EVALUATION OF URBAN CATALYSTS THROUGH HISTORY

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Abstract
Based on literature research 38 urban catalysts were chosen and evaluated using 19 parameters. This shows changes of urban catalysts through history. Four different groups of urban catalysts were framed after analyzing them with the SPSS statistics program. The main task of this evaluation was to better understand the origins of urban catalysts, reasons for their interconnectedness and further outcomes, as well as discover a basis for later city fabric modelling. The observed relation between the configuration of the first point and its influence on the surroundings might suggest a strategy for urban planners and architects in attempting to revitalize abandoned territories or bring economic and social changes to the existing neighborhoods in the future.

Keywords: catalytic processes; evaluation; historic overview; perception

INTRODUCTION

Catalytic processes in urbanism are visible throughout the whole history from the moment when the first cities were established. The idea behind an urban catalyst is that only minor changes are made in city fabric to evoke bigger consequences. One of the pioneers in this topic was Polish author Kazimierz Wejchert [K. Wejchert 1984]. The concept of an urban catalyst assumes that one point undergoes a change and leads to further, related changes in its surroundings (Fig. 1). That is why it is important to identify that first point of change and define the following process. This might help to make visible changes in urban structure without putting too much effort. Most observations show an effect which was not planned in the beginning but noticed after the catalytic process had already happened. The aim of this analysis is to provide an overview of the most outstanding urban catalysts throughout the history of cities and suggest an evaluation based on the type of the first point that sparked the process as well as the sort of its impact on the surroundings.

In reviewing the observed any of catalytic process, its main aspect can be noticed quite quickly, as

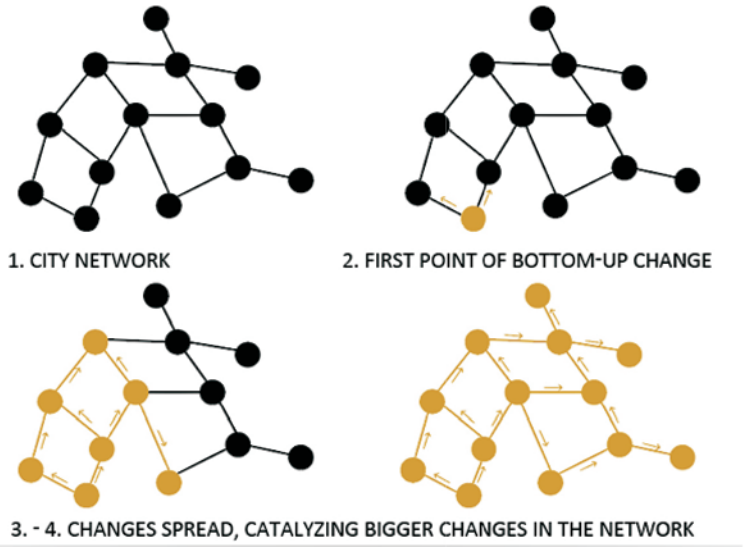

Fig. 1. Idea of Urban Catalyst; source: by the author

most of the time it is observed only after it has already occurred. Namely, some processes bring new quality to the city. It might be greenery and sustainable city solutions [M. Cerreta, I. Salzano 2009], new functions [P. Oswalt 2011], changes in regulations and law, cultural changes [K. Christiaanse, K. Hoege 2006], etc. But if a catalytic process could be stimulated by bottom-up principle, it is important to find the first point which needs to be stimulated and so that the forthcoming process might happen accordingly. The main task in this case would be the recognition and observation of this process within a time frame, because only by tracking is it possible to forecast what will happen next.

