ANALYSIS OF THE CONSUMER DECISIONAL SYSTEM USING A SOFTWARE APPLICATION

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Abstract: *The paper studies the endogenous factors, which determine the consumer decision, using computational methods. For studying the interaction of these influences, we have applied a simple own application which includes the Onicescu informational statistics formulas. The application, denoted „info-calculus" is realized in MS Excel program, with an accessible interface for entering data, and an auxiliary file for calculus. Though it is proposed for study the consumer decisional system, the software can be used for any other system of three dimensions in order to find the changes of energies, the influences between them.*

Key words: *information theory; calculus; factors interaction*

1. Introduction

Starting from the study of the people perception about the environment, our research had a particular interest in the field of entertainment, so we advanced two online surveys for knowing the consumer preferences in the new market of the anime culture products. The subject has not been researched so far in Romania, no marketing studies have been conducted, neither theoretically nor experimental. Following the Kotler (2016) cybernetical model of the consumer decisional model, we have composed our questionars on the endogenous influences, but for study their interactions and their importance in the system, we used the information theory, the Onicescu informational energy and all the other connected dimensions. The formulas have been introduced, for easier use, in a MS Excel register, we have called *INFO-CALCULUS.* The application results, for the data obtained from one of our surveys, are analyzed in the following, together with some connected images. The application register has included, under its two forms, in the annexes of this paper, like inserted object, in order to be easy accessed, because this is what we meant to do, offer an easier way of applying information theory formulas to an interacting system, particular, the decisional system of the consumer.

2.Methodology

The data obtained from the conducted online surveys (Google docs; Cazacu, 2016, 2018a), are organized in a 2^3 experiment tables. The endogenous influences measured in the author questionnaire were: the **perception**, the **knowledge**, the **motivation** and the **attitude** of the entertainment consumer (particularly the anime culture products consumer) elements which are responsible for the decision to buy (Kotler, 2016).

It have been made two online surveys, conducted by this author, which had different time of development and different number of respondents, but the results have been similar. The data in the tables correspond to the second survey (Cazacu, 2018a; Cazacu, 2019).

Table 1: Numerical data obtained from the survey

ENDOGENOUS INFLUENCE	ALTERNATIVE ANSWERS	NUMBER	PERCENT
PERCEPTION (Surprising)	YES	160	60%
	NO	108	40%
KNOWLEDGE	YES	260	97%
	NO	8	3%
MOTIVATION	YES	168	63%
	NO	100	37%
ATTITUDE	YES	169	63%
	NO	99	37%

Source: data results from author's research

It can be observed the similar percentage for the last two influences, in this case, though it must be mentioned they have been rounded at zero decimals format, for easier using in the calculus. For the motivation influence, there was a graduated question: "What was your purpose for buying…?" (the specific products) with three possible answers: "*for a present*"(8 answers=3%),"***for me***"(167 answers=62,5%) and "*I did not buy*"(92 answers=34,5%) so if we are interested only for the affirmative answer, that is *to the himself achievement*, the other cases being cumulated: 3%+34,5%, and the rounded percentage used.

In the next two tables, the data are reorganized in **2^3** pseudo experiment modality, in order to study the interaction of two endogenous influences over the third(Table 2 and Table 3) The studied factors are denoted with ***A,B,C*** meaning the mentioned endogenous influences, and, as variables in the pseudo experiments: ***X,Y,Z***.

Table 2: The perception and motivation influences over the consumer attitude

X(A) PERCEPTION (surprising)		Z(C) MOTIVATION		Y(B) ATTITUDE	
				NO	YES
NO	108	NO	68	25	43
		YES	40	15	25
YES	160	NO	59	22	37
		YES	101	37	64

Source: data results from author's research

Table 3: The perception and motivation influences over the consumer knowledge

X(A) PERCEPTION (surprising)		Z (C) MOTIVATION		Y(B) KNOWLEDGE	
				NO	YES
NO	108	NO	68	2	66
		YES	40	1	39
YES	160	NO	59	2	57
		YES	101	3	98

Source: data results from author's research

The MS Excel register we propose as application to be used, includes Onicescu informational statistics formulas (Onicescu, 1979). The two main dimensions based on which the entire information theory is developed, are the Onicescu informational energy ***E*** and the informational entropy ***H***. Most of the formulas in the application are based on the first of them, the energy, our interest being focused on the energies transfer, influences, contribution and gain, when two or three variables/ factors are involved.

