The Hyperscape project (2): Participative Game Informational Construction

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Summary: This paper develops Hyperscape participative game theoretical and methodological assumptions. As an hyper-structural ambient-dimensioned interaction system, Hyperscape constitutes a systemic way for territorial acknowledgement. An illustration of this principle presents a sound multisource analysis of soundscape from Malakoff, a district in Nantes, with using the *sound athmosphere generator*. Manipulation of this hypertool should provide information to evaluate sound interaction through Zipf law entropy dimensioning.

Résumé: Cet article présente les bases théoriques et méthodologiques du jeu participatif Hyperscape. Ce système de dimensionnement des interactions ambiantales vise une prise de connaissance territoriale par une méthode issue de la systémique. Pour illustrer ce principe, nous présentons une analyse multisource du paysage sonore de Malakoff (Nantes, France) en utilisant le *générateur d'ambiances*. Cet outil nous fournira les informations pour l'évaluation des interactions sonores par le dimensionnement de leur entropie *via* la loi de Zipf.

Keywords: Participative game, territorial soundscape, informational dimensioning, entropy evaluation, Zipf law.

Mots-clés: Jeu participatif, paysage sonore territorialisé, dimensionnement de l'information, évaluation de l'entropie, loi de Zipf.

Participative Game Informational Construction

1. INTRODUCTION

From biophysical to sociodynamical sciences, interaction laws (or, more generally, organizational principles) that emerge from the regularities in collective behaviour are most of time unlinear, as the actors teleological assumptions acts following environmental-dependent non-linear interactions [Minsky (1975)]. Their emergent properties are deeply networked to the system observers, in our case, inhabitants involved into the territorial observatory and acknowledgement process in Malakoff district, Nantes, France.
Our main hypothesis for Participative Game Informational Construction lies on supervenience principle [Davidson, (1970)], stating that mental properties and facts "supervene" on physical properties and facts. This principle edict totally disconnected laws between individual and collective behaviour processes. It assumes that subject actions are defined, on one side, by the relationships between elementary physical properties and individual representations, and, in the other side, between collective behaviours and global phenomenon manifestation. This leads us to qualify global environmental interaction set as a collection of interacting systems, showing collective behaviour at different scales, that means, for different proxemies [Woloszyn (2005)]. This observed structural organisation of the proxemical mechanisms of interactions laws will define the ambients perceptual representation system, through interaction flow organisation dimensioning [Woloszyn (2000a, 2000b)].
Therefore, ambient territory knowledge integration is enabled through the proposed Hyperscape action game process, allowed by socio-psycho-physical data feedback streaming through hypertools game-participative functions.
Thus, considered as multi-level emergent structures as for living organisms or social community structures (anthroposystems), the information flow dimensioning enables information entropy quantification. Measurement scaling law can be also deduced from the emergent characteristics of a number of hypermedia landscapes inquiries in perception.

2. INFORMATIONAL DIMENSIONING METHODOLOGY

Structural ambients deconstruction has to be referred to its reciprocal percept organisation through psychics and physics interdimensioning. Resulting psychophysical laws [Condamines (1985)] have to be articulate within micro-psycho-social concept rules [Moles (1988)], in order to model socio-ecologically valid interaction laws [Gibson (1986)].
This teleological construction uses a virtual formalisation of reality, Hyperscape play-ground, producing artefacts with territorial rules acting into the present depth. With acting into this interactive game, players would be able to interact into the virtual territory, idealization between territorial representations and projections.

2.1 Zipf law dimensioning

In order to estimate this cognitive distance between reality and imagination, we'll use an empirical law known as "Zipf law", named for Harvard linguistic professor George Kingsley Zipf, which models the occurrence of distinct objects in particular collections [Brookes (1968), Egghe (1991), Kunz (1988), Wyllys (1981)]. Zipf law says that the i^{th} most frequent object will appear $1/i^{th}$ times the frequency of the most frequent object in the collection. Also an expression of universal regularities, this law is applied in numerous domains: in English texts word occurrence frequency [Blair (1988), Li (1992), Zipf (1932)], as well as populations of cities [Gabaix (1999), Kali (2003), Kwok Tong Soo (2002)], immune system characterization [Burgos (1996)], bibliographical classification or prediction [Fairthorne (1969), Federowicz (1982)], or cancer classification [Li (2002)]. Nevertheless, except musical [Manaris (2002), (2003), (2005)] and audio medical signal [Dellandrea (2004)] applications, we didn't find Zipf law application for other audio domains such as soundscape acknowledgment in scientific literature. As it typically holds when the "objects" themselves have a property (such as length or size) which is modelled by an exponential distribution, we will use this method to evaluate sound entropy quantification relevant to Malakoff territory.
Zipf law states that in a tabulation of the occurrence of all words in a sufficiently comprehensive text, ranged by their frequency, will the product of rank number and frequency make up a constant. In addition will the number of different words in the vocabulary be equal to the frequency of the most common word, as seen following French text Zipf law application figure 1:

