub)themes.

The determination of the cultic character of a (sub)theme is based on the definition of the term “prime (sub)theme”. This term is given to the two major (sub)themes of the western wall: the offering table scene ((sub)themes 3 and 40) and the tomb owner standing and in physical contact with family ((sub)themes 2, 41 and 61).

The types of cultic character of (sub)themes are defined in chapter VII (section I, figure VII.3), where a division in types Ia (the daily professional and familial life of the tomb owner), Ib (the tomb owner responding to the offerings, IIa (unifying (sub)themes) and IIb (signalling/guiding (sub)themes) is made.

The determination of the cultic character is based on the following assumptions:

1. Two (sub)themes have the same cultic character if their interaction has a CP/SWS value indicating an association. This means that the designation of the cultic character of a (sub)theme depends on the reliability of determining its type of interaction with other (sub)themes of which the cultic character is known or defined.
2. On the false door and the remaining surface of the western wall those (sub)themes that can be considered to be the prime (sub)themes of the cult chapel are likely to be chosen.²⁵ The cultic character of these prime (sub)themes determines the cultic character of the other (non-prime) (sub)themes by the type of their interaction (association or dissociation).

V.1.1. The determination of the cultic character of (sub)themes by way of CP/SWS values.

The cultic character of a (sub)theme is determined by the CP/SWS values of its interaction with a prime (sub)theme:

1. The use lives of the (sub)theme (see appendix III.4 below) of which the cultic character has to be determined (in figure III.20 that is (sub)theme 4) and of the prime (sub)theme (here (sub)theme 1), are given as bars. The cultic character of the chosen prime (sub)theme is introduced (here type Ia).²⁶
2. The chronological division is given next to the bars.
3. The CP/SWS values of the interaction of the two (sub)themes is calculated for every period from figure III.13.

Because both the CP and the SWS values have to be taken into account, it is in the chronological ordering in figure III.13 that the interaction between (sub)themes 1 and 4 is studied separately for every period (the population per period is only three tombs and thus too small to give relevant results in a realistic situation).

²⁵ The term “prime (sub)theme” is not identical with the term “main theme” as used in the research program of the Leiden Mastaba Project (LMP). There the term “main theme” is attributed to every theme that is a conglomerate of a number of (sub)themes and/or attributes.

²⁶ The cultic character of the prime (sub)themes is defined as a working hypothesis.

The interaction between (sub)themes 1 and 4 in the period IV, consists of 3 co-occurrences of which 2 are on the same wall section.²⁷ The conclusion is that the CP = 100% and the SWS = 67%. In the same way, these values are determined for the other periods.

During the period V.M, due to a complete lack of co-occurrences of the two (sub)themes, the CP and SWS value are given as zero.²⁸ However, in order to describe the cultic character of a (sub)theme the cultic character for the other periods has to be determined.

In the periods where the SWS values of the interactions with (sub)theme 1 are relatively high (here the period IV), it is possible to conclude whether or not the interaction with (sub)theme 1 is an association, thus enabling the conclusion of a type Ia cultic character for (sub)theme 4 during this period.

However, if the SWS value is relatively low (in figure III.20 the periods V.E and V.L) no such conclusion is possible, because it cannot be concluded out of hand whether the value SWS = 50% indicates an association or a dissociation. So a method must be developed that makes it possible to decide whether the SWS value indicates an association or a dissociation, thus making it possible to conclude whether during a certain period the interaction between (sub)themes 1 and 4 is such that (sub)theme 4 also has a type Ia character or not.

(sub)theme 1 (prime (sub)theme)	← type Ia →				
(sub)theme 4					
	IV	V.E	V.M	V.L	VI ²⁹
CP =	100	200	0	100	---
SWS =	67	50	0	50	---

Figure III.20: Type-diagram giving interaction per period of (sub)themes 1 and 4.

V.1.2. The determination of the cultic character of (sub)themes by way of CPSD values.

In figure III.14 the CP values as determined in the chronological ordering of figure app.III.4.4 have been gathered. From this table the CPSD values for each interaction can be calculated (figure III.21).³⁰

²⁷ Multiple placements are treated according to the number of placements they contain.

²⁸ In this case "0" has been given as value, because the use life of the (sub)themes was not yet over (figure III.16) so there is no question of lack of overlap between the (sub)themes during that period.

²⁹ The interaction in this period are shown with "---" instead of "0" because in this period no interaction is possible between (sub)themes 1 and 4.

³⁰ The CPSD values that are marked by "---" cannot be determined because the population is too small or because the CP value is not present.

Figure III.21: The CPSD values determined from figure III.14.

(sub)theme		8	7	2	3	5	6	4	1
	no. placements	3	3	7	8	10	11	12	14
8	3	-	---	---	1.5	0.5	0.5	- 1.8	1.2
7	3		-	- 0.7	---	- 1.2	---	0.4	- 0.4
2	7			-	- 0.8	0.9	0.1	0.5	0.4
3	8				-	- 0.7	0.9	- 2.0	1.1
5	10					-	- 0.3	0.8	- 0.8
6	11						-	0.2	1.1
4	12							-	---
1	14								-

The CPSD value of the interaction between (sub)themes 3 and 4 (CPSD = - 2.0, marked in grey), is based on only one co-occurrence, and consequently its reliability is small.

The CP/SWS values from the table in figure III.18 are graphically rendered as points in figure III.22, but contrary to the diagram of figure III.19, the sign of their CPSD value (positive or negative) is also included.

It is evident that the CP/SWS = 13/100 of the interaction between (sub)themes 3 and 4 gives a point that is completely unacceptable, due to a small overlap in time. Consequently this interaction will not be incorporated in the discussion. The CP/SWS point 167/60 (interaction (sub)themes 3 and 8) has to be taken into account because it is not due to a small overlap in time.

The diagram shows that the interactions that have a negative CPSD value are strongly confined to the area of the diagram where the CP and SWS values are low. It is possible to draw two lines that give an indication of the demarcations between the two regions. The conclusion is that at a SWS value of ca. 40 (the vertical line) the CPSD value of the interactions switches from negative (dissociation) to positive (association). For the (horizontal) CP line the value is ca. 65. The conclusion is that within this set of CP/SWS and CPSD values association and dissociation are determined by a SWS value of ca. 40 and a CP value of ca.. 65.

This switch of the CPSD value from negative to positive at a certain value of CP and SWS can be used as a criterion by which it is possible to decide whether the SWS value of the interaction is high enough to consider the CPSD value positive thus indicating an association between the (sub)themes.

In figure III.20 all the SWS values (except the doubtful value for the period V.M) are higher than 44 – 45, and with this method it is possible to conclude that, if based on the SWS value, all the interactions between (sub)themes 1 and 4 are associations. This conclusion is corroborated by the CP values which are higher than 65. The conclusion is that (sub)theme 4 can be of type Ia.

