Can a Computer Laugh ?

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Abstract

A computer model of "a sense of humour" suggested previously [1, 2], relating the humorous effect with a specific malfunction in information processing, is given in somewhat different exposition. Psychological aspects of humour are elaborated more thoroughly. The mechanism of laughter is formulated on the more general level. Detailed discussion is presented for the higher levels of information processing, which are responsible for a perception of complex samples of humour. Development of a sense of humour in the process of evolution is discussed.

1. Introduction

In recent decades we observe a swift penetration of computers in different areas of human life: computers play chess, compose music, prove theorems and so on. However, there is one area, which is considered as unreachable for computers: it is an area of emotions. Already the thought that a computer can "feel" is often considered as sacrilegeous. Are possibilities of computers really so restricted?

Below we suggest an analysis, which shows the possibility to endow computers by simplest human emotions and in particular a "sense of humour", i. e. ability to react on jokes. The humorous effect is treated as a specific malfunction in the processing of information, conditioned by the necessity of a quick deletion from consciousness of a false version. The suggested model leads to a natural resolution for the problem of the biological function of humour. Indeed, what a purpose was followed by nature, when it has provided us with a sense of humour? The bare fact that there exists a complex biological mechanism which causes specific muscular contractions (laughter) as a reaction to a definite combination of sound or visual images leads us to conclude that the sense of humour originated at early

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stages of the evolution [2] and is not a product of human civilization. It will be shown below, that endowing a biological object by a sense of humour leads to quickening the transmission of processed information into consciousness and to a more effective use of brain resources.

The paper is organized as follows. The psychological analysis of jokes based on Freud's classification [4] leads to a hypothesis on the conditions of arising the humorous effect (Sec. 2). The natural model for the primary processing of information (Sec. 3) shows that the humorous effect, as other simple emotions (Sec. 4), arises already at this level (Sec. 5). Interpretation of more complex samples of humour requires investigation of the higher levels of information processing (Sec. 8 – 10). The old idea by Spencer [5] on relation of laughter with release of nervous energy acquires a clear physical sense, if information on the properties of neural networks [6] is taken into account (Sec. 6). We shall see in Sec. 7 that the model gives natural explanation to well-known facts: different succeptibility of people to humour, absense of humorous effect from a trite joke, nervous laughter, etc. Development of the sense of humour in the process of evolution is discussed in Sec. 11. At last, in Sec. 12 we discuss a question carried out to a title of the paper.

2. Humour from the psychological viewpoint

The technical ways of creating jokes was classified by Freud in the book [4]. Let us give an example to each technical method, in order to obtain the representative selection from enormous number of jokes [3].

1. Condensation:
   (1*)   *Rotshild treated me famillionairely.*

2. The repeated use of the same material:
   (2*)   *Put not your trust in money, but your money in trust.*

3. Ambiguity (a play on words, double entendre, etc):
   (3*)   *During Dreifus's process:*
            "This girl is like Dreifus: army does not believe in her innocence".

4. Pun:
   (4*)   *I have been in Calcutta as well, as this "Calcutta roast".*

5. Displacement (a shift of the accent from one part of the phrase to another):
   (5*)   *The horse tradesman: "If you mount this horse at 4 in the morning*
            then at 7 in the morning you will be at Pittsburg."
            The customer: "But what shall I do in Pittsburg at 7 in the morning?"

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[2] According to Darwin [3], antropoid monkeys possess a clearly distincted sense of humour.

[3] All examples are taken from [4], but given more briefly, if possible. Another classification of technical aspects of wit is suggested in [7].

6. The use of mistakes in the reasoning.

(a) A sense in the nonsense:

(6*)   *Isaak was a bad soldier. The officer annoyed by him advised:*
        "Listen, Isaak, buy your own gun and work separately."

(b) Sophistical mistakes:

(7*)   *Is this a place where Duke of Wellington said his famous words?*
        Yes, it is the same place but he never said such words.

(c) Automatic mistakes:

(8*)   *The marriage agent in the home of bride:*
        — You can judge by these things, how rich are these people.
        — But cannot they borrow these things to produce an impression?
        — Oh, nuts! Who will trust even a thing to these people?

