Dariusz Dukaczewski

IGiK – Instytut Geodezji i Kartografii, ZSIP
(Institute of Geodesy and Cartography, GIS Department)
ul. Modzelewskiego 27, 02 – 679 Warszawa (Warsaw), Poland
Tel: (+ 48 22) 3291970, Fax: (+48 22) 3291950
e-mail: dariusz.dukaczewski@igik.edu.pl, darek@igik.edu.pl

Biography

Position:	Tutor
Date of birth:	28.05.1962
Education:	
Institution:	University of Warsaw, Department of Geography, Institute of Cartography
Dates:	10.1982 - 05.1987
Degree/Diploma:	M.Sc. diploma in Geography with specialization in Cartography
Institution:	University of Paris VI (Pierre at Marie Curie)
Dates:	10.1993 - 07.1994
Degree/Diploma:	DESS diploma in Remote Sensing
Institution:	Polish Academy of Sciences, Institute of Geography
Dates:	10.1982 - 05.1987
Degree/Diploma:	Ph.D. diploma in Earth Sciences

Professional experience:
07.1987 - 09.1988 lecturer at Laboratory of Remote Sensing, Cartographic Institute (University of Warsaw)
10.1988 - 09.1992 lecturer at Institute of Geography, Polish Academy of Sciences.
Since 10.1992 lecturer, senior lecturer, tutor at IGiK.

Activities:
Research concerning: dynamic and interactive visualization, application of new media technologies to cartography, web cartography, application of remote sensing data in thematic mapping, decision – making management, GI, Data Policy. Author of 61 published works, author or co-author of many GIS, data bases, cartographic animations, thematic maps.

METHOD OF CHOICE OF VARIABLES AND CARTOGRAPHIC PRESENTATION METHODS FOR COMPLEX CARTOGRAPHIC ANIMATIONS

Dariusz Dukaczewski
Institute of Geodesy and Cartography (IGiK),
ul. Modzelewskiego 27, 02 – 679 Warszawa
e-mail: dariusz.dukaczewski@igik.edu.pl

Abstract

Recently, the complex cartographic interactive animations, have become more widespread. Using the author's results of investigations in possibilities and limitations of application of static and dynamic variables and related cartographic methods in the creation of animations, as well as new research author proposes the *entities – polystaymic method* of selection of variables for complex temporal cartographic animations.

Introduction

After over 45 years of development, digital cartographic animations have become entirely operational tool for the visualization of the dynamics. Recently it becomes also possible to create complex interactive animations, including a number of sub-animations, which allows to present more information about the correlated dynamic processes and/or about their causes. In author's opinion, one of the key factors of efficiency of cartographic animations is a proper choice of the variables at suitable levels of measurement and on an appropriate method of cartographic presentation. Using the results of investigations on entities-cartotrophic method (Dukaczewski, 2005) and new research on complex interactive animations properties author proposes the method of selection of variables and cartographic presentation methods for complex temporal animations. To achieve this goal it was necessary to propose a classification of complex animations, to investigate possibilities of combined usage of cartographic presentation methods in complex animations, to re-evaluate the possibilities of combined usage of static variables (size, value, colour, form; grain, orientation, transparency, and (proposed) brilliance, halo/aura) and dynamic variables (moment, duration, frequency, order, rate of change, and (proposed) way of transition). The next step was a creation of the matrix of combinations of groups of variables and related cartographic methods. The proposed method of choice of variables and cartographic presentation methods for complex

temporal animations employs the results of research in possibilities of use of variables in the creation of sub-animations. It uses also matrices of combined usage of cartographic presentation methods, as well as matrix of combined use of groups of methods and variables in the complex animations.

Classification of complex animations

Analysis of recent animations allowed author to propose classification based on criterion of concept of internal structure. It was possible to distinguish types of analytical and synthetical animations, and subtypes of simple and complex animations. Both in the case of simple and complex animations it is possible to distinguish monomodule and multimodule, as well as multilevel and monolevel animations. Analysing the types of scenarios, it was possible to distinguish: automatic and user-supervised scenarios of linear or non-linear type, of simple or tree structure, gradual or non-gradual order, parametrical or non-parametrical solutions and calculation or non-calculation character, what allowed to distinguish 512 types of scenarios. For the purposes of research all sub-animations were classified (like simple animations), using typology based on entity types and the measurement levels (Dukaczewski, 2005) and using the same system of notation.

Evaluation of the combinations of cartographic presentation methods

The object of evaluation were 24 main types of cartographic methods of presentation. Each combination was tested, taking into the consideration semiotic rules and criteria used in cartographic methodology. The result was matrix of evaluation of the combinations of cartographic presentation methods. It was possible to distinguish 191 correct combinations of methods. The most ‘connectible’ method were: ordinary level point signatures, dot method, ordinary level point choropleth maps, ordinary level point cartodiagrams (appendix 1).

Possibilities of combined usage of static and dynamic variables and related methods

Evaluation of the application of static visual variables (Dukaczewski, 2005) was completed for the new proposed variable of *aura* (fig. 1), allowing symbols to be a source of light, be ‘neutral’ or to be the object which absorbs the light. This (proposed) variable could be ranked

Fig 1. Proposed variable of *aura*

(like *grain, orientation, transparency and brillance*) among the 'facultative' static variables (Dukaczewski, 2006). The revised proposition of evaluation of application of static visual variables was shown in figure 2.

static visual variables	point symbols level			line symbols level			area symbols level		
	quantitative	ordinary	nominal	quantitative	ordinary	nominal	quantitative	ordinary	nominal
size			X			X			X
value			C			C			C
colour	C	C		C	X		X ?	X ?	
form	X	X		X	X		X	X	
grain	X ?	X ?	N SP	X			X	X	
orientation	X	X	SP ?	X	X	SP ?	X	X	
brilliance	X			X			X	X	C
transparency	X			X			X	X	C
aura				X	X	X	X	X	X

solution

	correct	SP ?	sporadically practiced, but doubtful
N SP	not practiced or sporadically practiced	X ?	incorrect, doubtful
C	conditional	X	incorrect