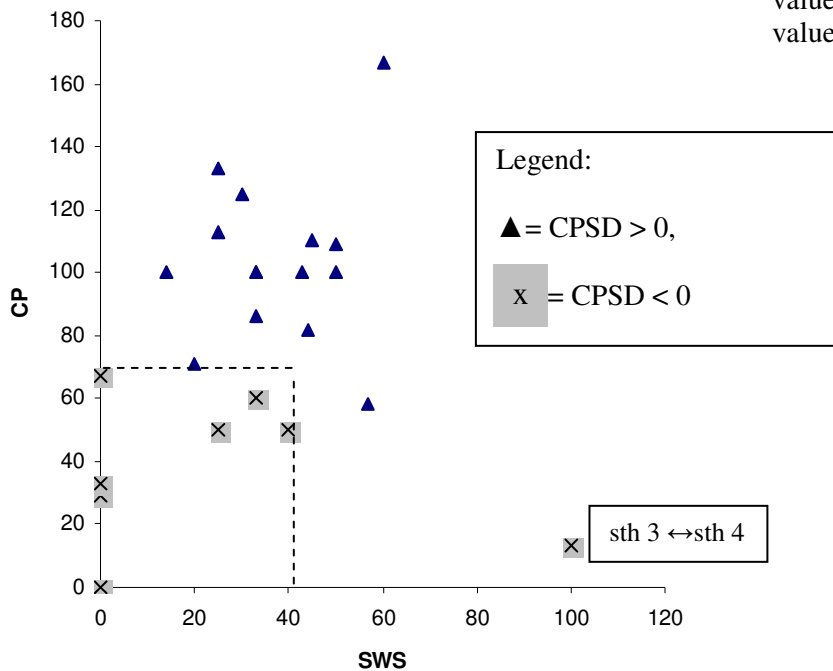


Figure III.22: Diagram showing the connection between the CP/SWS values and the sign of the CPED values of the interactions.

As a deduction from the above methods, it can be gathered that the procedure to determine the character of a (sub)theme is as follows:

1. A chronological ordering of (sub)themes is made (figure III.7).
2. The placements of the (sub)themes are compiled in this chronological ordering (figure III.13).
3. The CP and SWS values of the interactions are calculated from figure III.13 (figure III.18).
4. The CPED values of the interactions are calculated from the CP values in figure III.14 (figure III.21).
5. A CP/SWS diagram is made, and the CP and SWS values of the switch from negative to positive CPED values is determined (figure III.22).
6. A type-diagram is made and in this diagram the character of the (sub)theme being studied is determined (figure III.20).

VI. The determination of the influence between two (sub)themes.

VI.1. General considerations.

Two (hypothetical) (sub)themes X and Y can influence each others chronological development e.g. in the way that the growing presence of (sub)theme X provokes a decrease in the occurrence of (sub)theme Y, it is hereby irrelevant whether the two (sub)themes are placed on the same or on different elements of the western wall.

The only criterion to determine whether an influence over time exists between (sub)themes X and Y, is the CP/period diagram of their interaction.

In order to do this it has to be determined whether in comparison with the FO/period diagrams of the two (sub)themes over time the CP/period diagram of the interaction between the two (sub)themes

1. is exceptionally high or low.
2. shows a different pattern which might indicate a special connection between the two (sub)themes.³¹

There are several possibilities:

1. The CP/period diagram has much higher values than the two FO/period diagrams (an example in figure III.23). Such a CP/period diagram could be explained by supposing a strong positive interaction between the two (sub)themes (in this case an association throughout the whole period).
2. The CP/period diagram of their interaction has much lower values than the two FO diagrams (an example in figure III.24). This development of the CP/period over time can be explained by a negative interaction between the two (sub)themes (a dissociation throughout the whole period).

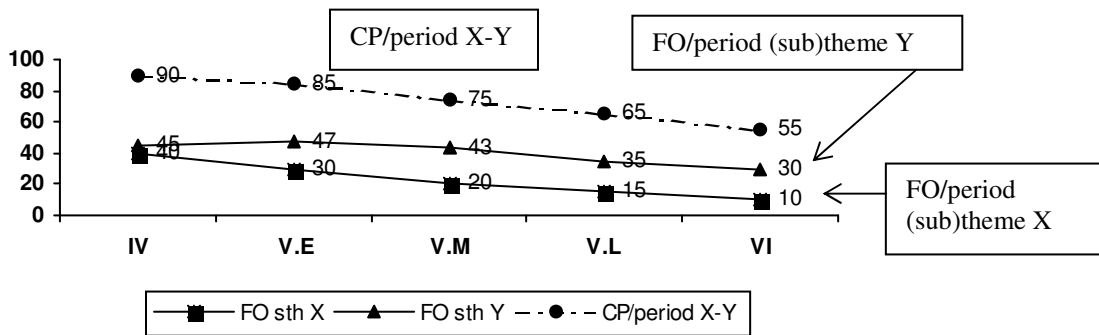


Figure III.23: The CP/FO diagram of (sub)themes X and Y that have a positive influence.

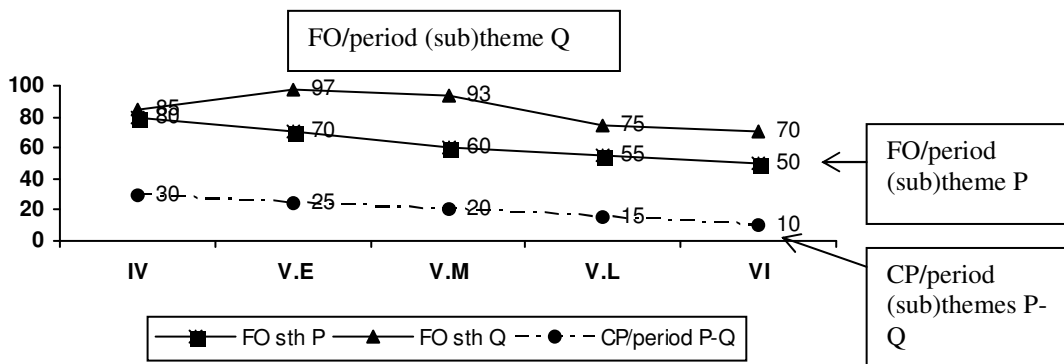


Figure III.24: The CP/FO diagram of (sub)themes P and Q that have a negative influence.

³¹ The bandwidth depicting the uncertainty of each of the FO/period curves is irrelevant because it is just their tendencies that are compared.

3. A change in interaction is depicted in figure III.25 (below). Until the period V.M the CP/period diagram lies between the FO/period diagrams of the two (sub)themes, and thus does not indicate any special connection between them. However, after the start of this period the CP values decrease which can be explained by a growing negative interaction between (sub)themes X and Y.