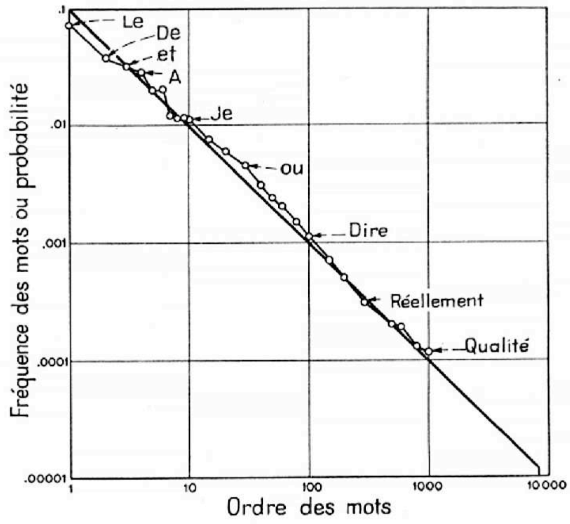

Figure 1: Frequency-rank Zipf's law for French language [Mandelbrot (1965)]

Zipf law may be stated mathematically as:

$$\log f_x = C - s \log k \qquad \text{eq. (1)}$$

where f_i, the frequency of the unit (wordform or lemma) having the rank *k*, *s*, the exponent coefficient (near to 1 for English language word frequency distribution), and *C*, a constant. In a logarithmic scale, Zipf law is expressed as a straight line with about – 45° angle, as seen figure 1.

2.2 Zipf principle and information treatment

Zipf also provided a theoretical explanation for his law [Zipf (1949)]. He found that the law was an expression of a competition between two economic principles: "The economics of the speaker", that tend towards a reduction of the number of words in language, and "the economy of the listener", that tend to use a new word in each new linguistic act that the speaker wish to do. In all persons speaking a language fluently there is a balance and Zipf law is an indication that this balance is reached. Consequently to this assumption, Zipf suggests a way to optimize the cost of communicative transactions between speakers and listeners by wedging their relative directories, as illustrated figure 2:

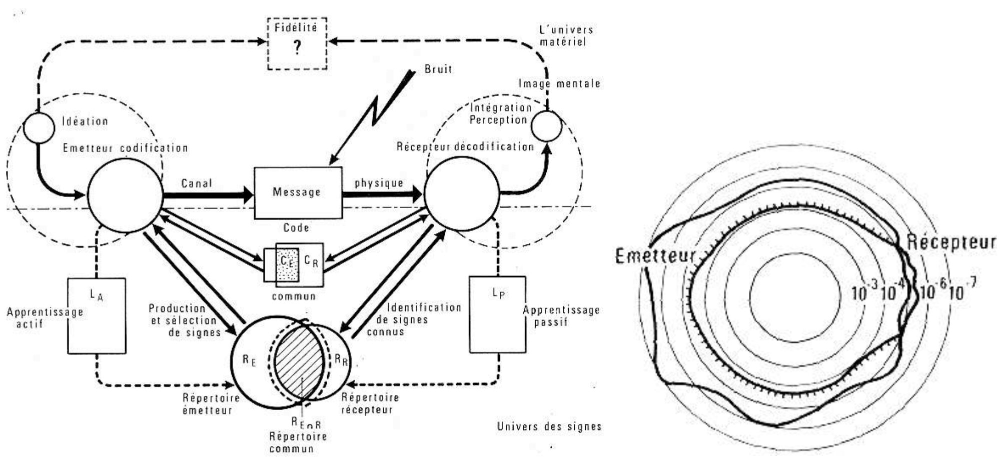

Figure 2: *Shannon informational scheme and "Informational impedance adaptation" : Transmitter-receiver directories fitting [Moles (1988)].*

A.A. Moles called this action "Informational impedance adaptation", acted though the apprenticeship process [Moles (1988)]. This process corresponds to an adaptative function which asymptote reveals perfect fitting between transmitter and receiver directories, that means Zipf balance is reached through a power law equal to 1.