1. URBAN CATALYSTS OVERVIEW. EVALUATION PARAMETERS

38 different catalysts, such as nature conditions, new buildings, innovations, diseases, connections, were chosen during literature review and evaluated using 19 parameters. The choice of the catalysts is based on the review of the literature on main changes in urban history on the chronology of these events and significant keywords. The catalysts were grouped according to the time they originated from, starting with nature conditions (rivers, hills, forests), which had an impact on the establishment of the first cities around 3000 BC [Y. Yasuda 2012], and going along the timeline until the emergence of such factors as new media, cinema and tourism, which have an influence on our cities right now (Fig. 2). Catalytic processes are seen in the establishment of the first cities, one of them being the junction of 3 main functions that formed a city center and expanded the surrounding territories [L. Mumford 1961]. The equality principle in Ancient Greece was clearly reflected in city plans, as they were divided by a grid, parts of it being very similar, where the smallest one was an individual unit with several households [A. Zuiderhoek 2016]. The invention of water supply and street formation encouraged even bigger changes and fostered the spread of the network [D. Deming 2020; C. van Tilburg 2007]. Roman forum and Greek agora were one of the first multifunctional meeting spots in the city, accumulating a lot of ongoings around them, bringing new functions and economical changes [S. O'Leary, B. Brasher 1996]. In later ages, such junctions and function-accumulating areas were monasteries and palaces [J.W. O'Malley 2013; J. Rowe 1958]. Renaissance aesthetics encouraged the creation of an axis in the city, which not only connected two points and formed a visual connection, but also created streets and attracted functions around it. Axial planning is clearly visible in such cities as Valetta, Grammichelle or Palmanova, a lot of Italian squares (St. Peter's and Campidoglio squares, Dei Quiriti square connected to Castel Sant' Angelos in Rome). In Lithuania, the Valakai reform established in 1547 drastically changed territory planning. Even though it was a planning document, not a physical addition or change, it brought territory expansions [P. Kalnius et al. 2008]. One of the biggest changes in territory planning was caused by the invention of steam engine and railway. It fostered traveling and thereby expanded the surrounding territories [W.T.L. Jiwei 2006]. At a later time, EXPO events brought a new cultural taste to cities, making huge expansions, i.e. organizing territories only for expositions, attracting new functions, but also bringing trouble to the city while trying to reuse expanded city parts [W.U. Zhi-qiang 2008]. Similar changes were brought about