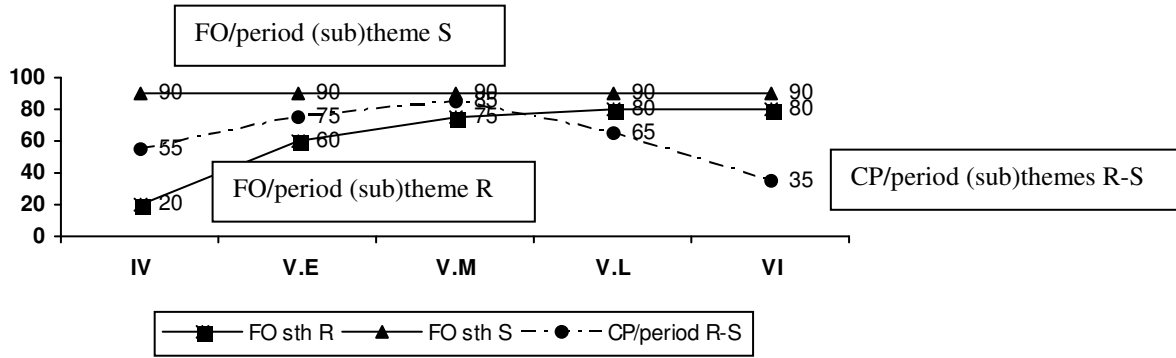


Figure III.25: The CP/FO diagram of (sub)themes R and S that develop a negative influence.

VI.2. The determination of group formation.³²

The above given considerations can be applied to determine whether (sub)themes, which appear to be closely linked, do really form a group. In a hypothetical situation (sub)themes U, V and W seem to be closely linked because their FO/period curves have a strong resemblance (figure III.26). However, this is no proof that a close connection between them really exists, because, despite this strong resemblance, the CP/period values of their interaction can be low, thus excluding this close relationship.

If a connection really exists between two (sub)themes, then the CP/period curve, the only criterion capable of indicating a connection between two (sub)themes, should *closely resemble the FO/period curve with the lowest values* (this is based on the reasoning that the FO value of a (sub)theme is a measure for the number of its occurrences, and that the maximum number of co-occurrences of an interaction is determined by the (sub)theme with the lowest number of occurrences).³³

³² For the term “group”, see table “Technical terms and abbreviations”.

³³ Also here the bandwidth of the uncertainty of each of the FO/period or CP/period curves is irrelevant because it is just their tendencies that are compared.

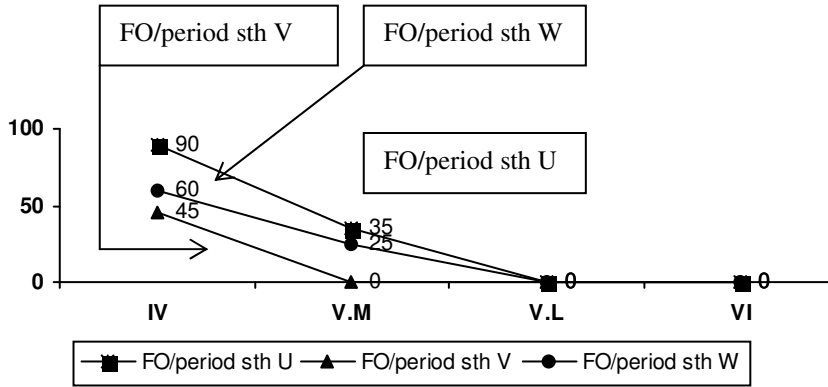


Figure III.26: FO/period (sub)themes U, V and W.

As an example, in figure III.27 the FO/period diagrams of (sub)themes U and V have been gathered from figure III.26 and their (hypothetical) CP/period curve has been added to the figure. The CP/period curve at first closely resembles the FO/period curve of (sub)theme V, and when this curve drops to zero the CP/period curve follows the then lowest FO/period curve, which is the lower part of the FO/period curve of (sub)theme U. The conclusion is that (sub)themes U and V form a group.

In a group of (sub)themes (in this example U, V and W), one of them always serves as the prime (sub)theme, and if this is (sub)theme U, then the CP/period diagrams of interactions $U \leftrightarrow V$ and $U \leftrightarrow W$ have to be determined.

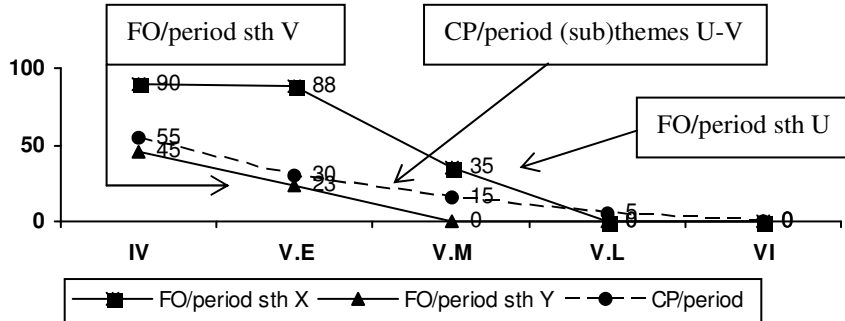


Figure III.27: The CP/FO diagram of (sub)themes U and V that form a group.

Appendix III.1. Various methods of calculating the difference factor CPSD.

Method I: In a hypothetical field the mean value of the field surrounding the central value of 50 is calculated ($200 / 8 = 25$). The difference coefficient CPSD is calculated as

$\text{CPSD} = \text{central field value} / \text{mean value surrounding field}$
--

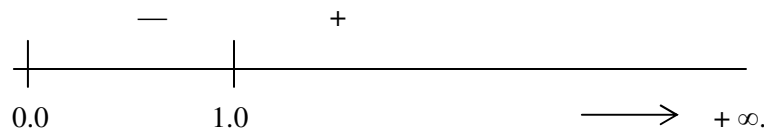
25	30	25
25	50	25
20	20	30

The midpoint can be calculated when the central value is identical to the mean value of the surrounding field, here 25. This gives a midpoint of 1.0.

If the central value is higher than the mean value of the surrounding field, e.g. 50, the CPSD is 2.0 in a scale going to $+\infty$.

If the central value is lower, e.g. 10, the CPSD value becomes $10/50$, giving 0.2 in a scale going to 0.

Values situated in the part of the scale between 0.0 and 1.0 must then be considered to be negative, and values over 1.0 as positive.



It is apparent that the two scales at both sides of the midpoint (1.0) are completely different and the values therein cannot be compared.

Method II: In the same hypothetical field the CPSD value is calculated in two steps:

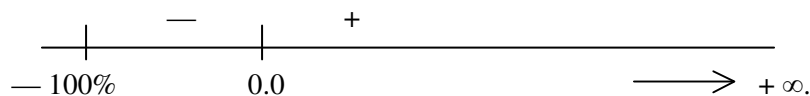
1. Central value – mean value surrounding field.
2. The result of step 1 is expressed as a percentage of the mean value of the surrounding field.