7. Unification (finding the common in the different):

(9*)   *Prince, travelling over his estates, notes a man very much alike*
            his own high person:
        — Did not your mother serve in the manor house?
        — Mother – no, but father – yes.

8. Indirect representation.

(a) Representation by the opposite:

(10*)   *— Can you conjure up the spirits?*
        — Yes, I can. But they never come.

(b) Representation by the exaggeration:

(11*)   *— Does she dye her hairs?*
        — No, they were always such. Since the time she has bought them.

(c) Representation by the similar (a hint):

(12*)   *Prince N. is a complete idealist.*

(d) Representation by the comparison:

(13*)   *A single-sleeping church chair.*

Analysing these examples, one can come to a following hypothesis: the humorous effect is related with interference in the human consciousness of two mutually exclusive images (versions, estimates). The statement of such kind (the so called concept of incogruity) was advanced by the Scotch poet Beattie in l776 [8] and is admitted in some form by most of researches (see e. g. [7, 9, 10, 11]).

The given jokes are constructed according two principal schemes: the "switching scheme" and "ambiguity scheme". For the jokes of the first group, two mutually exclusive versions follow in a definite succession: firstly, one of images arises, and then it is "switched" to

another image. Thus, the words of the tradesman in example (5*) realized as "the characteristic of horse speed" take on the interpretation "giving directions how to reach Pittsburg by 7 in the morning". The officer's advise in example (6*) is looking as "nonsense", but later is realized as "a deep penetration to Isaak's dreams" (e. g. to buy a shop and work separately). In example (7*), the second remark at first gives the impression of being "natural" or "logical" but later is perceived as "absurd". Analogously, a "natural" answer of the agent in example (8*) is realized as "silly" and going apart with his purposes. In example (9*), the prince's version "you are a bastard" is turned to himself. The answer "yes" in example (10*) in fact appears to be "no". In example (11*), a version "her hairs are so good that they need no drying" is switched by version "she has no hairs".

The jokes of the second group, constructed in accordance with the "ambiguity scheme", are characterized by equality of two versions: they exist more or less simultaneously and one cannot establish their correct succession. In example (1*), there is interference between "familiarly" and "millionaire". In example (2*), the word "trust" in the second part of the phrase can be interpreted as "reliable place" (in accordance with its immediate sense) or as "confidence" (in the analogy with the first part). The word "innocence" in example (3*) can be interpreted as "guiltlessness" or "virginity". In example (4*), "Calcutta roast" (the name of the dish) is interfered with "roast from Calcutta". In example (12*), "complete idealist" is resembling "complete idiot", while example (13*) deals with a chair for "sitting" or "sleeping" in the church.

The humorous effect is caused not only by a "wit" discussed above, but also by the "comic", the main characteristic of which is "deviation from the norm". Examples of the comic are exaggerated movements of a clown, grimaces, naive saying of children, accidently said silliness or nonsense, etc. The comic is created by caricature, parody, imitation, disguise, exposure, unmasking, and and so on. The humorous effect from the comic agrees with the formulated hypothesis, if one accept (see e. g. [4]) that there are oscillations between two contrasting notions, the observed comic and realized "norm".

The laughter from tickling can be connected with the attempt of the brain to localize the place of irritation of skin; the result of such localization is invariably rejected because the irritated place is changed unpredictably: that is the reason why the tickling should be done by another person.