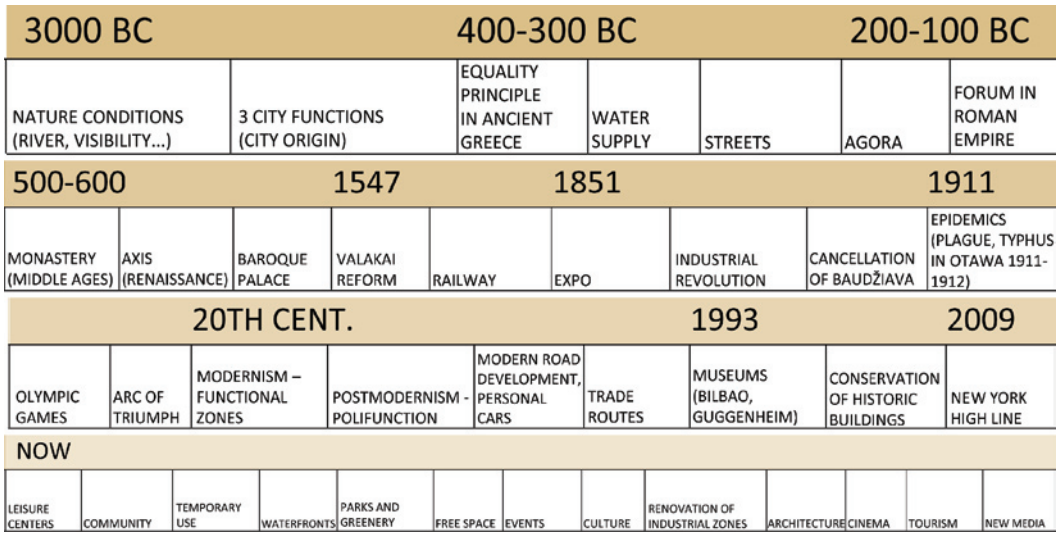

Fig. 2. Chronology of 38 chosen Urban Catalysts; source: by the author

by the organization of the modern Olympic Games in the 20th century [S. Essex, B. Chalkley 1998; E. Kassens-Noor 2010]. The industrial revolution brought even bigger changes to cities. Industrial factories started to grow, forming totally new cities around them. A new infrastructure was built very quickly in order to provide services to factory workers and their families, creating a dense and unhealthy environment to live and work [R.C. Allen 2009]. Next, the cancellation of serfdom, a system of land division in Lithuania, brought more freedom to territory planning – land did not belong to a small circle of rich landowners anymore, but was divided into smaller plots [T. Bairašauskaitė 2015]. Epidemics, such as plague and typhus, also led to the expansion of cities and changed their network, since it was crucial to keep right distances. Even nowadays it can be seen how many drastic changes a disease can bring to culture and the city in the conditions of the COVID-19 crisis [S. Lloyd 1979; C.B. Taylor et al. 2020]. One of the best examples of clearly spotted urban catalysts are triumphal arches. As a sculptural object, it can change territory planning around it because of its strong visual impact on the surroundings [A. Clerici, I. Mironowicz 2009]. Nevertheless, very distinct ideas of modernism and postmodernism have made great changes in cities by means of the top-down principle, as they both were intentional ideas later seized in planning documents created by city planners [S.M. Low 1999; J. Holston 1989; P. Harrison 1996]. Other modernist ideas brought private cars to cities, which considerably changed the perception and the territory network, since almost everyone had a private car and could work in the city while living in the suburbs. Distances shrank in a psychological dimension [S.M. Low 1999]. Museums, such as Bilbao and its Guggenheim, started to make a great impact on cities at the end of the 20th century, attracting new functions and forming local centers around them [C. Grodach 2008]. One of the well-known linear phenomena of our century is New York's High Line park, which not only formed connections and a green area in a densely populated territory, but also attracted commerce and culture as well as encouraged the creation of apartment buildings which are one of the most expensive in the city [K. Aitani, V. Sathaye 2018].

Nowadays, urban catalysts might have a physical shape and are similar to the ones mentioned before. Leisure centers are similar to museums and palaces, since they also attract functions and have a territorial character, forming the surrounding mini-centers [J. Bender 2003]. Reusing the existing capacity is one of the main ideas of sustainable design, thus it is very important that a catalyst should, for example, involve reusing old territories (such as big industrial zones in cities) or conserving historical buildings, bringing them back to life [A. Hurley 2010; W.S. Mahmoud, T.A. Mohammed 2015; B. Yan, R. Su 2014]. Waterfronts and parks are probably the most well-known public spaces which can also catalyze changes [R. Marshall 2004; M. Cerreta, I. Salzano 2009]. There are also ideas about a catalyst's function or even lack of it as a premise to be creative and bring changes. P. Oswalt is one of the pioneers in the urban catalyst movement, postulating an idea that a temporary use of a facility might encourage a lot of changes in the city. Thus, a strategically placed temporary use of empty places with no function at all can become an urban catalyst [P. Oswalt 2007, 2011]. Events, culture, cinema, new media, tourism and community can become urban catalysts without a physically expressed shape. These things have a potential to change the surroundings by means of the bottom-up principle, since the agents making such a change are people, their money, movement, ideas and creativity [P. Benneworth, H. Dauncey 2010; M. Camhis, S. Fox 1992; G. Ferilli et al. 2017; S. Kristo, J. Dhiamanti 2016; M.M. Oliveira 2020; T. Abdel-Ghani 2017; S.J.C.S.M. Fagence 1995, H. Weiner 2010; N. Walravens et al. 2014].

It is visible that the first points of catalysts have a clear physical structure. Still, they might also constitute changes in the legal system or even revolutionary events in history and science. This means that there are a lot of ways to achieve catalytic results without the existence of an architectural or urban tool.