The midpoint can be calculated by taking a central value of 25 ($25 - 25 = 0$), the result 0 is 0% of the mean value of the surrounding field.

If a central value of e.g. 100 is taken, the result is $100 - 25 = 75$, $75 \times 100/25 = 300\%$ on a scale going to $+\infty$.

A central field value of 10 gives $10 - 25 = -15$ and the second step gives $-15 \times 100/25 = -60\%$. This scale goes to -100% .

Again the two scales at both sides of the midpoint (0.0) are not identical; however the only advantage of this method is that a sign is automatically introduced by the calculation method.



Appendix III.2. Calculating the difference factor (CPSD) of the central value.

Method I (the CPSD calculation).

The calculation method is demonstrated on a field of CP values surrounding a (much higher) central CP value of 50 (marked in grey).³⁴

The first step is the calculation of the arithmetic average “M” of all the values in the field by means of the formula:

$$M = \text{sum of all the values in the field} / \text{number of values}$$

20	30	25
35	50	25
20	20	30

The sum of all the CP values in the diagram is 255 and the number of CP values is 9.

The result $M = 255 / 9 = 28.3$.

The next step is the calculation of the square of the difference between a value of the surrounding field (called x) and the arithmetic average “M” of the group ($x - M$). In formula:

$$(x - M)^2$$

This is calculated for every member of the group.

The square of the difference for every value of the field is:

$$\begin{array}{lll} (20-28.3)^2 = 68.89 & (30-28.3)^2 = 2.89 & (25-28.3)^2 = 10.89 \\ (35-28.3)^2 = 44.89 & (50-28.3)^2 = 470.89 & (25-28.3)^2 = 10.89 \\ (20-28.3)^2 = 68.89 & (20-28.3)^2 = 68.89 & (30-28.3)^2 = 2.89 \end{array}$$

The next step is that the sum “S” of all the $(x - M)^2$ values is determined.

$$S = \text{sum of all } (x - M)^2 \text{ values}$$

The result is $S = 750.01$.

This sum “S” is then divided by the number of members of the group (here 9), giving the value “ S_{mean} ”, the result is $750.01 / 9 = 83.33$.

$$S_{\text{mean}} = S / \text{number of values}$$

The last step is the calculation of the square root “R” of the value 83.33 thus obtained. The result is 9.13.

³⁴ This calculation method is originally meant for the calculation of the eccentricity or the deviation existing between a measured value and the normal distribution of all the measured values, a method which is described in Wijvekate, *Statistiek*, 60 ff..

$$R = \sqrt{S_{\text{mean}}}$$

As calculated above, the arithmetic average “M” of the total field is 28.3 and its difference $(x - M)$ with the central value is $50 - 28.3$ which comes to 21.7.

This value is higher than the calculated value of “R” of 9.13, in fact it is $21.7 / 9.13 = 2.4$ x higher. This value $(x - M) / R$ is called the CPSD of the central value.

In the same way this calculation can be made for a central CP value that is lower than the surrounding field.

50	45	55
30	10	50
45	55	35

The CPSD of the central value is calculated in the same way as the previous example.

The arithmetic average $M = 41.7$ and the values of the squared difference between the CP value and the arithmetic average are:

$$\begin{aligned} (50 - 41.7)^2 &= 68.89 & (45 - 41.7)^2 &= 10.89 & (55 - 41.7)^2 &= 176.89 \\ (30 - 41.7)^2 &= 136.89 & (10 - 41.7)^2 &= 1004.89 & (50 - 41.7)^2 &= 68.89 \\ (45 - 41.7)^2 &= 10.89 & (55 - 41.7)^2 &= 176.89 & (35 - 41.7)^2 &= 44.89 \end{aligned}$$

The sum “S” of these squared differences is 1700.01 and when divided by the number of values ($= 9$), the S_{mean} comes to 188.89, and its square root R is 13.74.

The CPSD of the central CP value is $(x - M) / R = (10 - 41.7) / 13.74 = -2.3$.

In this case the value of the CPSD is negative, thus expressing dissociation.

With this method the scales at both sides of the midpoint (0.0) are identical and a sign is automatically introduced (see figure III.11).

Method II (the chi-square (“ χ^2 ”) test).

There is another calculation method which is developed to determine whether observed values differ significantly from expected values the latter being based on an assumed (basic) hypothesis. This method is called the “ χ^2 ” (chi-square) test.³⁵

In this research project the test is based on the assumed hypothesis (the “a priori” theory) that the value of the CP in the middle of the field does not differ from the values surrounding it and with the test it is determined whether a difference exists between the central value and the surrounding field and whether this difference is significant (real) or not (is due to coincidence).

Basically the two calculation methods do not differ much, yet method I is more direct. Method II results in a value “p”, but its interpretation depends on the number of degrees of freedom

³⁵ Moroney, *Figures*, 249 ff..

available for the test at hand. The final result is a conclusion about the acceptability and the significance of the measured value compared to the basic hypothesis.

The disadvantage of the method is that no comparable value and sign attached to it, while both of them are directly available using method I.

Appendix III.3. Some aspects of the curves in this research project.

I. The plotting of a curve through a series of points.

The following discussion concerning curves as they are encountered in this research project is based on some preliminary considerations. Already the statement that a series of measurements can be turned into a curve just by joining these points by means of a line leads to the realisation that curves displaying a chronological development are basically non-continuous.

The resulting curve can have the appearance as in figure app.III.3.1, however, an appearance as in figure app.III.3.2 or even worse is also possible. Yet, the latter cannot a priori be rejected because it is the result of existing measurements, and is, as a consequence, dependant on the reliability of the points making up the diagram.³⁶

1. Some values, like FO and CP, are derivatives of other values and depend
 - a. on the number of tombs per period.
 - b. on the number of occurrences per period of a certain (sub)theme.
 - c. on the number of co-occurrences.
2. Some values, like CPSD and SWS, are calculated from two, thus obtaining a higher uncertainty.

But even primary data, like the type of (sub)themes placed on the western wall during a certain period, depend on a number of considerations that have no direct connection with the (sub)themes themselves.

Of these the most important and the one that affects the final appearance of the curve most is the consideration that everything pertaining to the chapel, like cult, decoration, and layout, is based on ideas concerning life after death, thus the sustenance of the *ka* of the deceased. These ideas are basically religious, and religion is conservative. This means that, although changes do occur, they are gradual.

A curve of a random appearance, like the one of figure app.III.3.2, even though it is the result of a series of measurements, has to be reconsidered taking into account the preceding discussion. The final curve, which has the least possible random appearance, is not going to be the result of sketching “an approximately best fitting line”, but of a calculation.

In the course of such a calculation the points, depicting the measurements, are “connected” by means of a line calculated to give “the best fit”. This does not mean that the calculated line really connects the points, most of them will not even be points of the calculated line, but the line approaches them as much as mathematics allow.

In figures app.III.3.1 and app.III.3.2 two (hypothetical) series of FO values are depicted.