Figure 2 Evaluation of application of static visual variables at different measurement levels

The next step was revision of matrix of correct combined applications of static variables (appendix 2) and revision of the matrix of semiotic evaluation of combined applications of 8 static and 7 dynamic variables: *duration, order, rate of change* (DiBiase, MacEachren et all., 1992), *frequency, display date* (MacEachren, A., 1994) and *way of transition* (Dukaczewski, 2000) (appendix 3). Each combination of static variables was evaluated, using criteria proposed by author (fig 2), solutions of Rød (1997), perceptual evaluations of visual variables (Köbben, Yaman, 1996), and semantic rules used in cartography. The introduction of proposed *aura* resulted in increase from 56 to 77 the number of correct combined applications of static variables and from 101 to 127 the number correct application of static and dynamic variables. The next step was to create the matrix of combinations of groups of variables and related cartographic methods, The result was big matrix of 127!/2 rows, based on correct combinations of static and dynamic variables (appendix 2) and matrix of correct combination of methods (appendix 1), employing the same criteria of evaluation (fig. 3).

Combination	Number of static visual variables		Number of static and dynamic variables	Dynamized variables	Entities and l evels	Combinations of variables	Methods of cartographic presentation	Method 1	Method 2	Evaluation
	Items	variables								
4 - 5	1	4	10	1 2 3 4	αb	1 (I, II, III, IV, V, VII) 2 3 4	Sαb, Kαb, Kdαb	Sαb	Kc	2,6
	1	4	10	1 2 3 4	αc	1 (I, II, III, IV, V, VII) 2 3 4	Kc, Sαc, Kαc (cs), Kdαc (cs)		Sαc	2,8
									Kαc (cs)	0,8
									Kdαc (cs)	0
								Kαb	Kc	0
									Sαc	2,08
									Kαc (cs)	0
									Kdαc (cs)	2, 08
								Kdαb	Kc	2,6
									Sαc	0
									Kαc (cs)	2,34
									Kdαc (cs)	0
4 - 6	1	4	10	1 2 3 4	αb	1 (I, II, III, IV, V, VII) 2 3 4	Sαb, Kαb, Kdαb	Sαb	Sβb	1,2
	1	4	10	1 2 3 4	βb	1 (I, II, III, IV, V, VII) 2 3 4	Sβb, Kβb, Kdβb		Kβb	1,2
									Kdβb	1,2
								Kαb	Sβb	1,08
									Kβb	0
									Kdβb	0,96
								Kdαb	Sβb	1,2
									Kβb	1,2
									Kdβb	1,2
4 - 7	1	4	10	1 2 3 4	αb	1 (I, II, III, IV, V, VII) 2 3 4	Sαb, Kαb, Kdαb	Sαb	lc	2,4
	1	4	10	1 2 3 4	βc	1 (I, II, III, IV, V, VII) 2 3 4	lc, Sβc, Kβc (cs), Kdβc (cs)		Sβc	2,4

Fig. 3 Extract of matrix of combinations of groups of variables and related cartographic methods

Method of selection of static and dynamic variables for complex temporal cartographic animations

To facilitate the choice of static visual variables, dynamic variables and related combinations of methods of cartographic presentation in the case of complex cartographic animations, author proposes a method, called 'entities – polystaymic'[1]. This method (based partially on author's 'enities – cartotrophic' method) employs the choice of dynamized entities and levels of measurement, the identification of types of changes and animation, the selection and verification of combinations of dynamized visual and dynamic variables as well as choice and verification of combinations of cartographic methods of presentation. Its stages are presented in figure 4.

The first two stages - definition of goals of the cartographic animation and data compilation and analysis are the same like in the 'enities – cartotrophic' method. Results of these stages will allow for the definition of general organization of the complex cartographic animation, concerning the type of complex animation, their type of scenario as well as number of subanimations, scale of time. The next stage is definition of organization of N sub-animation (including type of sub-animation, number and thematic scope of time layers), which will allow the identification of entities that are going to be used to the presentation of dynamic phenomena. The definition of the measurement levels of the entities and their types will allow to define the properties of the entities (taking into the consideration the potentialities and limitations of choice of static and dynamic variables). Like in the 'enities – cartotrophic' method, at the same time, using the typology of dynamic phenomena, it is possible to define the type of changes (Dukaczewski, 2005) and the type of animation (ibid).

[1] πολυσταυμη – polystaimi (gr.) is one of the synonym of 'multilevel'