2.3 Entropy calculation processing

Zipf power law can be readed as a linear relationship when plotting data in log-log coordinates, arranging dots along a line, which reveals the structural relationship between the number of sources occurrences and their rank, leading to informational dimension expression D_s as:

$$D_S = \frac{\sum_{x \in X} p(x) \log \frac{1}{p(x)}}{\log k} \qquad \text{eq. (2)}$$

where *p(x)* is the occurrence of element *x* of rank *k*. The numerator of this dimensional expression constitutes the entropy expression *H*, as:

$$H(x) = \sum_{x \in X} p(x) \log \frac{1}{p(x)} \qquad \text{eq. (3)}$$

This entropy calculation will enable transmitter-receiver directories fitting quantification of the perceived soundscape thanks to hypertools developed within the Hyperscape project.

3. APPLICATIONS TO THE HYPERSCAPE PARTICIPATIVE GAME FEATURES

The hypertool based on a soundscape territorial ambient sampling is presented thereafter, as an acknowledgement of the ambient sound territorialization. This ambient re-construction game pad we propose will help us to evaluate the cognitive distance between real world environments and ideal world projections [(Woloszyn & al. 2007)] through soundscape description and composition analysis.
This is the reason why our game-informational research-action approach, Hyperscape, formulates ambients through event/phenomenon homeomorphic multimedia description, in order to interact with the territorial "players". For this aim, Hyperscape system behaviour will allow coupling physical characterisation of a specified environment (i.e. soundscapes recordings of Malakoff territories) with the corresponding cognitive representations (through environmental psychological game-inquiry process), through an ambient scene construction (namely the sound athmosphere generator presented in the theme A contribution of the present conference: *"Landscapes observatory, a Tool Coproduction and Acknowledgment Participative Challenge-Games"*). Technically, Hyperscapes methodologies are based on visual, sonic and textual contents, including trans-media navigation features as an on-line "clickable" media navigation process into the territorial representation, in order to constitute an useful tool which facilitates the mediation among the actors of the territory. Therefore, the corresponding hypertools exploits a specific software library, developed through various types of data (sound, video, pictures, vectorized data, text). Actually, games for territory discovering includes a landscape beat box, and a sound atmosphere generator.

3.1 An example of Sound data treatment through *sound atmosphere generator* hypertool exploitation

The *sound atmosphere generator* uses a specific way for soundscape acknowledgment, with associating a photography with the sound, in order to realize a proper representation from a neighbourhood locality with a visual support (figure 3).