In order to determine the most probable form, the curve formed by the points of the measurements is compared against two types of curves which have the following appearance:

³⁶ If the points have a high degree of uncertainty, the curve can easily be rejected, which is not the case if the points of the curve have a relatively high degree of certainty.

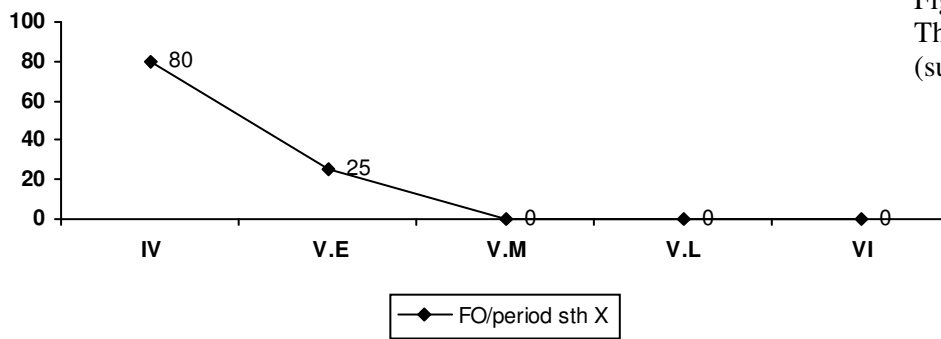


Figure app.III.3.1:
The FO/period of
(sub)theme X.

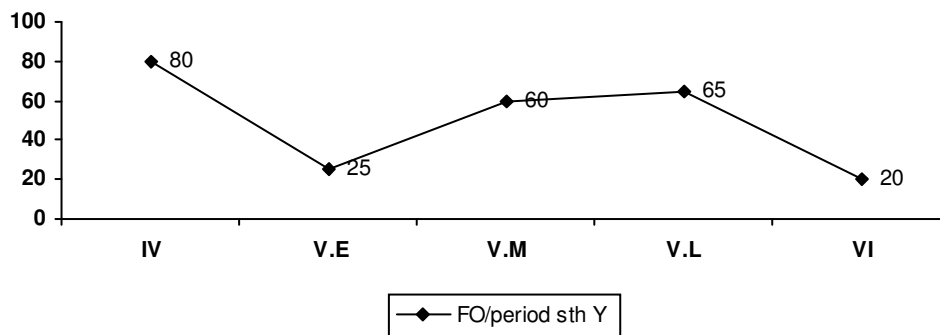


Figure app.III.3.2:
The FO/period of
(sub)theme Y.

1. A straight line, in the legend of the diagram called “linéaire” or “linear”. This line represents the calculated best fit that can be found for a straight line in the population of points.³⁷
2. A non-linear line, called “polynomial”. This is the best fitting non-linear line that can be found between the points of the population.³⁸

As already mentioned, the points of the population are not necessarily also points of the calculated line, and a criterion has to be defined by which the type of curve that is ultimately chosen (that has the best fit) is going to be determined.

The reliability of the calculated curve (“the fit”) is expressed by way of its “coefficient of determination” (R^2).³⁹

³⁷ Moroney, *Figures*, 279 ff..

Also see the sections “coefficient of determination R^2 ” and “statistical properties of the parameters” in http://www.aiaccess.net/English/Glossaries/GlosMod/e_gm_regression_linear_simple.htm

³⁸ The mathematical background of the calculations leading to these two curves is beyond the scope of this research project.

³⁹ The value of R^2 is automatically calculated while constructing the curve connecting the measured points. The value of R^2 is given with four decimals, which means that in figure app.III.3.3 the values introduced into the calculation are not 25 and 80 but 25.0000 and 80.0000. Consequently, the resulting line is based on data that are interpreted as far more precise as they really are. The points of the diagrams each have their own absolute error and while calculating the term R^2 all of these add up to the final (absolute) error (<http://mathworld.wolfram.com/Accuracy.html>). This means not only that the calculated curve can just be

This value is calculated from the difference between the proposed curve and the measured or calculated points of the population. The value of the coefficient is between 0 and 1, and the closer it is to 1, the more reliable the calculated curve is.

In figures app.III.3.3 and app.III.3.4 both types of curves are drawn.

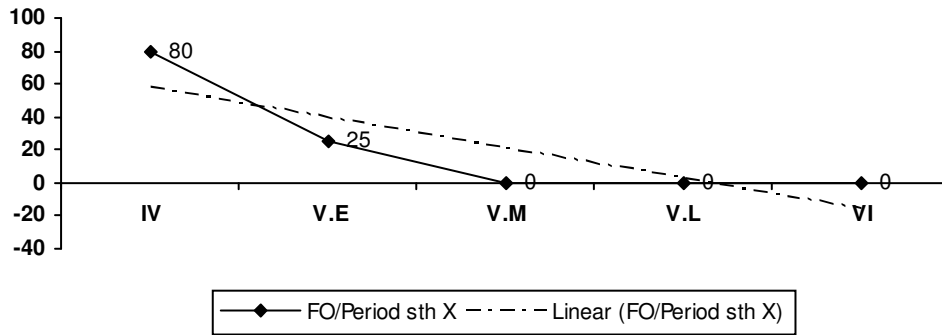


Figure app.III.3.3: The linear in the diagram of FO/period (sub)theme X.

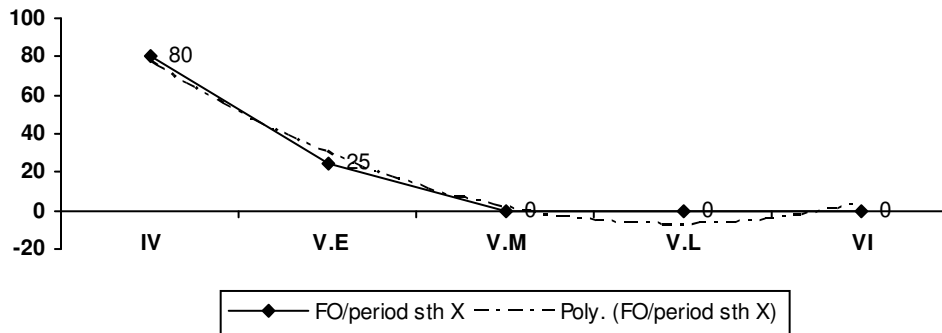


Figure app.III.3.4: The polynomial in the diagram of FO/period (sub)theme X.

It is evident that the polynomial has the best fit here, and the resulting curve is not the straight line of figure app.III.3.3 but the curved line of figure app.III.3.4.

However, if the same is done for the population of points in figure app.III.3.2, the result is completely different (see figures app.III.3.5 and app.III.3.6).

The spread of the points is such that both the linear and the polynomial give a bad fit, bad enough to conclude that there is no real connection between the points of the population and that they do not represent a chronological development in the sense in which the term is employed in this research project.

utilized as an indication, but also that the R^2 value is of no avail for the determination of the best fitting curve because, due to the high uncertainty of the measurements its decimals are without meaning. The mathematical background of this term is beyond the scope of this research project.