The selected evaluation parameters are to show the connection between catalyst establishment and the result it brought about. It could give a strategic shape to a catalytic action in the future. The main parameters represent: how catalysts were established or originated (1), what is the shape of the catalyst (2), what kind of result it brought to the city (3). The parameters are based on a yes/no (1/0) principle matrix and are listed below:

1. Based on impact:
   - It was a planned act (yes/no);
   - Brought an expansion of territories (yes/no);
   - Brought a new function (yes/no);
   - Increased people flow (yes/no);
   - Brought economical changes (yes/no);
   - Changed opinion (yes/no);
   - Its impact was predicted (yes/no);
   - The change was bottom-up (yes/no);
   - The impact was stable (yes/no).
2. The first point was:
   - A new function;
   - External conditions;
   - An innovation;
   - A connection.

3. Its shape was:
   - A spot or a junction;
   - Linear;
   - Territorial;
   - Seeming, imaginary.
4. Its origin was:
   - Human-made (yes/no);
   - Contextual or contrast-based.

A 19x38 matrix was formed to see how changes in the results change for each catalyst and it has goes without sayingshown that there is no visible evidence, that for the similarity of the catalysts that occurred catalysts were somehow similar in a particular period of time. The Matrix looks scattered, which shows,proves that there were appeared all types of urban catalysts throughalong the timeline (fig. 3).