3. The primary processing of information

We begin the formulation of the computer model of "a sense of humour" from the consideration of the primary processing of information. Suppose that a succession of symbols A_1, A_2, A_3, ... ("text") is introduced from the outside world to the brain: it can be a succession of words during visual or auditory percepption. In the brain a set of images $\{B_n\}$ is associated with each symbol A_n: for example a set of meanings (a dictionary family) is put in correspondence to each word. The problem of the primary processing of information consists in choosing one image $B_n^{i_n}$ (which is implied in the given context) from the
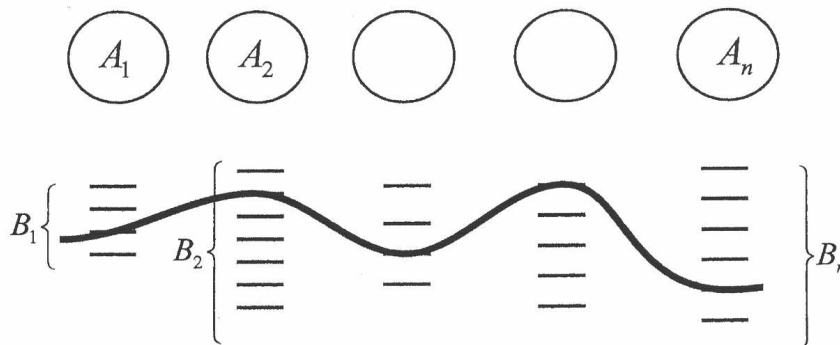
Figure 1: The scheme of information processing: a set of images $\{B_n\}$ is put in correspondence to each symbol A_n and one image $B_n^{i_n}$ should be chosen from the set $\{B_n\}$. The succession $B_1^{i_1}$, $B_2^{i_2}$, $B_3^{i_3}$, ... looks as a "trajectory" in the space of images.

set $\{B_n\}$. The text will be considered as "understood" if the succession $B_1^{i_1}$, $B_2^{i_2}$, $B_3^{i_3}$, ... (which visually can be imagined as the trajectory in the space of images — see Fig. 1) is put in correspondence to the succession A_1, A_2, A_3, ... In principle, the algorithm of the primary processing of information consists in the following:

(1) all possible trajectories in the image space are constructed;

(2) a certain probability is ascribed to each trajectory on the basis of the information on the correlation of images stored in memory;

(3) the most probable trajectory is chosen.

Only step 2 is nontrivial here, i. e. the algorithm of ascribing the probability to a given trajectory. For example, such algorithm can be based on the binary correlations of images; in this case the set p_{ij} should be stored in the memory where p_{ij} is the probability of the event that in a meaningful text image i will be followed by image j; the probability of a trajectory $ijkl\ldots$ is given by the product $p_{ij}p_{jk}p_{kl}\ldots$. The probabilities p_{ij} can be obtained by the statistical treatment in the course of the "learning" process, during which a sufficiently long fragment of the "deciphered" text (i. e. recorded in images but not symbols) is introduced to the brain. A more complex algorithm can take into account the correlation between n images ($n > 2$): then the probabilities $p_{i_1\ldots i_{n-1};i_n}$ of the succession of images $i_1\ldots i_{n-1}$ followed by image i_n should be stored in the memory. It is possible to base the algorithm on binary correlations but with the syntactical connections taken into account [4] and so on. Algorithms of such type are being worked out in the investigations on

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[4] The syntactic structure of a sentence may be represented in the form of "a tree", so that each dependable word is linked with its "host". The probability of a trajectory is represented as a product of binary probabilities according to the structure of a syntactical "tree". The practice of machine translation
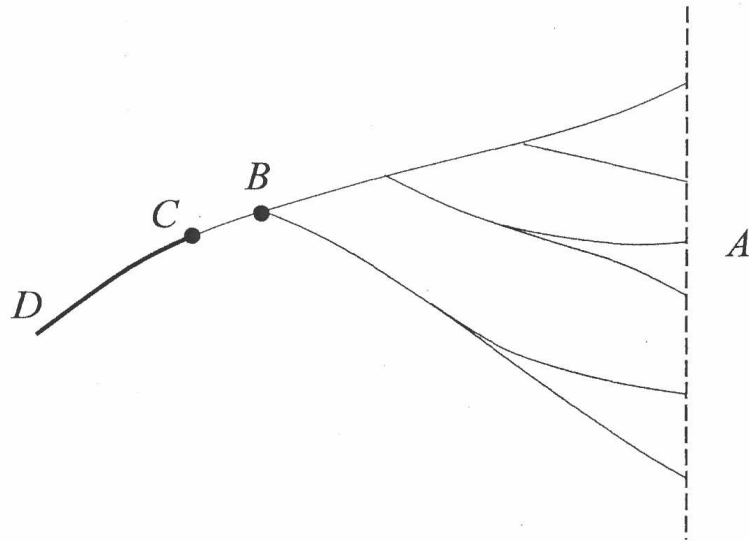
Figure 2: The visual imagination of information processing: thin solid lines are trajectories conserved in operative memory, A is a front, B is the point where the branching is over, CD is a fragment of deciphered trajectory transmitted to consciousness.