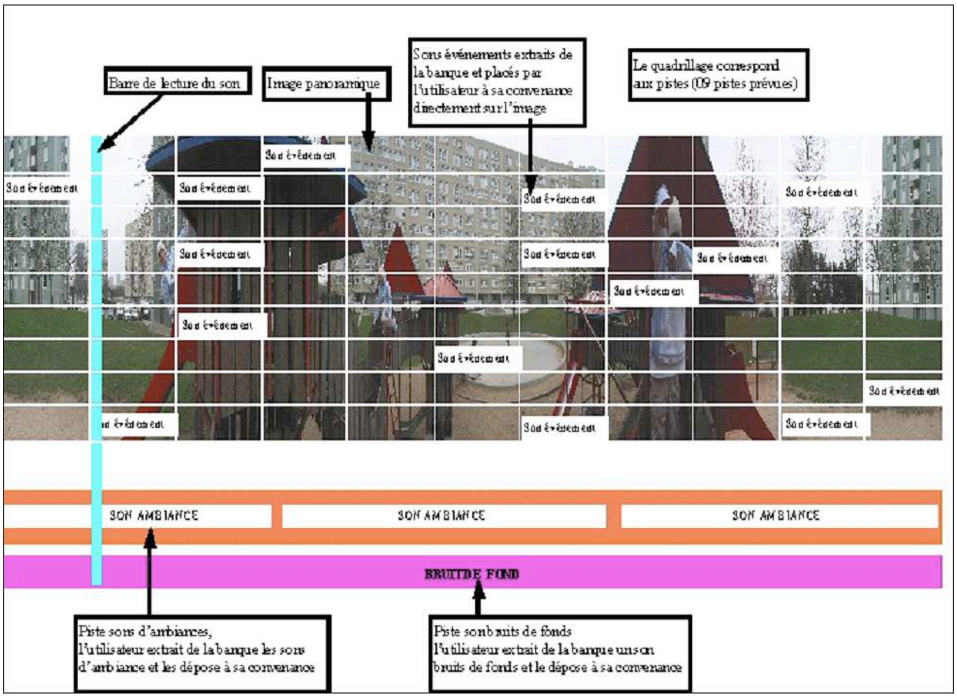

Figure 3 : Sound atmosphere generator functioning principle

Its goal is to allow each inhabitant to reconstruct her/his perception of the Malakoff sound atmosphere, which would recompose the global sound thanks to the sound database described herafter.
This tool allows concretely to act on the neighbourhood landscapes to transform them, taking into account the different cognitive soundscape levels: background noise, ambient sounds and acoustic events.
The "clicking" traceability available into HPU system afford us to keep the trace of sound data manipulation, that means, every recomposition step of the mean sound atmosphere generator is readable via a specified file.
Therefore, in order to understand the neighbourhood territory representations, qualitative data will be collected to analyze the sound composition process, in respect with the temporal occurrences of the analyzed sounscape sound source composing.

3.2 Malakoff soundscape analysis

Taken as a powerful tool for environment acknowledgement evaluation, the previously mentioned Zipf competition principle can analogously be transposed to sound ambient environment, aiming to evaluate "Sound environmental economics (the transmitter)" and " Economy of the atmosphere composer (the receiver)" that will be evaluated through the sound atmosphere generator experimentation.
In an analogical way, sound sources are here considered as the soundscape words (sound items) to be analyzed, as computation of their citation order and frequency. This sound atmosphere generator data treatment will define the Zipf proximal law for each Malakoff constitutive soundscape.
Then, we will estimate soundscape informational entropy through sound event density probability distribution calculation, as mentioned before.
Ambient sound source classification is made from direct territory observation through sound recording. In order to achieve it, a soundscape database has been recorded *in situ*, taking the main sound atmospheres of the neighbourhood into account (figure 4).

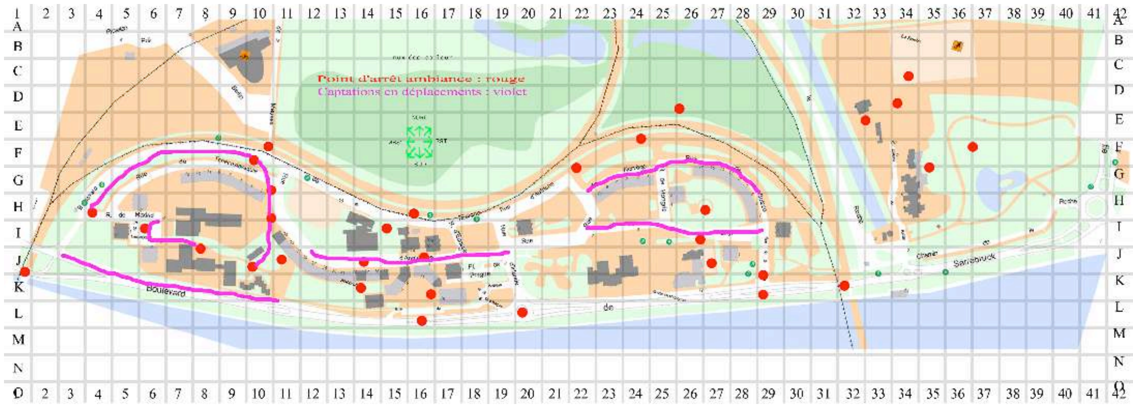

Figure 4 : Territorial soudscape map : Malakoff captation points

Several series of sonic walks (purple lines), marked out by about thirty-two fixed recording points (red dots) presented in the above soundscape map, have been made to register sound sequences representing rather faithfully the districts' various sound atmospheres.
These walks allow to take a phonograph of the evolution of the Malakoff district soundscape [Schafer (1981)]. They represent to the greatest extent possible the various atmospheres that a passer-by would encounter when wandering into the urban district. Each sequence, examined through headphone audition, can therefore be described according to each of the sources occurrence frequency.
These noises are then classified according to the SaCCSO methodology [Léobon (1993)], with providing six sound sources classes, constituted by elementary sonic items, indexable as following:
— the source "Urban activity", accounting for engine noise, road traffic, transport noise and works noise,
— the source "Human presence", relating to indications of people passing through,
— the source "Human activity", signing the noises relating to individual activities,
— the source "Language and communication", for really challenging messages such as set of signs, musical animation, understandable conversations,
— the source "Wildlife noise" for nature and animals sounds, referring generally to open spaces,
— and the source "background noise", signalling indirectly the notion of calm of a soundscape [Léobon (1995)].