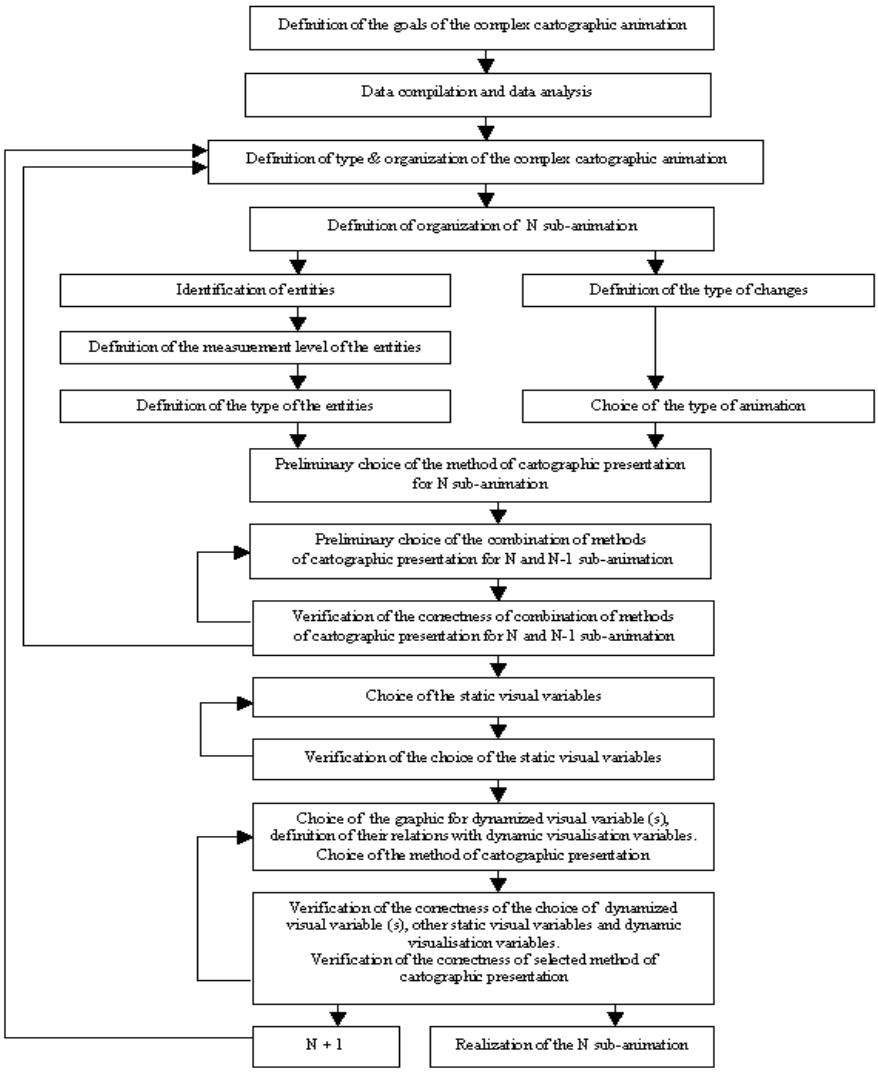

Figure 4. Entities – polystaymic method of selection of static and dynamic variables for complex temporal cartographic animations

This information can be used to carry out a preliminary choice of the method of cartographic presentation for the N sub-animation (using solutions proposed by Korycka – Skorupa, 2002, Dukaczewski, 2003). Using the matrix of the evaluation of the combinations of cartographic presentation methods (appendix 1) it is possible to make the preliminary choice of the combination of these methods in complex temporal cartographic animations for N and N-1 subanimation. The big matrix of evaluation of combinations of groups of the variables of 127!/2 rows allows to verify the correctness of this choice. If the result is positive, it is possible to go to the next stage or to redefine of type & organization of the complex cartographic animation. In the next stage, using the revised evaluation of application of static visual variables (fig. 2) and work on visual differentiation (Kraak, Ormeling, 1998) it is possible to choose dynamized static variables, which can be used in N sub-animation. The following stage is verification of efficiency of this choice. It should be carried out with the

revised matrix of correct combined applications of static variables (appendix 3). In the case of satisfying result, it is possible to choose (using the same matrix) the graphic form for the dynamized variables and to define their relations with dynamic variables as well as the methods of cartographic presentation for N sub-animation. After the verification of the correctness of this choice, it is possible to carry out the N sub-animation and then to pass to the N+1 subanimation.

Conclusion

The aim of this research was to contribute to the discussion on the properties and applications of variables and, hopefully, to the development of the cartographic animation methodology. Like in the case of the 'enities – cartotrophic' method, the 'entities – polystaimic' method was tested during preparation of an electronic methodological atlas of the types of cartographic animations. These tests proved that this method is operational and can be a useful aid in the preparation of complex temporal cartographic animations.

Bibliography

1. Bertin, J., 1967, Sémiologie graphique: Les diagrammes – les reseaux – les cartes; Mouton / Gauthier – Villars: Paris / La Haye, 431 p. ;
2. DiBiase, D., MacEachren, A. M., Krygier, J., Reeves, C., Brenner, A., 1992, Animation and the role of map design in scientific visualisation. Cartography and Cartographic Information Systems, vol. 19 (4), p. 201 – 214 ;
3. Dukaczewski, D., 2000, Kartograficzna prezentacja dynamiki zmian użytkowania ziemi, za pomocą animowanych map elektronicznych na przykładzie Gór Izerskich; PAN, Instytut Geografii i Przestrzennego Zagospodarowania: Warszawa, PhD thesis, 183 p.;
4. DukaczewskI, D, 2003, Metody prezentacji dynamiki za pomocą zmiennych możliwych do stosowania w elektronicznych animacjach kartograficznych. report of KBN grant, Warszawa, 58 p., electronic methodological atlas;.
5. Dukaczewski, D., 2005, Entities – cartotropic method of selection of static and dynamic variables for temporal cartographic animations. Proceedings of the XXII rd ACI/ICA International Cartographic Conference 2005, A Coruña, 9 - 16 July;
6. Dukaczewski, D., 2006**,** Metody prezentacji dynamiki informacji przestrzennych za pomocą interaktywnych animacji kartograficznych. report of KBN grant, Warszawa, 89 p.;
7. Köbben, B., Yaman, M., 1996, Evaluating Dynamic Visual Variables. Proceedings of the seminar on teaching animated cartography, ACI / ICA, Madrid, p. 45 – 51;
10. Korycka–Skorupa, J., 2002, Od danych do mapy. Polski Przegląd Kartograficzny, vol. 34 (2), p. 91 – 102;
11. Kraak, M.–J., Ormeling, F., 1998, Kartografia. Wizualizacja danych przestrzennych; Wydawnictwo Naukowe PWN: Warszawa, 274 p.;
12. Kraak, M.–J., MacEachren, 1999, A. M., Visualisation for exploration of spatial data. The International Journal of Geographic Information Science, vol. 13 (4), p. 285 – 287;
13. MacEachren, A., 1994, Visualisation in modern cartography: setting the agenda**,** [in:] MacEachren, A., Taylor, D.R.F., Visualisation in Modern Cartography. Modern cartography, vol. 2; Elsevier Science Ltd.: Oxford,.
14. Rød, J. K., 1997, The third choice. Colloque 30 Ans de la Sémiologie Graphique, Paris, 12-13 Décembre 1997, p. 172 – 206;