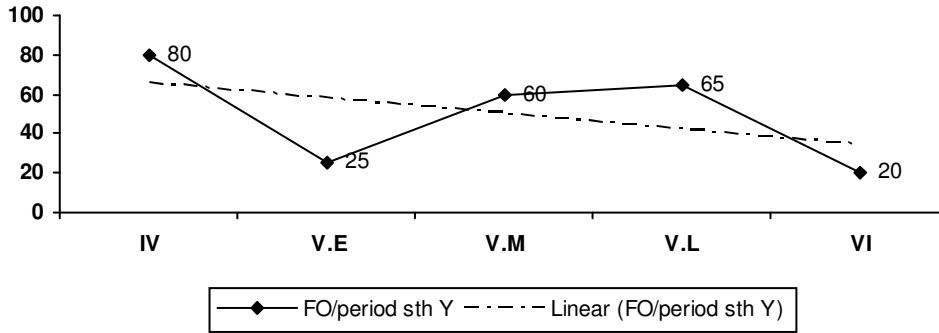


Figure app.III.3.5: The linear in the diagram of FO/period (sub)theme Y.

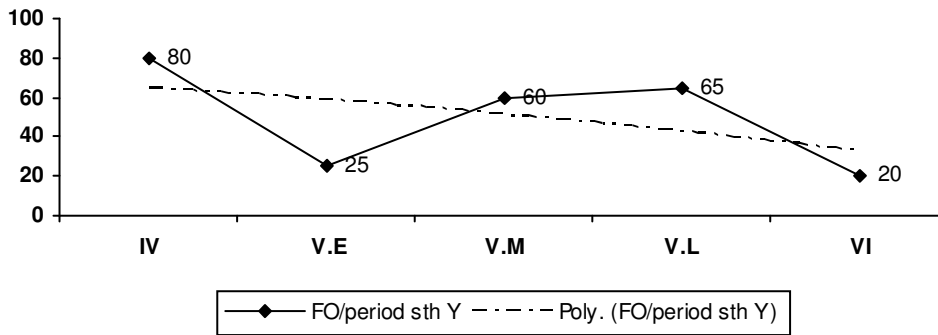
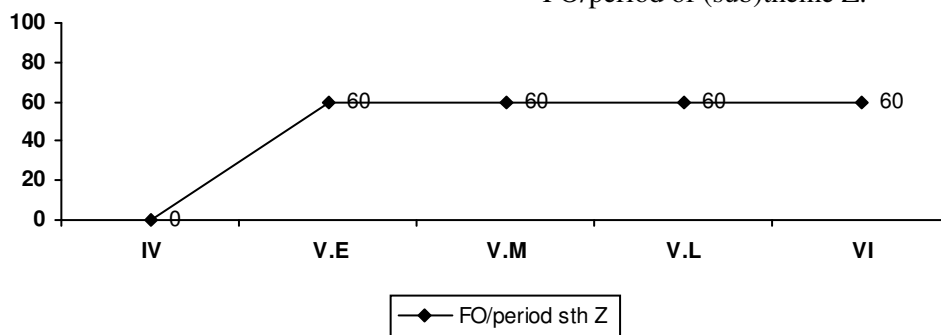


Figure app.III.3.6: The polynomial in the diagram of FO/period (sub)theme Y.

In this type of curve both lines do not give an acceptable fit. Taking into account the assumed hypothesis about religious conservatism, this means that the values measured and/or calculated are biased by circumstances beyond control. Although just as the result of a series of measurements the curve has to be accepted, within the assumed hypothesis it is hardly acceptable as the result of a chronological development.

Another problem is a diagram with a curve of the form given in figure app.III.3.7.

Figure app.III.3.7: Hypothetical curve of FO/period of (sub)theme Z.



Here there are three possible curves instead of two:

1. The linear (in figure III.3.8, the fit of this type of curve is extremely poor).
2. The polynomial (see figure III.3.9), this curve has a better fit than the linear.
3. The curve as it is. In this case this appears the best solution; the curve obtained in figure III.3.7 is possible.

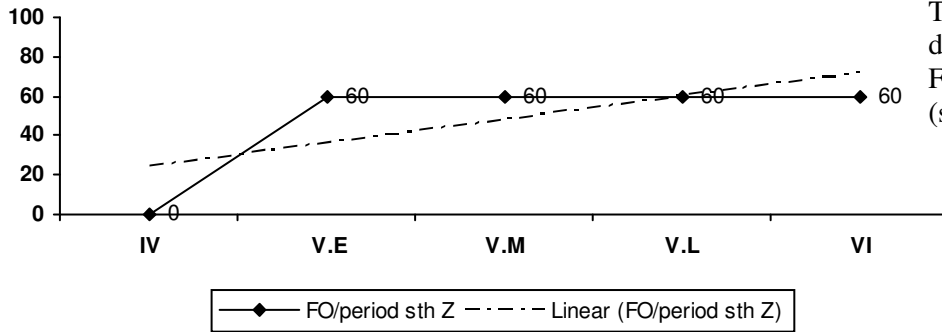


Figure app.III.3.8:
The linear in the diagram of FO/period (sub)theme Z.

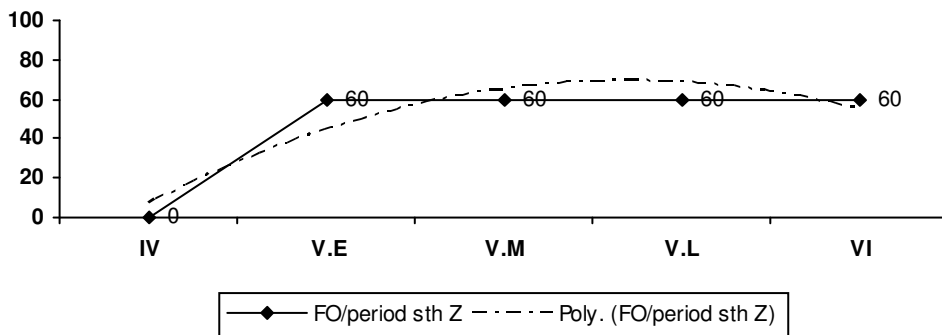


Figure app.III.3.9:
The polynomial in the diagram of FO/period (sub)theme Z.

II. The algebraic equation of a straight line.

A straight line is defined by the equation $y = ax + b$. Here is "a" the "direction coefficient" which defines the angle α that the straight line has with the horizontal axis (figure app.III.3.10 below), and $a = \text{tg } \alpha$. This means that if the value a is very small (approaching zero) the angle is small and the line is nearly horizontal, if the value a is high the line is nearly vertical.