3.3 Zipf law application

After this typological construction born of soundscape source enumeration by headphone hearing , we quantify the citation occurrence of each source, in regard with its citation order. As indicated equation (1), mathematical expression of Zipf law involves the number of occurrences of a done sound source, understood as an acoustic event, and provides the relationship between the number of sound source occurrences with respect to their occurrence frequencies. Result of soundscape quantification should then provide a rank-order Zipf power law, which, compared to the power law resulting from sound atmosphere generator experimentation, should provide the informational impedance adaptation level between real and imagined soundscape. The resulting event density probability distribution will then allow information dimension computation, through relative entropy calculation of the soundscape sources.
As entropy expression (equation (3)) reveals the sharp (H=1) or low (H<1) correlation between the real sources present in the studied territory and their evocation, sound source distribution within a done environment constitutes an elementary indicator of the evocation force of a given soundscape.
As a complementary result, the three "metaclasses", background noise, ambient sounds and acoustic events, will be defined through the respective sound sources Zipf scaling values, as those lasts describe cognitive distance of soundscape elements.
Relying on a structuralist hypothesis [Moles (1990)], we claim that every soundscape can thus be described as a combination of the previous sonic items (sound sources), belonging to the three specified metaclasses, feeding the sound athmosphere generator.

Conclusion

The interesting perspectives offered by Zipf law have led us to evaluate its pertinence for environmental sound sources classification and evaluation. Thus, Zipf competition principle can be analogously transposed to sound ambient environment perception, in order to evaluate cognitive distance between real and imaginary soundscape

in Malakoff territory.
To do this, Zipf power-law distribution on ranked sound data enables acoustical information flow dimensioning, which will be applied on both sound athmosphere qualification through soundscape listening and sound atmosphere generator hypergame.
This way to analyse urban atmospheres may enable us to define the notions of sensible sound territory, with finding significant relationships between dimensional evaluation of a soundscape and its appreciation level through a participative ambience reconstruction game.
The global participatory approach that makes this approach possible involves the development of complex processes, touching transversely to both public and private performances, as well as individuals and cultural groups. A more complete computer-adapted knowledge and culture sharing is actually under development within Hyperscape project, implying territorial politic structures and organisations. This will experience their participation to the Malakoff urban development process, through knowledge, tools and goals sharing.
Within territorial rules integrations, intelligent territorial system HyperScape should be able to operate an ecologically valid transcription of the representations of a given territory as a collective construction in spatial terms as well as in social ones.

Bibliography

Blair; D. C. (1990). Language and Representation in Information Retrieval. Amsterdam: Elsevier.

Brookes, B. C. (1968). The derivation and application of the Bradford-Zipf distribution. Journal of Documentation, 24(4), 247-265.

Burgos, J. D., and Moreno-Tovar P. (1996) "Zipf-Scaling Behavior in the Immune System." Biosystems 39(3): 227-232.

Condamines R. : “ Acoustique psycho-physique ”, Paris, Masson, 1985, 276 p.

Davidson D., (1970) How is Weakness of the Will Possible ? Moral Concepts, Joel Feinberg ed., Oxford University Press, reprinted 2001.

Dellandréa E., Makris P., Vincent N. (2004) “Zipf analysis of audio signals”, Fractals Vol.12, 1, World Scientific Publishing, , Singapore, pp.73-85.

Egghe, L. (1991). The exact place of Zipf's and Pareto's law amongst the classical information laws. Scientometrics, 20(1), 93-106.

Fairthorne, R. A. (1969). Empirical hyperbolic distributions (Bradford-Zipf-Mandelbrot) for bibliometric description and prediction. Journal of Documentation, 25(4), 319-343.

Fedorowicz, J. (1982). The theoretical foundation of Zipf's law and its application to the bibliographic database environment. Journal of the American Society for Information Science, 33(5), 285-293.