Appendix 1 Evaluation of combined usage of cartographic presentation methods

Method	Evaluation of combined usage of cartographic presentation methods																												
Sαb	X																												
Kαb	ns	N																											
Kdαb	N	ns	W																										
Kc	X	N	X	X																									
Sαc	X	ns	N	X	X																								
Kαc (cs)	ns	N	W*	N	W*	N																							
Kdαc (cs)	N	ns	N	X	X	W*	X																						
Sβb	X	W*	X	X	X	W*	X	X																					
Kβb	X	N	X	N	ns	N	X	ns	X																				
Kdβb	X	ns	X	X	X	W*	X	W	W***	X																			
Ic	X	X	X	X	X	X	X	X	W***	X	X																		
Sβa	X	X	X	X	X	W*	X	X	X	X	X	X																	
Sβc	X	W*	X	X	X	W*	X	W	W***	X	X	X	X																
Kβc (cs)	X	N	X	N	ns	N	X	N	R?	W***	ns	X	W***	X															
Kdβc (cs)	X	W*	X	X	X	W*	X	W	W***	X	X	X	X	X	X														
KαBb	N	N	ns	N	N	N	N	N	N	N	W***	X	W***	N	W***	N													
Kγb	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N	X****												
KDγb	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N	N	X****											
KαBc	ns	N	ns	N	N	N	N	N	N	N	W***	X	W***	N	W***	N	N	R?	N										
Kγc(cs)	X	W**	X	X	X	W*	X	X	X	X	X	X	X	X	X	N	N	N	R?	X****									
KDγc(cs)	X	W**	X	X	X	W*	X	X	X	X	X	X	X	X	X	N	N	N	?S	N	X****								
QKBγc	W	N	W	X	W	N	W	X	W	X	X	X	W	N	W	N	N	N	N	N	N	N							
QKVγc	X	N	W	X	W	N	W	X	W	X	X	X	W	N	W	N	N	N	N	N	N	N	N						
QKEγc	X	N	X	X	X	N	X	ns	ns	ns	ns	ns	ns	N	ns	N	N	N	N	N	N	N	N	N					
QKGγc	X	N	X	X	X	N	X	X	X	X	X	X	X	N	X	N	N	N	N	N	X	N	N	N	N				
Sαa	X	W*	X	X	X	W*	X	X	X	X	X	X	X	W***	X	N	X	X	N	X	X	X	X	X	X	X			
MCa	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	?S	N	N	N	N	N	X	X	X	X	X	X		
MZa	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X***	X***	X***	X***	X	X	X	X	N	X	X	X	X	X
	Sαb	Kαb	Kdαb	Kc	Sαc	Kαc (cs)	Kdαc (cs)	Sβb	Kβb	Kdβb	Ic	Sβa	Sβc	Kβc (cs)	Kdβc (cs)	KαBb	Kγb	KDγb	KαBc	Kγc(cs)	KDγc(cs)	QKBγc	QKVγc	QKEγc	QKGγc	Sαa	MCa	MZa	

Notations:

Cartographic methods

Sαb – ordinary point signature,
Kαb – ordinary point choropleth map,
Kdαb – ordinary point cartodiagram
Kc – dot method,
Sαc – quantitative point signature,
Kαc (cs) – point choropleth map,
Kdαc (cs) – point cartodiagram
Sβb – ordinary line signatures,
Kβb – ordinary line choropleth map,
Kdβb – ordinary line cartodiagram
Ic – isoline method,
Sβa – nominal line signatures
Sβc – quantitative line signatures,
Kβc (cs) – line choropleth map,
Kdβc (cs) – line cartodiagram,
KαBb – ordinary Bertin's choropleth map,
Kγb – ordinary choropleth map,
KDγb – ordinary dasymetric choropleth map,
KαBc - Bertin's choropleth,
Kγc(cs) - choropleth map,
KDγc(cs) - dasymetric choropleth map,
QKBγc –Bürgener's pseudochoropleth map,
QKVγc – rectangle choropleth map,
QKEγc – eumorfic choropleth map,
QKGγc –variodensity networks,
Sαa – point signatures,
MCa - chorochromatic method,
MZa – range map

Evaluation

X	correct	R?	sporadically practiciced, but doubtful
ns	not practiced or sporadically practiced	?S	incorrect, doubtful
W	conditinal	N	incorrect

* Only i cace of dot geometrical chorpoleth map, occupying the fragment of the map