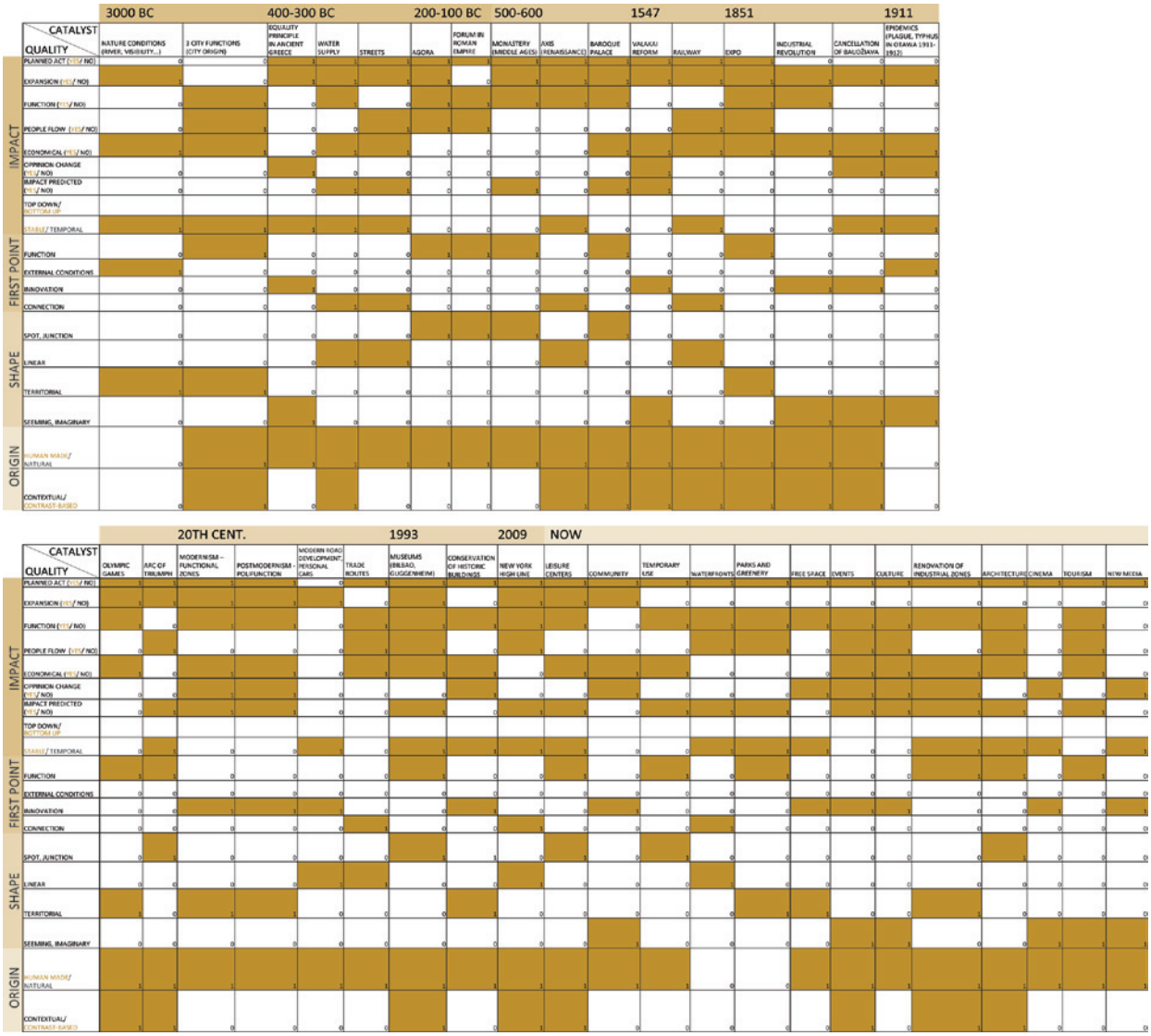

Fig. 3. Catalysts and parameters matrix (yellow box symbolizes a “yes” answer); source: by the author

2. MULTI-DIMENSIONAL SCALING

A multidimensional scaling procedure was chosen to analyze catalysts and exclude similarities between them. This procedure can reduce the number of dimensions in the statistical model, which has a lot of different variables. The model counts similarities between the variables and projects these similarities in a chosen (in this case – two-dimensional) view. The MDS procedure conducted in the SPSS statistics program has led to the creation of four clusters (Fig. 4).

Multi-dimensional scaling shows catalysts which are most similar to one another, based on analysis parameters. Smaller distances between catalysts (variables) in the distance model diagram show greater similarity, while bigger distances show that the variables are not similar to one another.

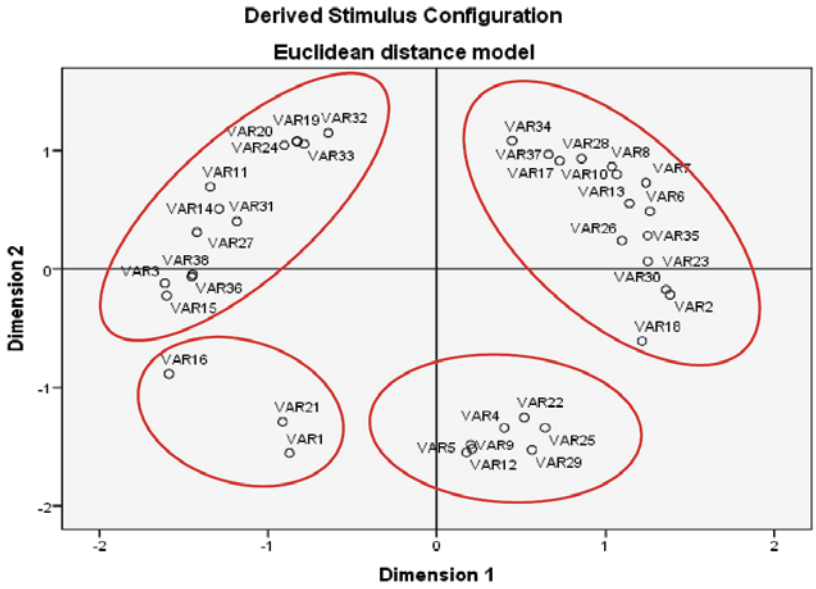

Fig. 4. Variables after the MDS procedure in a two-dimensional view; source: by the author

The MDS research formed 4 clear clusters in a two-dimensional view. Two of them are visibly bigger than other. The group composed of variables 1, 16 and 21 is the smallest and the clustering result is not as clear as in other 3 groups.