In the following considerations, the affirmative alternative of a variable is subscript indexed with "$_2$" or superscript with "^{1}", and the negative alternative is subscript indexed with "$_1$" or superscript with "^{0}".

3. Results

In order not to reload the formulas for every case, we present, as example, the formulas used in the X←→Z determination, the influence of the perception over the motivation and inverted (Table 2). The contribution of energy, brought from ***X*** to ***Z***, or from ***A*** to ***C***, is calculated, as it is known, using an average of the conditioned energies of the variable ***X***(or the influence ***A***) in equations (1), where W_1 and W_2 are the specific weights(the numerical contributions of each kind of answers: **no** and **yes**), in this case: W_1=108/268 and W_2 = 160/268.

$$AI(Z/X) = E(Z/X_1)\cdot W_1 + E(Z/X_2)\cdot W_2 - E(Z) \tag{1}$$

equivalent with the resumed form, we prefer:

$$AI(Z/X) = \overline{E(Z/X)} - E(Z) = 0{,}53 - 0{,}50 = 0{,}03$$

The same numerical result is obtained if the two variables a re inverted, as the two influences action equally one upon the other.

$$AI(X/Z) = \overline{E(X/Z)} - E(X) = 0{,}03 \tag{1'}$$

Though, the motivation factor has a significant informational gain, due to the perception. The informational gain verifies the equations (2) including the adjusted energies, denoted with the subscript "***a***", described in detail, in equations (3).

$$\Delta(Z/X) = W_1\cdot E_a(Z/X_1) + W_2\cdot E_a(Z/X_2) - E_a(Z) \tag{2}$$

equivalent with:

$$\Delta(Z/X) = (\overline{E(Z/X)})_a - E_a(Z)$$

the component terms being described in the following:

$$E_a(Z/X_1) = 2\cdot E(Z/X_1) - 1 = 0{,}07 \quad E_a(Z/X_2) = 2\cdot E(Z/X_2) - 1 = 0{,}07$$
$$(\overline{E(Z/X)})_a = 2\cdot E(Z/X) - 1 = 0{,}07 - 0 = 0{,}07 \tag{3}$$

It is also important to measure the contribution of each influence to the system energy, as a result of their interaction, when referring to the three of them. For example, to measure the result of ***X*** and ***Y*** action over ***Z***, we are interested about the informational contribution and gain, which verify equations (4), detailed in equation (5-i):

$$AI(Z/X,Y) = \overline{E(Z/X,Y)} - E(Z) = 0{,}3$$
$$\Delta(Z/X,Y) = \overline{E(Z/X,Y)}_a - E_a(Z) = 0{,}7 \tag{4}$$

the first is the informational contribution and the next, the informational gain. The average of the adjusted energies, moderated with the specific weights gives the follow result:

$$\Delta(Z/X,Y) = W_1 \cdot E_a(Z/X_1,Y_1) + W_2 \cdot E_a(Z/X_1,Y_2) \tag{5}$$
$$+ W_3 \cdot E_a(Z/X_2,Y_1) + W_4 \cdot E_a(Z/X_2,Y_2) - E_a(Z) = 0{,}07$$

or similarly, the result of ***Y*** and ***Z*** action over ***X***, with equation (6) (Figure 1), in which we replaced the specific weights with the correspondent frequencies, being the same thing:

$$\Delta(X/Y)/Z = P(Y_1,Z_1) \cdot E_a(X/Y_1,Z_1) + P(Y_1,Z_2) \cdot E_a(X/Y_1,Z_2) \tag{6}$$
$$+ P(Y_2,Z_1) \cdot E_a(X/Y_2,Z_1) + P(Y_2,Z_2) \cdot E_a(X/Y_2,Z_2) - E_a(X) = 0{,}06$$