** Not in the case of continouus choropleth map

*** Only in the case when both method are not is used in the same place

**** Only in the case choropleth maps with cross legend or in the case of chorochromatic maps

Appendix 2. Matrix of correct combined applications of static variables

Number of items	Number of variables	COMBINATIONS OF VARIABLES													
0	4	1 2 3 4 α β γ													
1	4	1 2 3 4 αb, αc, βb, βc, γb, γc	1 2 3 4 αa, γa	1 2 3 4 αb, αc βb, βc γb, γc	1 2 3 4 αa βa, γa										
1	5	1 2 3 4 5 βa, βb γa	1 2 3 4 δ	1 2 3 4 7 αa, αb βa, βb	1 2 3 4 8 αa, αb βa, βb	1 2 3 4 9 αa, αb αc									
2	4	1 2 3 4	1 2 3 4 αb βb, βc γb, γc	1 2 3 4	1 2 3 4	1 2 3 4 αa, γa	1 2 3 4								
2	5	1 2 3 4 5 βb,	1 2 3 4 δ	1 2 3 4 7 αb, βb	1 2 3 4 8 αb, βb	1 2 3 4 9 αb, αc	1 2 3 4 5 γa	1 2 3 4 6	1 2 3 4 7 αa	1 2 3 4 8 αa	1 2 3 9 αa	1 2 3 4 5 βb	1 2 3 4 6	1 2 3 4 7 αb, βb	1 2 3 4 8 αa, αb, βb	1 2 3 4 9 αb, αc
2	5	1 2 3 4 5 βa, γa	1 2 3 4 δ	1 2 3 4 7 αa, βa	1 2 3 4 8 αa, βa	1 2 3 4 9 αa,										
2	6	1 2 3 4 5 δ	1 2 3 4 5 7 βa, βb,	1 2 3 4 5 8 βa, βb,	1 2 3 4 5 9	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8 αa, βa, βb,	1 2 3 4 7 9 αb	1 2 3 4 8 9 αa, αb					
3	4	1 2 3 4	1 2 3 4	1 2 3 4 βc	1 2 3 4											
3	5	1 2 3 4 5	1 2 3 4 δ	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9 αb, αc	1 2 3 4 5 βb	1 2 3 4 6	1 2 3 4 7 βb	1 2 3 4 8 αb, βb	1 2 3 4 9 αb, αc	1 2 3 4 5 βb	1 2 3 4 6	1 2 3 4 7 βb	1 2 3 4 8	1 2 3 4 9
3	5	1 2 3 4 5	1 2 3 4 δ	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9	1 2 3 4 5 γa	1 2 3 4 6	1 2 3 4 7 αa	1 2 3 4 8 αa	1 2 3 4 9 αa	1 2 3 4 5	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9 αb, αc
3	6	1 2 3 4 5 δ	1 2 3 4 5 6	1 2 3 4 5 δ	1 2 3 4 5 6	1 2 3 4 5 8 βb	1 2 3 4 5 8 αa βa	1 2 3 4 5 8 βb	1 2 3 4 5 6 βa	1 2 3 4 5 7 βb	1 2 3 4 5 7 βa	1 2 3 4 5 7 βb	1 2 3 4 5 7 βa	1 2 3 4 7 8 αb, βb	1 2 3 4 7 8 αa βa	1 2 3 4 7 8 αb, βb
3	6	1 2 3 4 7 8 αa, βa	1 2 3 4 7 9 αb	1 2 3 4 7 9 αa,	1 2 3 4 7 9 αb	1 2 3 4 7 9 αa,	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 8 9 αb	1 2 3 4 8 9
3	6	1 2 3 4 8 9 αb	1 2 3 4 8 9 αa													
3	7	1 2 3 4 5 6 7	1 2 3 4 6 8	1 2 3 4 5 6 9	1 2 3 4 5 7 8 βa, βb	1 2 3 4 5 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 7 8 9 αa, αb							
4	4	1 2 3 4														
4	5	1 2 3 4 5	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9	1 2 3 4 5	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9	1 2 3 4 5	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9 αb, αc
4	5	1 2 3 4 5 δ	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9										
4	6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 δ	1 2 3 4 5 7	1 2 3 4 5 7 βb	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 8 βb	1 2 3 4 5 8	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 6 7	1 2 3 4 6 7	1 2 3 4 6 7
4	6	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 6 8	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8	1 2 3 4 7 8 αb, βb	1 2 3 4 7 8	1 2 3 4 5 6	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8	1 2 3 4 7 9	1 2 3 4 5 6
4	6	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 8	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8	1 2 3 4 7 9	1 2 3 4 5 6	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 9	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 9
4	6	1 2 3 4 5 6	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 9	1 2 3 4 6 7 8	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8 αa,	1 2 3 4 7 8	1 2 3 4 7 9					
4	7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 6 7 8	1 2 3 4 6 7 8	1 2 3 4 6 7 8	1 2 3 4 6 7 8	1 2 3 4 5 7 8 βb	1 2 3 4 5 7 8	1 2 3 4 5 7 8 βa	1 2 3 4 5 7 8 βb	1 2 3 4 5 6 8	1 2 3 4 5 6 8	1 2 3 4 5 6 8
4	7	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 7 8 9 αb	1 2 3 4 7 8 9
		1 2 3 4 7 8 9 αb	1 2 3 4 7 8 9													
4	8	1 2 3 4 5 6 7 8														
5	5	1 2 3 4 5	1 2 3 4 6	1 2 3 4 7	1 2 3 4 8	1 2 3 4 9										
5	6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 7	1 2 3 4 5 7	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 8	1 2 3 4 5 6	1 2 3 4 6 7	1 2 3 4 6 7	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 8	1 2 3 4 6 8
		1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 6 9	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 6	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 9	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8	1 2 3 4 7 9
		1 2 3 4 7 8	1 2 3 4 7 8	1 2 3 4 7 8	1 2 3 4 7 8	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9								
5	7	1 2 3 4 5 6 7	1 2 3 4 6 7 8	1 2 3 4 5 7 8	1 2 3 4 5 6 8	1 2 3 4 5 6 7	1 2 3 4 6 7 8	1 2 3 4 5 7 8 βb	1 2 3 4 5 6 8	1 2 3 4 5 6 7 βb	1 2 3 4 6 7 8	1 2 3 4 5 7 8	1 2 3 4 5 6 8	1 2 3 4 5 6 7	1 2 3 4 6 7 8	1 2 3 4 5 7 8
		1 2 3 4 5 6 9	1 2 3 4 5 6 7	1 2 3 4 6 7 8	1 2 3 4 5 7 8 βa	1 2 3 4 5 6 8	1 2 3 4 5 6 9	1 2 3 4 6 7 8	1 2 3 4 5 7 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 6 7 9	1 2 3 4 5 7 9	1 2 3 4 5 8 9	1 2 3 4 5 6 9	1 2 3 4 6 7 9
		1 2 3 4 5 7 9	1 2 3 4 5 8 9	1 2 3 4 5 6 9	1 2 3 4 5 7 9	1 2 3 4 5 8 9	1 2 3 4 5 8 9	1 2 3 4 5 7 9	1 2 3 4 5 8 9	1 2 3 4 5 6 9	1 2 3 4 5 7 9	1 2 3 4 5 8 9				
5	8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
		1 2 3 4 5 7 8 9														
6	6	1 2 3 4 5 6	1 2 3 4 5 7	1 2 3 4 5 8	1 2 3 4 5 9	1 2 3 4 6 7	1 2 3 4 6 8	1 2 3 4 6 9	1 2 3 4 7 8	1 2 3 4 7 9	1 2 3 4 8 9					
6	8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
		1 2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9													
7	7	1 2 3 4 5 6 7	1 2 3 4 5 6 8	1 2 3 4 6 7 8	1 2 3 4 5 7 8	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 6 7 9	1 2 3 4 5 7 9	1 2 3 4 7 8 9						
7	8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9						
8	8	1 2 3 4 5 6 7 8	1 2 3 4 5 7 8 9	1 2 3 4 6 7 8 9												
9	9	1 2 3 4 5 6 7 8 9														

correct solutions

Appendix 3 Matrix of semiotic evaluation of combined applications of static and dynamic variables and related methods of presentation