3. CHARACTERISTICS OF 4 GROUPS OF URBAN CATALYSTS

1. Group 1 contains 13 out of 38 initial catalysts. It can unarguably be observed that all catalysts in this group have one thing in common – they all are not physical structures, but laws, new inventions and culture events. Hence, this group of catalysts can be defined as human-made innovations (Fig. 5).
2. Group 2 is the smallest and is made up of only 3 catalysts (Fig. 5). They are all rather drastic events or changes in history and nature conditions which had an extensive impact on the life of the first civilizations. All of them were unplanned, had a stable outcome and expanded the surrounding territories. Because of their drastic nature, it is not surprising that these catalysts did not relate to any other catalyst groups.
3. Group 3 is the biggest and contains 15 catalysts. Apart from its considerable size, it is also the most complex one. Almost all catalysts in this group are planned and human-made; all of them changed the function around them. They all are territorial and spotted, which means that they have a clear physical shape.

1 GROUP												
PRINCIPLE OF CITIZEN EQUALITY IN ANCIENT GREECE	RESCISION OF BAUDŽIAVA	CINEMA	NEW MEDIAS	COMMUNITY	INDUSTRIAL REVOLUTION	FREE SPACE	VALAKAI REFORM	CONSERVATION OF HISTORIC BUILDINGS	CULTURE	POSTMODERNISM - POLIFUNCTION	MODERNISM – FUNCTIONAL ZONES	EVENTS

2 GROUP		
NATURE CONDITIONS (RIVER, HILL...)	EPIDEMICS (PLAGUE, TYPHUS)	MODERN ROAD DEVELOPMENT, PERSONAL CARS

3 GROUP													
RENOVATION OF INDUSTRIAL ZONES	TOURISM	TEMPORARY USE	OLYMPIC GAMES	BAROQUE PALACE	MONASTERY (MIDDLE AGES)	FORUM IN ROME EMPIRE	AGORA	EXPO	LEASURE CENTERS	ARCHITECTURE	MUSEUMS (BILBAO GUGGENHEIM)	PARKS AND GREENERY	3 CITY FUNCTIONS (CITY ORIGIN)	ARC OF TRIUMPH

4 GROUP						
WATER SUPPLY	TRADE ROUTES	AXIS (RENAISSANCE)	STREETS	NEW YORK HIGH LINE	WATERFRONTS	RAILWAY

Fig. 5. Groups of catalysts; source: by the author

4. Group 4 contains 7 catalysts which are all human-made, linear and connecting something. Similarly to the catalysts in group 3, they all have a clear linear, though different, shape.
5. 3 out of 4 groups could be changed by people, and only one cannot. This means that the directly changing first point of the process in groups 1, 3 and 4 could bring a planned change in the urban fabric. The first point may not only be a structural physical change of the environment, but it can also involve intentional changes in laws and urban documents (it has no physical shape), bringing an initial change in the city. These four groups constitute only a direction for later arrangements of urban catalysts, since it gives a better understanding about how the initial change and the consequences might correlate. It also provides clear evidence that catalysts can be evaluated by their initial shape and origin, which is very important for modelling city changes on the computer.

These 4 groups bring a better understanding about the origins of urban catalysts and a manner of elaborating on further changes. It is very important to understand the principle of catalytic changes in order to make them into a strategic action. The evaluation of urban catalysts might suggest a basis for later computer modelling of the city fabric and give architects and urban planners a new point of view in reviving and improving our cities with a smaller effort.

4. URBAN CATALYSTS AND SPACE SYNTAX

The city structure can be explained by a lot of different theories, such as the fractal city theory, the cellular automaton, the mathematical network model and others. The fractal city theory is analyzed by such authors as Nicos A. Salingaros or Ch. Alexander and later used by many others. It explains connectivity and hierarchy of the city and it can highlight pathological changes or deformations of the city, such as urban sprawl, similarly to the principles used to recognize early oncological lesions in the human body in medicine [N.A. Salingaros 2000; C. Alexander, J. Quinan 1981]. It can demonstrate and predict how changes on a smaller scale might influence other city parts. This theory, on the other hand, is mostly based on analyzing the existing city structures. This kind of analysis can signalize if the city structure is symmetrical, if individual parts of the city are easily accessible and if the structure is not too complex, yet not too simple. Symmetry in this case is understood as if A was a neighbor to B, then B was a neighbor to A. Accessibility shows the number of connections within one place in comparison to others. Complexity involves comparing how a pattern's detail changes with the scale against which it is juxtaposed. It means that structures should be balanced – not too simple, yet not too complicated, and this can be expressed mathematically.