P(X**$_i$**,Y**$_j$**), ***P(X**$_i$**,Z**$_j$**)*** and ***P(Y**$_i$**,Z**$_j$**)*** are the specific weights for each case, calculated by dividing the corresponding numerical frequencies to the total responds. For more details about how are calculated the specific weights, we have selected the case solved in equation (5). The calculus is explained in the list included in Specific weights, calculated in the case of the ***X*** and ***Y*** action over ***Z***:

$W_1=P(Z/X_1,Y_1)/T...$=40/268, $W_2=P(Z/X_1,Y_2)/T...$=68/268, $W_3= P(Z/X_2,Y_1)/T...$=59/268, $W_4= P(Z/X_2,Y_2)/T...$=101/268

If we are interested also, in one variable alternative influence over the system or other variables, there is the corresponded adapted formulas, that we propose. For example, the informational gain of ***X*** variable, as a result of ***Y*** variable action, combined with the affirmative alternative of ***Z,*** denoted with Z_2 (the negative one beeing denoted with Z_1)(Figure 2), solved in equation (7).

$$\Delta(X/Y)/z_2 = \Delta(X/Y,Z^1) = \overline{E_a((X/Y)/z_2)} - E_a(X) = \tag{7}$$
$$= E_a((X/Y_1)/z_2) \cdot P(Y_1,Z_2) + E_a((X/Y_2)/z_2) \cdot P(Y_2,Z_2) - E_a(X) = 0{,}06$$

Even more, in order to measure the influence of two variables alternatives over the third variable, we propos another formula. For example, the case in which the negative alternatives of ***X*** and ***Y***, influence the third variable, ***Z*** (Figure 2) solved in equation (8). In this formula, the negative alternatives of the negative alternatives of the determining variables were superscript indexed, with "^{0}", equivalent with the subscript notation "$_1$", both of them being used in our register of calculus.

$$\Delta(Z/Y^0)/X^0 = I(Z/Y^0,X^0) - \theta(Z) =$$
$$E_a((Z/Y^0)/X^0) \cdot P(Y^0,X^0) - E_a(Z) = 0{,}01 \tag{8}$$

The first form of the INFO-CALCULUS application brings supplementary information about haw all the three variables, due to their interactions, influence the decisional system, in its evolution, meaning that the resulted energy contributions determine the consumer decision.

These results are: *energy contribution of one variable, caused by the other two variables presence*, similar with the informational contribution in equation (4), *energy from not maching* (equation (9)) and *energy contribution due to the other two variables combination* (equation (10))

The energy from *not matching* between the variable ***Z*** and the variable ***X***, or the variable ***Y***, written with the usual notations:

$$\boldsymbol{AI}(Z/X,Y) = \overline{\boldsymbol{E}(Z/X,Y)} - \boldsymbol{E(Z/X)} \qquad \boldsymbol{AI}(Z/X,Y) = \overline{\boldsymbol{E}(Z/X,Y)} - \boldsymbol{E(Z/Y)} \tag{9}$$

and the other four formulas, obtained by circular permutations, which, in the studied case, are all null. In order not to use equations in comments, in the application had to be done some conventional notations, meaning the same thing, notations that are easy to associate:

AI(Z/X,Y) = M(E(Z/X,Y)- M(E(Z/X) or: **AI(Z/X,Y) = M(E(Z/X,Y)- M(E(Z/Y)** (9')

The energy provided from *one variable contribution due to the other two variables combination*, for example, the energy provided from the variable ***Z***, due to the combination of the variables ***X*** and ***Y***, written with the usual notations, is as follows:

$$\boldsymbol{AI}(Z/X \oplus Y) = \overline{\boldsymbol{E}(Z/X)} + \overline{\boldsymbol{E}(Z/Y)} - \overline{\boldsymbol{E}(Z/X,Y)} - E(Z) \tag{10}$$

and, in the application, written with the conventional notations:

AI(Z/X⊕Y) = M(E(Z/X)+ M(E(Z/X,Y) - M(E(Z/X,Y)- E(Z) (10')