Number of static visual variables		Number of static and dynamic variables	Dynamized variables	Entities and levels	Combinations of variables	Methods of presentation	Evaluation				
items	variables						(1)	(2)	(3)	(4)	(5)
1	4	10	1 2 3 4	αb	1 (I, II, III, IV, V, VII) 2 3 4	Sαb, Kαb, Kdαb	0,1	6	3	6	4
1	4	10	1 2 3 4	αc	1 (I, II, III, IV, V, VII) 2 3 4	Kc, Sαc, Kαc (cs), Kdαc (cs)	0,1	6	7	6	4
1	4	10	1 2 3 4	βb	1 (I, II, III, IV, V, VII) 2 3 4	Sβb, Kβb, Kdβb	0,1	9	3	6	4
1	4	10	1 2 3 4	βc	1 (I, II, III, IV, V, VII) 2 3 4	Ic, Sβc, Kβc (cs), Kdβc(cs)	0,1	9	4	6	4
1	4	10	1 2 3 4	γb	1 (I, II, III, IV, V, VII) 2 3 4	Kγb (cs), KαBb, KDγb	0,1	8	4	6	5
1	4	10	1 2 3 4	γc	1 (I, II, III, IV, V, VII) 2 3 4	KαBc, Kγc (cs), KDγc(cs), QKVγc, QKEγc, QKGγc	0,1	8	6	6	5
1	4	10	1 2 3 4	αa	1 2 (I, II, III, IV, V, VII) 3 4	Sαa	0,1	6	1	2	7
1	4	10	1 2 3 4	γa	1 2 (I, II, III, IV, V, VII) 3 4	MCa, MZa	0,1	7	2	2	7
1	4	10	1 2 3 4	αb	1 2 3 (I, II, III, IV, V, VII) 4	Sαb, Kαb, Kdαb	0,1	6	3	6	3
1	4	10	1 2 3 4	αc	1 2 3 (I, II, III, IV, V, VII) 4	Kc, Sαc, Kαc (cs), Kdαc (cs)	0,1	6	7	6	3
1	4	10	1 2 3 4	βb	1 2 3 (I, II, III, IV, V, VII) 4	Sβb, Kβb, Kdβb	0,1	9	3	6	4
1	4	10	1 2 3 4	βc	1 2 3 (I, II, III, IV, V, VII) 4	Ic, Sβc, Kβc (cs), Kdβc(cs)	0,1	9	4	6	4
1	4	10	1 2 3 4	γb	1 2 3 (I, II, III, IV, V, VII) 4	Kγb (cs), KαBb, KDγb	0,1	8	4	6	5
1	4	10	1 2 3 4	γc	1 2 3 (I, II, III, IV, V, VII) 4	KαBc, Kγc (cs), KDγc(cs) QKBγc	0,1	8	6	6	5
1	4	10	1 2 3 4	αa	1 2 3 4 (I, II, III, IV, V, VII)	Sαa	0,1	6	1	3	7
1	4	10	1 2 3 4	βa	1 2 3 4 (I, II, III, IV, V, VII)	Sβa, MZa	0,1	8	2	3	7
1	4	10	1 2 3 4	γa	1 2 3 4 (I, II, III, IV, V, VII)	MCa, MZa	0,1	7	2	3	8
1	5	11	1 2 3 4 5	βa	1 2 3 4 5 (I, II, III, IV, V, VII)	Sβa, MZa	0,09	8	2	3	4
1	5	11	1 2 3 4 5	βb	1 2 3 4 5 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,09	9	3	3	4
1	5	11	1 2 3 4 5	γa	1 2 3 4 5 (I, II, III, IV, V, VII)	MCa, MZa	0,09	7	2	3	5
1	5	11	1 2 3 4 7	αa	1 2 3 4 7 (I, II, III, IV, V, VII)	Sαa	0,09	6	1	4	2
1	5	11	1 2 3 4 7	αb	1 2 3 4 7 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,09	6	3	4	2
1	5	11	1 2 3 4 7	βa	1 2 3 4 7 (I, II, III, IV, V, VII)	Sβa, MZa	0,09	8	2	4	2
1	5	11	1 2 3 4 7	βb	1 2 3 4 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,09	9	3	4	2
1	5	11	1 2 3 4 8	αa	1 2 3 4 8 (I, II, III, IV, V, VII)	Sαa	0,09	6	1	4	3
1	5	11	1 2 3 4 8	αb	1 2 3 4 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,09	6	3	4	3
1	5	11	1 2 3 4 8	βa	1 2 3 4 8 (I, II, III, IV, V, VII)	Sβa, MZa	0,09	7	2	4	3
1	5	11	1 2 3 4 8	βb	1 2 3 4 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,09	9	3	4	3
1	5	11	1 2 3 4 9	αa	1 2 3 4 9 (I, II, III, IV, V, VII)	Sαa	0,09	6	1	4	4
1	5	11	1 2 3 4 9	αb	1 2 3 4 9 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,09	6	3	4	4
1	5	11	1 2 3 4 9	αc	1 2 3 4 9 (I, II, III, IV, V, VII)	Kc, Sαc, Kαc (cs), Kdαc (cs)	0,09	6	7	6	4
2	5	16	1 2 3 4	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	Sαb, Kαb, Kdαb	0,125	6	3	5	3,5