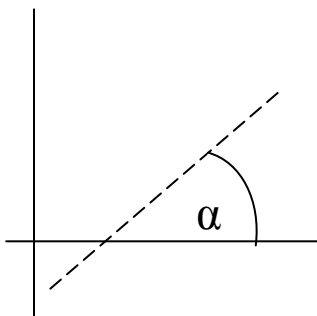


Figure app.III.3.10: The definition of the direction coefficient.

III. Some considerations concerning the reliability of the results.

As in all research employing data directly obtained by means of exploration in the field (be it a laboratory, be it a desert) they are biased by errors. In the case of the research project at hand, which employs the decoration in the chapels of Old Kingdom mastabas in Giza as its “raw” material, these data can be and, no doubt, are biased by several major errors, some of them being:

1. In case the decoration has been documented epigraphically, systematic errors are possible, but certainly random errors which are introduced by the epigraphist are inherent to the result.⁴⁰
2. If the decoration has been photographed the most probable error is the inverted printing of the negative.
3. If the result of the excavation is finally printed, despite modern scanning and printing techniques, relevant detail can be obscured

Another source of uncertainty is an unreliable or wrong dating of one or several tombs in the catalogue of chosen tombs. This leads to a fault in the chronological ordering of the tombs, and because this ordering is going to be the foundation of the further research project, such a fault introduces a systematic error.

This error also is the source of a possible faulty division in the chronological periods,⁴¹ which are necessary for the determination and depiction of chronological developments. This error introduces deviations in all diagrams showing values of a quantity per period (e.g. FO/period or CP/period).

The division in chronological periods might introduce another problem; not only the number of tombs per period can be too small to allow reliable FO/period calculations,⁴² but if in such a small population of tombs the number of co-occurrences per period between two (sub)themes is small, the thus calculated CP percentage has a large degree of uncertainty.⁴³

The consequence of this is that all diagrams, tables, etc. in which CP and/or FO values are directly or indirectly employed are more or less influenced by this uncertainty. This appears to render the curves employed in this research project useless. However, the curves are not used as entities in which the measured points are absolute. Keeping in mind that the time-scale is non-continuous, they are used as figures representing areas of probability which are depicted as the parts of the vertical lines that are between the two dotted lines in figure III.3.11.

The probability inherent in every value makes it possible to draw several valid curves in the diagram. The lines $A_1 - B_2$ and $A_2 - B_1$ are for several of the measured points situated outside the area of probability, and do not represent possible curves. The (not represented) line $A_1 - C_2 - D_1 - B_2$ is completely embedded within the probability areas and is possible. Although this line does not “follow” the line through the measured points, it remains within the tendency-area of the original line and can be interpreted as such.

⁴⁰ John Robert Taylor (1999). *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*. University Science Books. p. 94, §4.1.

⁴¹ An (fictitious) example is if in figure III.3 tomb C has not been placed in period IV, as it is here, but in period V.E.

⁴² The degree of uncertainty in the FO values (expressed as a percentage) depends on the value of the number of tombs in the period.

⁴³ The degree of uncertainty in the CP values (expressed as a percentage) depends on the value of the maximum possible number of co-occurrences.

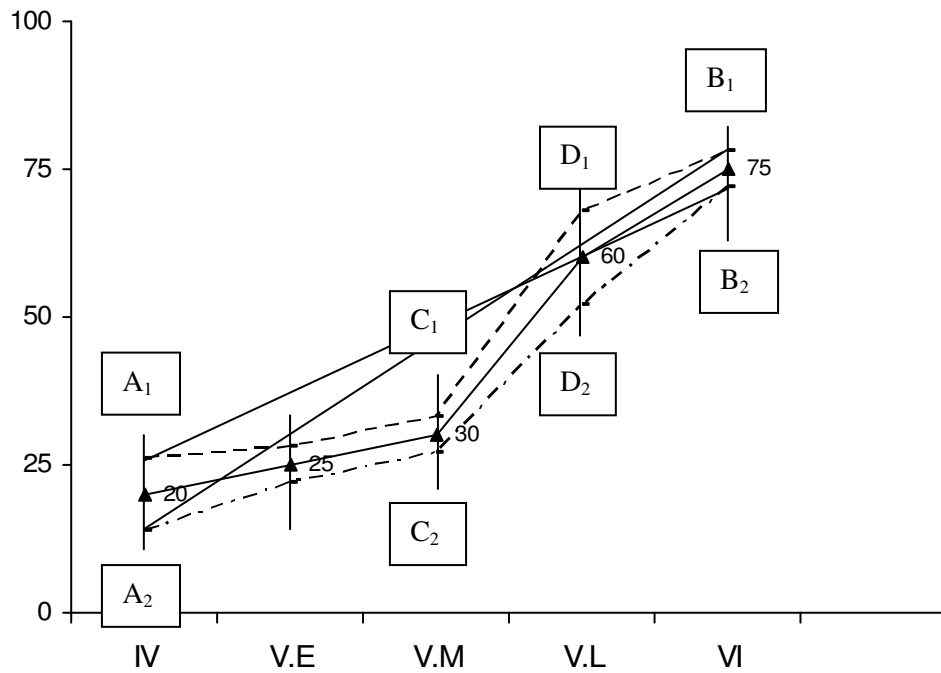


Figure III.3.11. A (fictitious) curve with the probability areas of some points of the curve.

The R^2 value has been rejected as a means to determine “the best fit” for a curve, because considerations concerning the certainty of the FO and CP values in a diagram have demonstrated that these values are too uncertain to be given with decimals. This makes a four-decimal quantity like R^2 completely out of place.

The above mentioned considerations are taken into account only then when this is necessary for the interpretation of the diagrams at hand.

Appendix III.4. The making of a chronological ordering.

A chronological ordering is the best fitting order of attributes according to a predetermined criterion, and in this case the attributes are (sub)themes 1–8 and the predetermined criterion is the period of occurrence of the (sub)themes.⁴⁴

Chronological orderings can be made with a simple chart,⁴⁵ or by means of a computer program.⁴⁶

In this example the number of tombs is not sufficiently large to make a computer-aided chronological ordering useful, nor is this the case for the chronological orderings involved in the research project itself.

The general organization of a chronological ordering of 8 (sub)themes is shown in figure app.III.4.1.

The lines representing the *use life* of an attribute can be placed in the chronological ordering in three ways:

1. According to their point of first appearance.
2. According to their midpoint.
3. According to their point of last appearance.