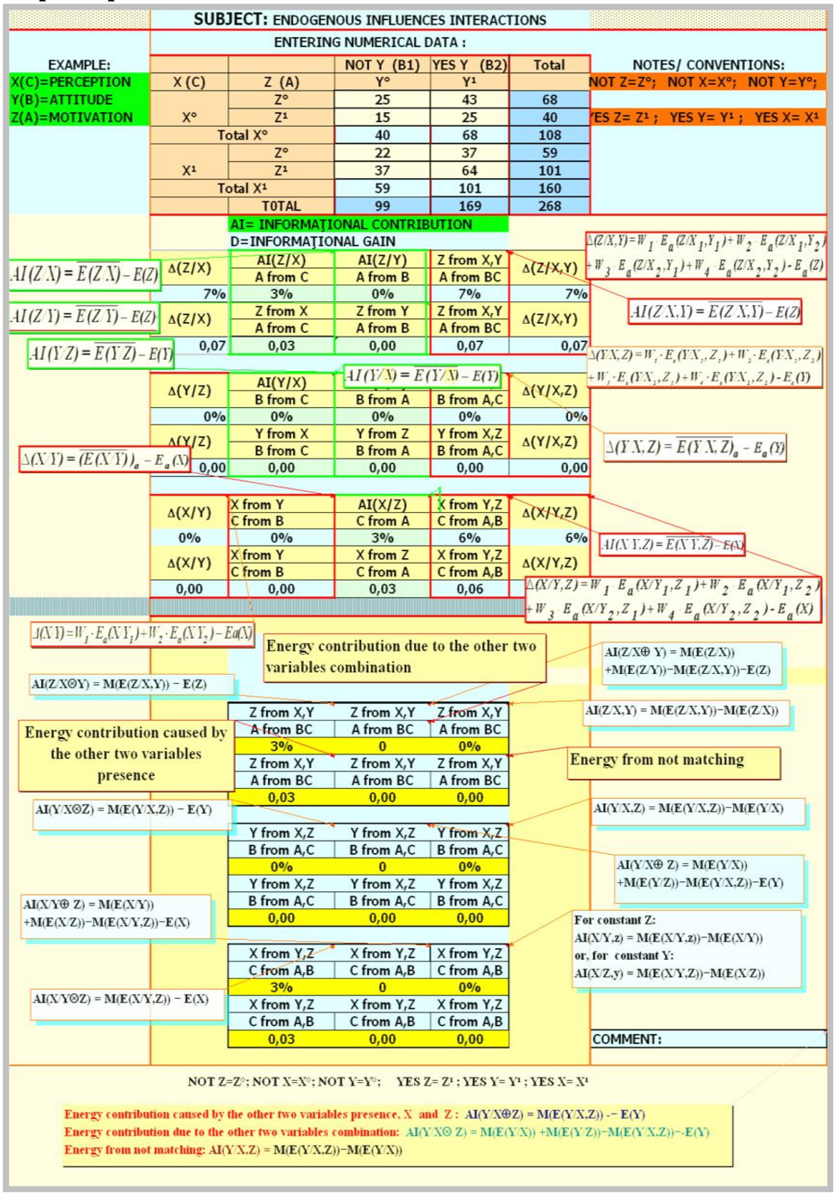
We have proposed and used two equivalent notations, as the application user can choose for which of them seems more appropriate to his scope, but they have the same significance (Cazacu, 2018b; Mihăiță,2016). When the formulas are used in text, as it is in many specialty works, it's more easier to use the subscript notation, as it is also in the "*auxiliary-file*" of the application and in comments, but in the main results, in the "*data-analysis*" file, we have selected the superscript indexing (Figures 2 &3)for the application portability.