Number of static visual variables		Number of static and dynamic variables	Dynamized variables	Entities and levels	Combinations of variables	Methods of presentation	Evaluation				
items	variables						(1)	(2)	(3)	(4)	(5)
2	5	16	1 2 3 4	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	Sβb, Kβb, Kdβb	0,125	9	3	5	4
2	5	16	1 2 3 4	βc	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	Sβc, Kβc (cs), KDγc(cs)	0,125	9	4	5	4
2	5	16	1 2 3 4	γb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	Kγb (cs), KαBb, KDγb	0,125	8	4	5	5
2	5	16	1 2 3 4	γc	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	KαBc, Kαc (cs), KDγc(cs), QKVγc	0,125	8	6	5	5
2	5	16	1 2 3 4	αa	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	Sαa	0,125	6	1	2	3,5
2	5	16	1 2 3 4	γa	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4	MCa, MZa	0,125	7	2	2	5
2	5	17	1 2 3 4 5	βb	1 (I, II, III, IV, V, VII) 2 3 4 5 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	1	4
2	5	17	1 2 3 4 7	αb	1 (I, II, III, IV, V, VII) 2 3 4 7 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,12	6	3	2	3
2	5	17	1 2 3 4 7	βb	1 (I, II, III, IV, V, VII) 2 3 4 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	2	3
2	5	17	1 2 3 4 8	αb	1 (I, II, III, IV, V, VII) 2 3 4 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,12	6	3	2	3,5
2	5	17	1 2 3 4 8	βb	1 (I, II, III, IV, V, VII) 2 3 4 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	2	3,3
2	5	17	1 2 3 4 9	αa	1 (I, II, III, IV, V, VII) 2 3 4 9 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	1	4
2	5	17	1 2 3 4 9	αc	1 (I, II, III, IV, V, VII) 2 3 4 9 (I, II, III, IV, V, VII)	Sαc, Kαc (cs), Kdαc (cs)	0,12	6	7	6	4
2	5	17	1 2 3 4 5	γa	1 2 (I, II, III, IV, V, VII) 3 4 5 (I, II, III, IV, V, VII)	MCa, MZa	0,12	7	2	1	6
2	5	17	1 2 3 4 7	αa	1 2 (I, II, III, IV, V, VII) 3 4 7 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	1	4,5
2	5	17	1 2 3 4 8	αa	1 2 (I, II, III, IV, V, VII) 3 4 8 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	1	5
2	5	17	1 2 3 4 9	αa	1 2 (I, II, III, IV, V, VII) 3 4 9 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	1	5,5
2	5	17	1 2 3 4 5	βb	1 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	1	4
2	5	17	1 2 3 4 7	αb	1 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,12	6	3	2	2,5
2	5	17	1 2 3 4 7	βb	1 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	2	3
2	5	17	1 2 3 4 8	αa	1 2 3 (I, II, III, IV, V, VII) 4 8 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	3	3
2	5	17	1 2 3 4 8	αb	1 2 3 (I, II, III, IV, V, VII) 4 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,12	6	3	3	3
2	5	17	1 2 3 4 8	βb	1 2 3 (I, II, III, IV, V, VII) 4 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	3	3,5
2	5	17	1 2 3 4 9	αa	1 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	3	3,5
2	5	17	1 2 3 4 9	αc	1 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαc, Kαc (cs), Kdαc(cs)	0,12	6	7	6	3,5
2	5	17	1 2 3 4 5	βa	1 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII)	SβaMZa	0,12	8	2	2	5,5
2	5	17	1 2 3 4 5	γa	1 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII)	MCa	0,12	7	2	2	6,5
2	5	17	1 2 3 4 7	αa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	2	4,5
2	5	17	1 2 3 4 7	βa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	SβaMZa	0,12	8	2	2	4,5
2	5	17	1 2 3 4 8	αa	1 2 3 4 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	2	5
2	5	17	1 2 3 4 8	βa	1 2 3 4 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,12	8	2	2	5
2	5	17	1 2 3 4 9	αa	1 2 3 4 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	2	5,5
2	6	18	1 2 3 4 5 7	βa	1 2 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	SβaMZa	0,11	8	2	2	3
2	6	18	1 2 3 4 5 7	βb	1 2 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,11	9	3	2	3
2	6	18	1 2 3 4 5 8	βa	1 2 3 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,11	8	2	2	3,5
2	6	18	1 2 3 4 5 8	βb	1 2 3 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,11	9	3	2	3,5
2	6	18	1 2 3 4 7 8	αa	1 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,11	6	1	3	2,5
2	6	18	1 2 3 4 7 8	βa	1 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,11	8	2	3	2,5
2	6	18	1 2 3 4 7 8	βb	1 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,11	9	3	3	2,5
2	6	18	1 2 3 4 7 9	αb	1 2 3 4 7 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,11	6	3	3	3
2	6	18	1 2 3 4 8 9	αa	1 2 3 4 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,11	6	1	3	3,5
2	6	18	1 2 3 4 8 9	αb	1 2 3 4 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,11	6	3	3	3,5
3	4	22	1 2 3 4	βc	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 (I, II, III, IV, V, VII)	Ic, Sβc, Kβc (cs), Kdβc(cs)	0,138	9	4	1	5
3	5	23	1 2 3 4 5	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,136	9	3	1	4
3	5	23	1 2 3 4 7	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,136	9	3	1	3,3
3	5	23	1 2 3 4 8	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,130	6	3	2	3,3
3	5	23	1 2 3 4 8	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,130	9	3	2	3,6
3	5	23	1 2 3 4 9	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαa	0,130	6	1	1	3,66
3	5	23	1 2 3 4 9	αc	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαc, Kαc (cs), Kdαc (cs)	0,130	6	7	6	3,66
3	5	23	1 2 3 4 9	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαb	0,130	6	1	1	4,6
3	5	23	1 2 3 4 9	αc	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 9 (I, II, III, IV, V, VII)	Sαc, Kαc (cs), Kdαc (cs)	0,130	6	7	6	4,6
3	5	23	1 2 3 4 5	βb	1 (I, II, III, IV, V, VII) 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,130	9	3	1	5
3	5	23	1 2 3 4 7	βb	1 (I, II, III, IV, V, VII) 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,130	9	3	1	4,3
3	5	23	1 2 3 4 5	γa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII)	MCa, MZa	0,130	7	2	1	6,5
3	5	23	1 2 3 4 7	αa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sαa	0,130	6	1	1	5,3
3	5	23	1 2 3 4 8	αa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,130	6	1	1	5,6
3	5	23	1 2 3 4 9	αa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,130	6	1	1	6
3	6	24	1 2 3 4 5 8	βb	1 (I, II, III, IV, V, VII) 2 3 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	2	3,6
3	6	24	1 2 3 4 5 8	αa	1 (I, II, III, IV, V, VII) 2 3 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	4
3	6	24	1 2 3 4 5 8	βa	1 (I, II, III, IV, V, VII) 2 3 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	1	4,6
3	6	24	1 2 3 4 5 8	βb	1 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	1	3,6
3	6	24	1 2 3 4 5 8	βa	1 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	1	4,6
3	6	24	1 2 3 4 6 7	βb	1 (I, II, III, IV, V, VII) 2 3 4 6 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	1	3,3
3	6	24	1 2 3 4 5 7	βa	1 2 (I, II, III, IV, V, VII) 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	1	4,3
3	6	24	1 2 3 4 5 7	βb	1 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	1	3,3
3	6	24	1 2 3 4 5 7	βa	1 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	2	4,3
3	6	24	1 2 3 4 7 8	αb	1 (I, II, III, IV, V, VII) 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,125	6	3	2	3
3	6	24	1 2 3 4 7 8	βb	1 (I, II, III, IV, V, VII) 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	2	3
3	6	24	1 2 3 4 7 9	αb	1 2 (I, II, III, IV, V, VII) 3 4 7 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,125	6	3	2	3,33
3	6	24	1 2 3 4 7 8	αa	1 2 (I, II, III, IV, V, VII) 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	4
3	6	24	1 2 3 4 7 8	βa	1 2 (I, II, III, IV, V, VII) 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	2	4
3	6	24	1 2 3 4 7 9	αa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	4,33
3	6	24	1 2 3 4 7 8	αb	1 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,125	6	3	2	2,6
3	6	24	1 2 3 4 7 8	βb	1 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,125	9	3	2	3
3	6	24	1 2 3 4 7 9	αb	1 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,125	6	3	2	3,33
3	6	24	1 2 3 4 8 9	αa	1 2 3 4 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	3,33
3	6	24	1 2 3 4 8 9	αc	1 2 3 4 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαc, Kαc (cs), Kdαc (cs)	0,125	6	7	6	4,66
3	6	24	1 2 3 4 7 8	αa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	4
3	6	24	1 2 3 4 7 8	βa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,125	8	2	2	4
3	6	24	1 2 3 4 7 9	αa	1 2 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,125	6	1	2	4,33
3	7	25	1 2 3 4 5 7 8	βa	1 2 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,12	8	2	2	3
3	7	25	1 2 3 4 5 7 8	βb	1 2 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,12	9	3	1	3
3	7	25	1 2 3 4 7 8 9	αa	1 2 3 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαa	0,12	6	1	2	3
4	6	30	1 2 3 4 5 7	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,13	9	3	1	3,5
4	6	30	1 2 3 4 5 8	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,13	9	3	2	3,75
4	6	30	1 2 3 4 7 8	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαb, Kαb, Kdαb	0,13	6	3	2	3
4	6	30	1 2 3 4 7 8	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,13	9	3	1	3,25
4	6	30	1 2 3 4 7 8	αa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sαa	0,13	6	1	1	4,75
4	7	31	1 2 3 4 5 7 8	βb	1 (I, II, III, IV, V, VII) 2 3 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,129	9	3	1	3,25
4	7	31	1 2 3 4 5 7 8	βb	1 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,129	9	3	1	3,25
4	7	31	1 2 3 4 5 7 8	βa	1 2 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,129	8	2	1	4
5	7	37	1 2 3 4 5 7 8	βb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	Sβb, Kβb, Kdβb	0,135	9	3	1	3,4
5	7	37	1 2 3 4 7 8 9	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb	0,135	6	1	2	3,2
5	7	37	1 2 3 4 7 8 9	αb	1 (I, II, III, IV, V, VII) 2 3 (I, II, III, IV, V, VII) 4 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII) 9 (I, II, III, IV, V, VII)	Sαb	0,135	6	1	2	3,2
5	7	37	1 2 3 4 5 7 8	βa	1 2 (I, II, III, IV, V, VII) 3 4 (I, II, III, IV, V, VII) 5 (I, II, III, IV, V, VII) 7 (I, II, III, IV, V, VII) 8 (I, II, III, IV, V, VII)	SβaMZa	0,135	8	2	1	4,6