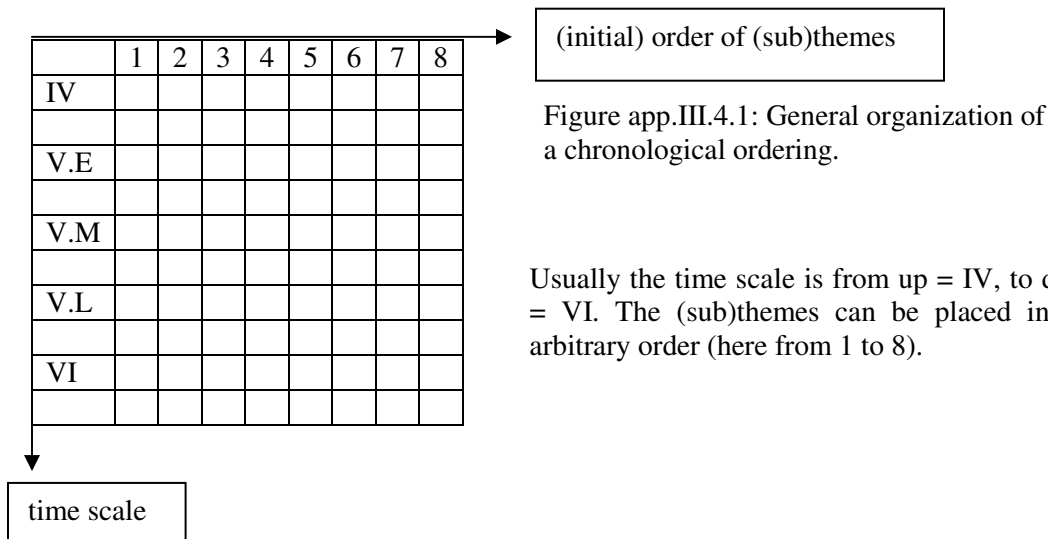


Figure app.III.4.1: General organization of a chronological ordering.

Usually the time scale is from up = IV, to down = VI. The (sub)themes can be placed in any arbitrary order (here from 1 to 8).

The result for (sub)themes 1 – 8 in figure III.3 is given in figure app.III.4.2. The lines in the chronological ordering represent the *use life* of the (sub)themes, and the midpoint is given as a “dot”.⁴⁷

From this type of unorganized representation, it is not possible to form conclusions about chronological developments of the (sub)themes in the set.

⁴⁴ Renfrew, *Archaeology*, 104 – 8.

⁴⁵ As was the case in the “sequence dating” of Flinders Petrie.

⁴⁶ Kemp, *Dating*, 259-291 and Kemp, *Automatic analysis*, 5-15.

⁴⁷ Polz, *Recording methods*, 122.

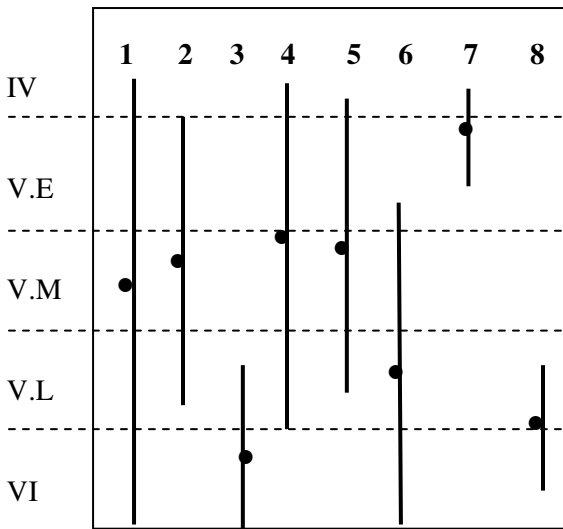
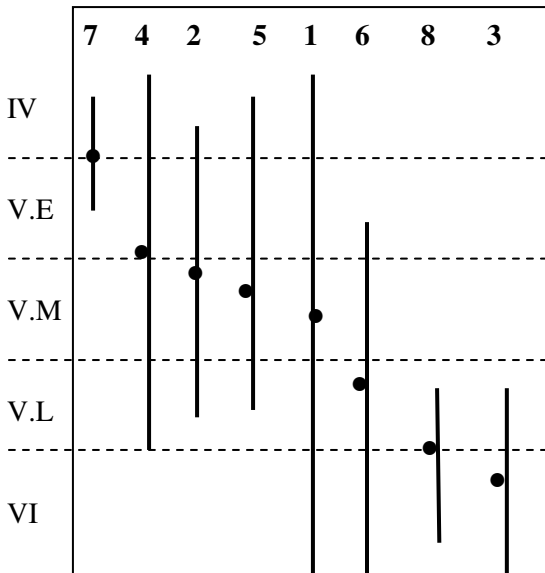


Figure app.III.4.2: The *use life* of (sub)themes 1 to 8.

In the chronological ordering in figure app.III.4.2 the next step is to change the order of the (sub)themes in such a way that the total development becomes a smooth continuation of lines (based on the descending order of the midpoints (see figure app.III.4.3). In the process of finding the proper order of (sub)themes, the tendencies of the diagrams of the FO/ period of the (sub)themes (e.g. figures III.4-III.6) can be helpful. In this research project the chronological orderings are made in this manner.⁴⁸



It is possible that this is not yet the definitive order, because in some cases small adjustments in the order of the (sub)themes are necessary to obtain the desired smooth continuation of the lines. From figure app.III.4.3 it is evident that the order of (sub)themes is different for a chronological ordering based on midpoints than one based on first appearance.

Figure app.III.4.3: Chronological ordering of the *use life* of (sub)themes 1 to 8.

The chronological ordering given in figure app.III.4.3 is only theoretical, but as a method it can be directly applied in the research project.

⁴⁸ Kemp, *Dating*, 262-3.

	(sub)theme	7	4	2	5	1	6	8	3
period	tomb								
IV	A	•	•			•			
	B	•	•		•	•			
	C	•	•	•	•	•			
V.E	D		•		•				
	E	•	•	•					
	F		•	•	•	•	•		
V.M	G			•	•	•			
	H		•	•	•	•	•		
	I		•		•				
V.L	J		•	•		•	•		
	K			•	•	•		•	•
	L		•				•	•	•
VI	M					•	•	•	•
	N					•	•	•	•
	O					•			•
total		3	10	7	7	10	6	2	5

Figure app.III.4.4: The result of the (midpoint) chronological ordering of (sub)themes 1 through 8.

This method is employed in making the same chronological ordering employing the (sub)themes and data compiled in figures III.1 and III.3. In order to enhance visibility, all the “x’s” given in table III.3 are introduced as “dots” in figure app.III.4.4.⁴⁹

The order of the (sub)themes in figure app.III.4.4 is identical to the one in figure app.III.4.3. (The even number of places of (sub)theme 8 is only a problem caused by this way of presenting a chronological ordering. However, the use life of a (sub)theme in a chronological ordering is a continuous line and the midpoint can be placed anywhere, because it has no chronological reality).

In this type of chronological ordering the assigned place of a tomb is based on its dating. Although the chronological ordering may give the impression that a vertical change of place of one of more tombs might lead to a smoother chronological ordering, that would cause the date of these tombs to change.

However, a chronological ordering is not a refined dating tool, and such an indication of a change in dating has to be supported by other, more conclusive evidence.

⁴⁹ Only the “x”’s can be introduced in this figure because they represent placements which are certain.