The equivalent notations of the calculated information theory dimensions, used in the application, and in other works, are enumerated in the following list:

1) **AI(X,Y)=AI(Y/X)** => equivalent notations, used for formalizing the informational contribution from variable X to variable Y, the first notation being the usual
2) **Δ(X,Y)=CI= Δ(Y/X)** => equivalent notations, used for formalizing the informational gain from variable X to variable Y, the first notation being the usual
3) **AI(Y/X,Z)** =**AI(Y/X)/Z** equivalent notations, used for calculate the informational contribution, relative to three variables(brought by the variables X and Z to the variable Y), the first notation being the usual
4) **Δ(Y/X,Z)** = **Δ(Y/X)/Z** => equivalent notations, used by the author, for formalizing the informational gain of the variable Y due to the the variables X and Z, the first notation being the most usual
5) **M(E(Y/X)** => notation used by the author in calculations, for the average of the component energies of the variable Y, in the presence of the variable X, usual notation is: $\overline{\mathrm{E}(\mathrm{Y}/\mathrm{X})}$
6) **Ma(E(Y/X)**=> notation used by the author in calculations, for the adjusted average of the component energies of the variable Y, in the presence of the variable X; usual equivalent notations are: $\overline{\mathrm{E}_{\mathrm{a}}(\mathrm{Y}/\mathrm{X})} = \left(\overline{\mathrm{E}(\mathrm{Y}/\mathrm{X})}\right)_{\mathrm{a}}$
7) **M(E(Y/X,Z)** => for the average of one variable components energies, in the other two variables structures presence; usual equivalent notations: $\overline{\mathrm{E}(\mathrm{Y}/\mathrm{X},\mathrm{Z})} = \overline{\mathrm{E}(\mathrm{Y}/\mathrm{X})}/\mathrm{Z}$

8) **Ma(E(Y/X,Z)= M(Ea(Y/X,Z)**=> notation used by the author in calculations, for the adjusted average of one variable components energies, in the other two variables presence; usual equivalent notations: $\overline{E_a(Y/X,Z)} = \overline{E_a(Y/X)/Z} = \overline{(E(Y/X,Z))_a}$

Figure 1: The results of the INFO-CALCULUS application, concerning the perception and motivation actions over the consumer attitude

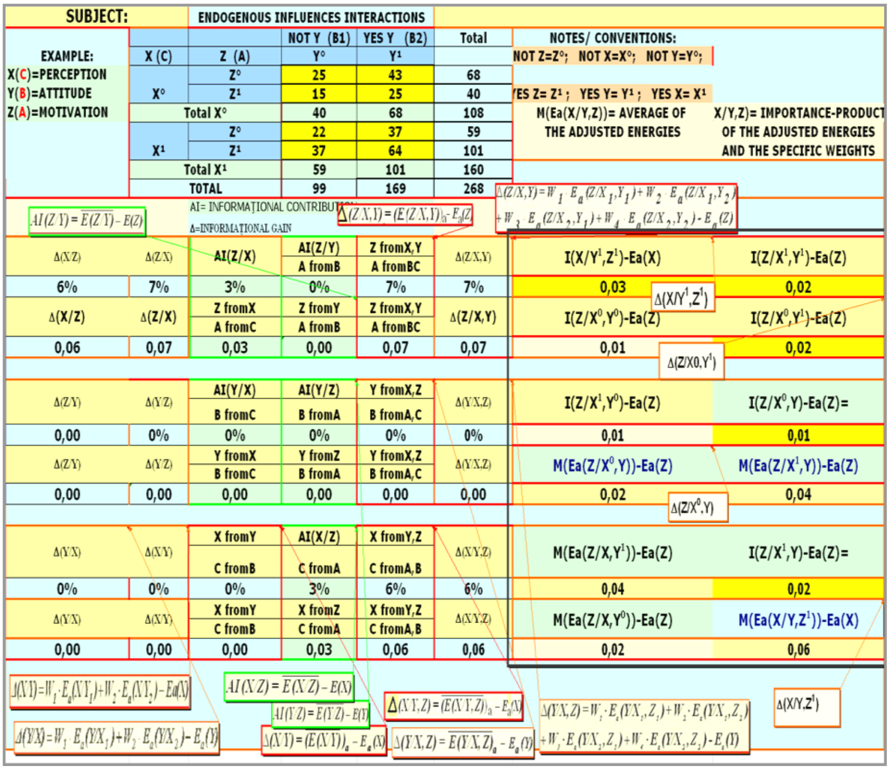


Source: author's research results (using INFO-CALCULUS,FORM I)

Referring to the X←→Z determination, the influence of the perception over the motivation and inverted, in both cases, we can notice the importance of the informational gain (7%) of motivation, due to perception, and conversely (6%)(meaning the consumer can be subjective).