A cellular automaton is a research theory based on an infinite grid filled with autonomous cells. Each of them can change its state when the ones next to it change theirs. Changes happen synchronously, based on rules set before the experiment. Changes happen as time (or steps) of the experiment changes. The best-known example of this system is called the "Game of Life". In this example cells have only two possibilities: to be dead or alive. These changes are based on the state of the neighbors. The cell stays alive if it has 2 or 3 living neighbors, otherwise it dies of loneliness or crowdedness. If the cell is dead, it may become alive again if it gets 3 living neighbors. This system might be used as a starting point for agent-based modelling, predicting and observing the dynamics of a city, explaining social, economic, urban changes by self-regulation in the city [M. Delorme, J. Mazoyer 2013].

The complex graph model of Space Syntax partially connects the two aforementioned models. It is based on self-regulation principles of the city and a graph-theoretic representation (nodes and edges), as well as on the hierarchy and the number of connections, real or hypothetical lengths of walk between the nodes (it shows the deepness of the structure). The origin of this theory dates back to the 18th century, when L. Euler described the problem of Königsberg Bridges. The city of Königsberg was situated on both sides of the Pregel River, which also had two islands. The city and islands were connected by seven bridges. The problem raised by Euler for the citizens was to find the way to walk through the city so that one would cross every bridge only once. However, Euler himself already knew that this route did not exist and the underlying problem was geometry [L. Euler 1956]. The idea of urban catalysts is deeply connected with spatial analysis, since it is based on city network modelling as well as predicting changes in the city fabric. Space Syntax is a tool which cannot only suggest design patterns for architects and urban designers, but also making these changes more reasonable in terms of connectivity and visibility, or making arrangements for the public space network. The urban catalyst idea involves change prediction, which would allow for making the first point of the action intentional and clear. From the previous research it can be observed that the initial shape of urban catalysts can be: a spot or a junction (crossroads, connections); linear (roads, rivers, borders); territo-

ASPECTS OF SPATIAL CAPITAL	EXPLANATIONS ACCORDING TO LM	INDICATORS OF SEGMENT GRAPH	INDICATORS OF VISUAL GRAPH	INDICATORS OF CONVEX GRAPH	INDICATORS OF BUILDING GRAPH (TRADITIONALLY NOT USED IN SPACE SYNTAX MODELS)
DIVERSITY	CERTAIN URBAN AREAS ATTRACT MORE ACTIVITIES/USERS /OBJECTS AND SUPPORT DIVERSITY IN THIS WAY THROUGH CREATION OF CO-PRESENCE CONDITIONS	INTEGRATIONS (AIN) (PLACES OF HIGH REACHABILITY); CHOICE (ACH) (TRANSIT FLOW WHEN MOWERS ARE BROUGHT TOGETHER)	VISUAL CONNECTIVITY, STEP DEPTH, ENTROPY, INTEGRATION, CLUSTERING COEFICIENT AND OTHER VGA INDICATORS; METRIC STEP DEPTH AS SOCIAL –SPATIAL CONTROL INDICTOR; NORMALIZED SOCIAL-SPATIAL READABILITY INDEXES (K2)	DEGREE OF CONSTITUDTEDNESS, DEPTH, INTERVISIBILITY	BUILDING BETWEENNES, REACH, CLOSENESS
SELF-ORGANIZATION	HIGHER CONNECTIVITY AS A BACKGROUND FOR CREATION OF NEW FUNCTIONAL PROCESSES INSTEAD OF THE OLD ONES.	METRIS REACH WITHIN LIMITED RADIUS; EMBEDDEDNESS (EBD); LOCAL INTEGRATION (AIN); LOCAL CHOICE (ACH) MAX AND MEAN VALUES RATIO; NORMALIZED ANGULAR CHOICE AND INTEGRATION (NAIN, NACH)	VISUAL CONNECTIVITY, LOCAL INTEGRATION, CLUSTERING COEFFICIENT AND OTHER INDICATORS OF VGA	FRAGMENTATION OF CONVEX GRAPH	BUILDING REACH WITHIN LIMITED RADIUS
MEMORY	CERTAIN DEGREE OF AUTONOMY OF HISTORIAL PARTS OF URBAN STRUCTURE WHICH ALLOWS THEM TO SURVIVE AND BE USED AS REFERENCE POINTS IN FUTURE URBAN DEVELOPMENT IF NEEDED	METRIC REACH, EMBEDDEDNESS WHICH DOES NOT OVERLAP WITH HIGHEST VALUES OF GLOBAL INTEGRATION AND CHOICE	INDEXES OF VGA AS CLUSTERING COEFICICENT, MEAN DEPTH, ETC. WITH LOCAL RADIUSES	DEGREE OF CONSTITUDTEDNESS, DEPTH, INTERVISIBILITY IN COMBINATION WITH LOCAL I NDICATORS OF ANOTHER GRPHS	BUILDING REACH WITHIN LIMITED RADIUS IN COMBINATIONS WITH LOWER VALUSES OF GLOBAL BETWEENNES AND CLOSENESS