Notations:

Evaluation **rank:**

low	mean	high	very high

Static visual variables

1 size; 2 form; 3 value; 4 colour; 5 grain; 6 orientation; 7 brilliance; 8 transparency; **9 aura**

dynamized variables are underlined

Dynamic visual variables

I display date; II duration; III frequency; IV order; V rate of change; VI synchronization; VII way of transition;

high perceivable variables are bolded

Entities / measurement levels

α point entities; β line entities; γ area entities;

a nominal scale measurable entities; b ordinary scale measurable entities; c quantitative scale measurable entities

Cartographic methods

Sαb – ordinary point signature,
Kαb – ordinary point choropleth map,
Kdαb – ordinary point cartodiagram
Kc – dot method,
Sαc – quantitative point signature,
Kαc (cs) – point choropleth map,
Kdαc (cs) – point cartodiagram
Sβb – ordinary line signatures,
Kβb – ordinary line choropleth map,
Kdβb – ordinary line cartodiagram
Ic – isoline method,
Sβa – nominal line signatures
Sβc – quantitative line signatures,
Kβc (cs) – line choropleth map,
Kdβc (cs) – line cartodiagram,
KαBb – ordinary Bertin's choropleth map,
Kγb – ordinary choropleth map,
KDγb – ordinary dasymetric choropleth map,
KαBc - Bertin's choropleth,
Kγc(cs) - choropleth map,
KDγc(cs) - dasymetric choropleth map,
QKBγc –Bürgener's pseudochoropleth map,
QKVγc – rectangle choropleth map,
QKEγc – eumorfic choropleth map,
QKGγc –variodensity networks,
Sαa – point signatures,
MCa - chorochromatic method,
MZa – range map