As for three of them, the perception combined with the attitude(or knowledge) acts over the motivation, justifying an informational gain of 7%. There is also the inverted action when the perception is influenced by the combined action of motivation and attitude(or knowledge), meaning that the consumer decision, besides the subjectivity, can be influenced by more information, knowledge, finally, could be educated(informational gain of perception was 6%)

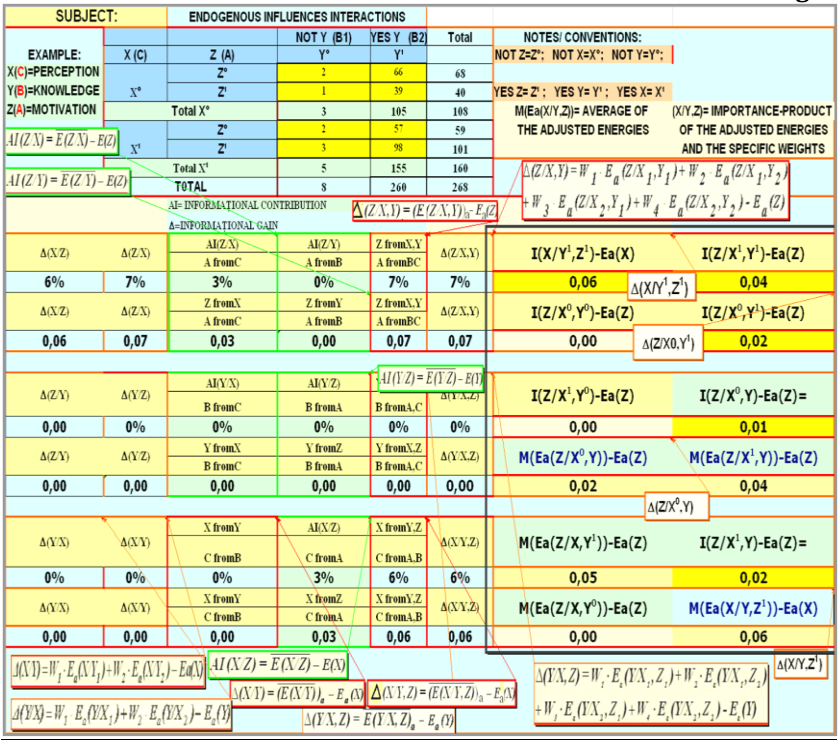
Figure 2: The results of INFO-CALCULUS application, regarding the perception and motivation alternatives actions over the consumer attitude



Source: author's research results(using INFO-CALCULUS, FORM II)

Using the data inserted in Table 3, but the same application form, we studied all the transferred energies or interactions between three factors, on their alternatives, and obtained different results, as it was expected, though in the left columns, the main results are similar, because the numerical data are the same for the variables ***X*** and ***Z***, only the third variable, the determined one, is different: the **attitude** factor(Figure 2) is replaced with the **knowledge** factor (Figure 3).

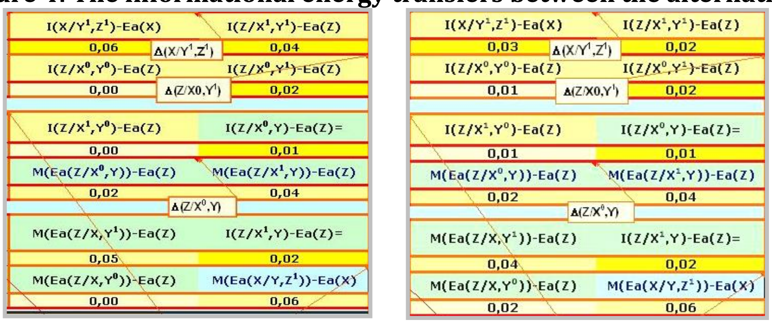
Figure 3: The results of INFO-CALCULUS application, regarding the perception and motivation alternatives actions over the consumer knowledge



Source: author's research results(using INFO-CALCULUS, FORM II)

For comparison, we have selected the detailed results of the variables alternatives, and put them together in Figure 4. It results, from the comparison, that at the micro level of the variables alternatives actions, coming from the perception and motivation, in majority, they have, if are not null, a little more powerful impact over the knowledge, than over the consumer attitude.