Gabaix, Xavier (1999). Zips's law for cities: An explanation. Quarterly Journal of Economics, 114(3), 739-67. Available at: http://econ-www.mit.edu/faculty/download_pdf.php?id=530 (Retrieved 2007-08-16).

Gibson, J.J. (1986) The Ecological Approach to Visual Perception. Hillsdale, New Jersey.

Kali R. (2003). The city as a giant component: a random graph approach to Zipf's law. Applied Economics Letters, 10(11), 717-720.

Kunz, M.: Lotka and Zipf: (1988) Paper dragons with fuzzy tails. Scientometrics, 13(5-6), 289-297.

Kwok Tong Soo, (2002), Zipf’s Law for Cities: A Cross Country Investigation, mimeo. An updated version has been published in 2005 in Regional Science and Urban Economics 35(3): 239-263.

Léobon A. (1993) The cartography of a town center soundscape, Noise and Man'93, Nice.

Léobon A. (1995) La qualification des ambiances sonore urbaines, Natures - Sciences - Sociétés. III(1) p 26-41.

Li, W. (1992). "Random Texts Exhibit Zipf's-Law-Like Word Frequency Distribution." IEEE Transactions on Information Theory 38(6):1842-1845.

Li, W., and Y. Yang. (2002). "Zipf's Law in Importance of Genes for Cancer Classification using Microarray Data." Journal of Theoretical Biology 219:539-551.

Manaris, B., T. Purewal, and C. McCormick (2002). "Progress Towards Recognizing and Classifying Beautiful Music with Computers: MIDI-Encoded Music and the Zipf-Mandelbrot Law." Proceedings of the IEEE SoutheastCon 2002. New York: Institute of Electrical and Electronics Engineers, pp. 52-57.

Manaris B. and alii (2005) “Zipf's Law, Music Classification, and Aesthetics” Computer Music Journal Volume 29 , Issue 1 , Pages: 55 - 69

Manaris, B., et al. (2003). "Evolutionary Music and the Zipf-Mandelbrot Law: Progress towards Developing Fitness Functions for Pleasant Music." Proceedings of EvoMUSART2003--1st European Workshop on Evolutionary Music and Art. Berlin: Springer-Verlag, pp. 522-534.

Mandelbrot B. (1965). "Information Theory and Psycholinguistics", in B.B. Wolman and E. Nagel: Scientific psychology. Basic Books.

Mandelbrot B. (1968). "Information Theory and Psycholinguistics", in R.C. Oldfield and J.C. Marchall: Language. Penguin Books.

Minsky, M. (1975). A framework for representing knowledge. In P.H. Winston (Ed.) The psychology of computer vision. New York: McGraw-Hill, pp. 211-280.

Moles, A.A. (1988) Théorie structurale de la communication et société, Paris, Masson / CNET / ENST, 295 p.

Moles A. (1990). Les sciences de l’imprécis, Paris : Seuil

Schäfer M. (1992). The tuning of the world, New-York: A. Knopf. Le paysage sonore, Paris: J. C. Lattès, 1981

Woloszyn P., Joanne P., Barlet A., (2000a) Proxémie acoustique et équilibre sonore dans un ensemble d'habitation. in : CFA 2000 Actes du 5e congrès français d'acoustique, Lausanne, 3-6 septembre 2000. Lausanne: Presses polytechniques et universitaires romandes, pp.468-471

Woloszyn, P., Follut, D. (2000b). The visualisation of the urban "ambients" parameters. in : 14th International symposium, in: Computer Science for environmental protection, Gesellschaft für Informatik (GI), Bonn. Marburg (DE) : Metropolis Verlag, pp. 173-186.

Woloszyn, P. (2005). An acoustic ambience study by immersive sound recognition, in: European conference Building with sounds, Paris.

Woloszyn, P, Bourdin, G. (2007). Urban HyperScape: a community game for territorial knowledge, Second international annual conference of territorial intelligence, Huelva, Spain, October 24th -27th (2007).

Wyllys, R. E. (1981). Empirical and theoretical bases of Zipf's Law. Library Trends, 30(1), 53-64.

Zipf, G.K. (1932). Selected Studies of the Principle of Relative Frequencies of Language. Cambridge, Massachusetts: Harvard University Press.

Zipf, G. K. (1949). Human behaviour and the Principle of the Least Effort. Reading, MA: Addison-Wesley.