• ALL INDICATORS COULD BE CALCULATED WITH ADDITIONAL WEIGHTS OF THE GRAPH NODES, E.G. BUILDING REACH COULD BE WEIGHTED BY BUILDING PERIMETER, ETC.

Fig. 6. Urban Catalyst idea through the Space Syntax (Spatial Capital) concept; source: by the author

rial (squares, parks, plazas); seeming, imaginary (with no initial physical shape). The first three have a clear shape and can be modelled using a Space Syntax visual graph or segment analysis. It would allow for predicting what kind of benefits catalytic changes could bring to the city and how to better justify the outcome of new projects. The ideas could be implemented into a design process.

"Spatial" catalysts could be modelled on the base of the Spatial Capital concept by Lars Marcus [L. Marcus 2010]. He claims that certain spatial urban configurations create additional values for urban functions and support social/cultural activities. In terms of the city as a complex system, Marcus describes three "functions"/aspects of the Spatial Capital: support for diversity, self-organization which depends on connectivity and memory (subscribed differently) (Fig. 6). All the three aspects of the spatial urban structure could be modelled while using Space Syntax – an approach based on the mathematical graph. Various existing and new combined syntactic indicators could be used/tested for modelling the above-mentioned aspects. In all cases it is required to validate the calculations against real data.

CONCLUSIONS

1. A historical overview suggested a clear evaluation of urban catalysts which would not only allow for better recognition of the changes implemented in the city, but also for predicting the possible outcome. 4 groups of catalysts were established which can be later supplemented by new urban catalysts. This explains the connection between the nature of the urban catalyst and the observed outcome.

2. Group 2 is visibly the smallest, since it includes only 3 catalysts. This group is exceptional because all of the catalysts were not planned by people, and they all brought stable changes to the city. However, this group of catalysts could not be somehow influenced, because its establishment was not planned.

3. All other groups contain catalysts which were somehow planned or made by people. Group 1 contains human-made innovations which are not physical. All of them are innovations, legal principles, etc., and not buildings or territories.

4. Group 3 is the most complex and the relations and similarities within it are not so clear. Thus, it can be observed that all the catalysts in this group have a clear shape – they are spots or territorial; also, all of them changed the function around them after being established. Most of them were made by people.

5. Group 4 is really clear in the shape of the included catalysts. All of them are linear and human-made.

6. The research shows that catalysts can be evaluated, based on their shape and origin, also in terms of the impact they brought. In this case the table of catalysts might be supplemented by other catalysts, since the core of each group is known.

7. There are a lot of indicators of Space Syntax, which might supplement the idea of urban catalysts and help to model these changes in the urban fabric. Numerous values of Space Syntax could bring a quantitative component to the further research.

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