Figure 4: The informational energy transfers between the alternatives



Source:the results in Figure 3

In the left there the results relative to the consumer knowledge; in the right, there are the results relative to data relative to the consumer attitude

4. Using the proposed application for the data analysis

INFO-CALCULUS, as we have named it, is a MS Excel register for the informational analysis of three endogenous influences, and of any other factors, so it can be considered, eventually, an application. In order to use this register, in any of the two presented forms(the first, in Figure 1, the second, in Figure 2), it must double-click on the object, then enlarge the image, for better observe the obtained results.

The figures in the above considerations are images of interactive objects, which have, each of them, two files: the first, named "data analysis", contains the results, corresponding the informational formulas inserted in the comments; the second file, named "auxiliary_file" contains the hole calculus attached to the first file, by hiperlink. Any change in the "entering data" sequence of the first file, have the consequence of changing the data used by all the formulas in the second file, and, finally, changing the main results in the first one.

As it have been mentioned, this program is, in fact a MS Excel register with two files: the main file and the auxiliary file. The second file includes many more formulas than the first, because the main formulas need partial results obtained from using many other formulas. All these formulas a connected, but we can mention some of them, as being of more priority or importance for any research(Table 4), well known formulas in the information theory, also used in studying the perception consumer(4),(7),(8),(9).

Table 4. Some of the most used formulas involved in the application (The notations are connected to the presented dimensions in the auxiliary files of the INFO-CALCULUS application two forms)

The formula of the informational energy, for the variable ***X*** and the relative formula for the adjusted informational energy of it. The informational energies of the variable ***X*** alternatives(no/yes) denoted ***X₁*** and ***X₂***.	$E(X)=\sum_{i=1}^{m=2}\frac{X_i}{T}^2 \quad E_a(X)=2\cdot E(X)-1$ $E(X_1)=\sum_{i=1}^{n=2}\frac{x_{i1}}{Y_1}^2 \quad E(X_2)=\sum_{i=1}^{n=2}\frac{x_{i2}}{Y_2}^2$
Cramer' V coefficient for the power of the association between the variables X, as determining-horizontal, and the determined variable Y-vertical, in the **2**^{3} tables	$V=\frac{y_{11}\cdot y_{22}-y_{12}\cdot y_{21}}{\sqrt{T_{1.}\cdot T_{2.}\cdot T_{.1}\cdot T_{.2}}}$
K-coefficient of correlation,for the interaction of two variables: the action of the determining variable X-horizontal position, over the determined variable Y-vertical position in the **2**^{3} tables	$C(Y/X)=\sum_{i=1}^{m=2}\frac{y_{i1}}{T_{.1}}\cdot\frac{y_{i2}}{T_{.2}}$ $K(Y/X)=\frac{C(Y/X)}{((E(X/Y_1)\cdot(E(X/Y_2))^{1/2}}$
The intrinsic importance, on alternatives for The variable X	$R_E(X_1)=E_a(X_1)/S_{Ea} \quad R_E(X_2)=E_a(X_2)/S_{Ea}$ $S_{Ea}=E_a(Y_1)+E_a(Y_2)$

The global adjusted importance, of the variable ***X*** alternatives, and the global importance for the variable, using the pondered average .***W***(***Xi***) are the specific weights of the ***Xi*** alternatives.	$I_a(X_1) = \frac{I_E(X_1)}{I_G} = \frac{W(X_1)\cdot R_E(X_1)}{I_G}$ $I_a(X_2) = \frac{I_E(X_2)}{I_G} = \frac{W(X_2)\cdot R_E(X_2)}{I_G}$ $I_G = \frac{\sum_{j=1}^{m} W(X_j)\cdot R_E(X_j)}{\sum_{j=1}^{m} W(X_j)}$

Conclusions

1) Following the previous considerations, we will state the main conclusions:

A) Even if the study is referring to the endogenous influences of the so called "black-box" decisional system of Kotler, the INFO-CALCULUS application is **portable**.

It can be applied for arbitrary numerical data. In order to prove this, we propose an example, without any connection with the endogenous influences. Let's consider three elements which interact in any possible way: X,Y,Z, and some numerical arbitrary data resulting from a survey(eventually), with arbitrary percentages, and organize these data in a $\mathbf{2^3}$ experiment table.

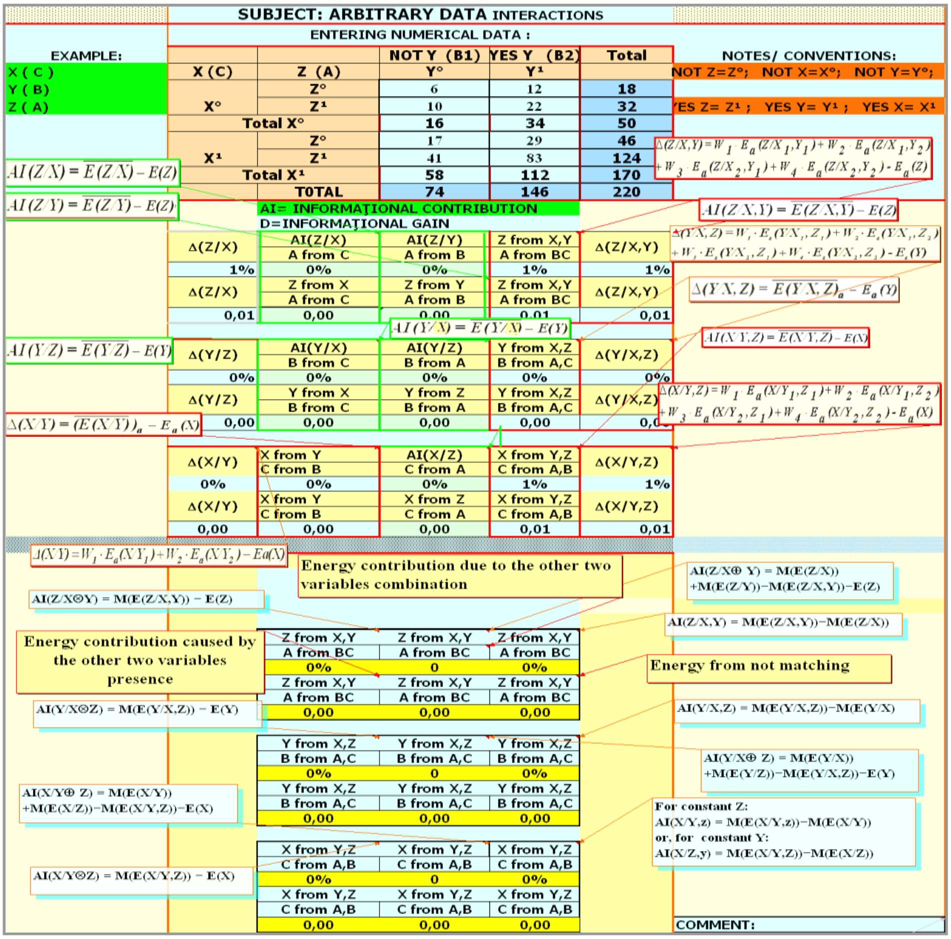
Table 5

X(A)		Z(C)		Y(B)	
				NO	YES
NO	50	NO	18	6	12
		YES	32	10	22
YES	170	NO	46	17	29
		YES	124	41	83

Souce: arbitrary data proposed by the author

Let's use the first form of the application, insert the new arbitrary data, and see the results of their interaction. The application enlightens, in this **arbitrary** case, only a weak informational gain, from ***X*** to ***Z***, from ***X*** and ***Y*** to ***Z***, and from ***Y*** and ***Z*** to ***X***, all the rest being null:(the figure below)

Figure 5



Source: author's research results

2) With aid of this application, it was proved in this paper, that the **human perception** can be improved by **education, knowledge**, together with his own motivation, the last being subjective.

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