machine translation [12, 13, 14]; the concrete form of the algorithm is not essential for the following.

The number of operations demanded for the realization of any algorithm of such kind increases exponentially with the length of the text. So only fragments of the text containing no more than L symbols can be immediately treated by such a method. How can longer texts be processed? The natural possibility is the following: during the processing of the first L symbols not one but several (M) of the most probable trajectories are remembered; then translation on one step is made — the fragment from the second to the $(L+1)$-th symbols is considered — and for each of the M conserved trajectories all possible continuations are constructed; then again M of the most probable trajectories are conserved and so on. It is reasonable to make the number M variable, so at each stage as many trajectories are remembered as the operative memory can hold. In the whole, the process looks as follows (Fig. 2): immediately after the front A the trajectory is branched heavily; at a certain point B the branching is over (the distance between A and B is restricted by the volume of operative memory provided for remembering the trajectories); the deciphered part of the

[12, 13, 14] shows that the syntatic structure in most cases can be established by purely grammatical analysis (word order, adherence to a part of speach, harmonization of the endings, etc.) and can be considered as known for the purposes of the present work.

trajectory DC with some delay AC is transmitted to the consciousness of the man and is realized by him as a thought (while the whole process takes place in the subconscious and is not perceived immediately).

4. The role of emotions in information processing

If numbers L and M are sufficiently large and the algorithm of calculating the probability of N-symbol trajectory is good enough, then the described scheme will operate successfully. However the probabilitistic nature of the algorithm makes mistakes inevitable: so a mechanism is desirable for minimizing their consequences. Such mechanism exists and it consists in communicating to the consciousness some information about the course of the processing in the subconsciousness; the man perceives such information as emotions.

For example, such parameters of the process are essential as the probability p_{max} of the trajectory transmitted to consciousness and the probability p_{comp} of the most probable of the competing trajectories. The high values of p_{max} and p_{max}/p_{comp} signal a successful course of the process and are perceived as positive emotions (pleasure, confidence): the information obtained is considered as reliable. The low values of p_{max} and p_{max}/p_{comp} signal an unsatisfactory course of the process and are realized as negative emotions (annoyance, doubt): the corresponding information should not be taken too seriously. For very low values of p_{max} no versions are transmitted to consciousness (complete incomprehension) and so on.

The possible relationship of emotions with the parameters of the process can be illustrated on the basis of the semi-empiric "emotion formula" proposed by Simonov [10]

$$\mathcal{E} = \mathcal{N}(I - I_0)$$

where $\mathcal{E}$ is the emotion strength (which is objectively measured by the pulse rate, the blood pressure etc.), $\mathcal{N}$ is a strength of some need, I_0 is the quantity of information demanded for the satisfaction of this need, I is the quantity of information the subject has at his disposal (both informations are estimated subjectively). An emotion is positive ($\mathcal{E} > 0$) for $I > I_0$ and negative for $I < I_0$. We can suppose that in the course of processing $\mathcal{N}$ is the need in information and the different parameters of the process determine I and I_0 for different emotions. For example, p_{max} can be used as I for the emotion "pleasure of understanding - annoyance of incomprehension" (accordingly, I_0 is the typical value of p_{max} ensuring the satisfactory course of the process). Analogously, p_{max}/p_{comp} can be used as I if $\mathcal{E}$ is the emotion "confidence – doubt" and so on.

These speculations lead us to conclude that the emotion expressing the humorous effect is also related to some specific situation in the processing of information.
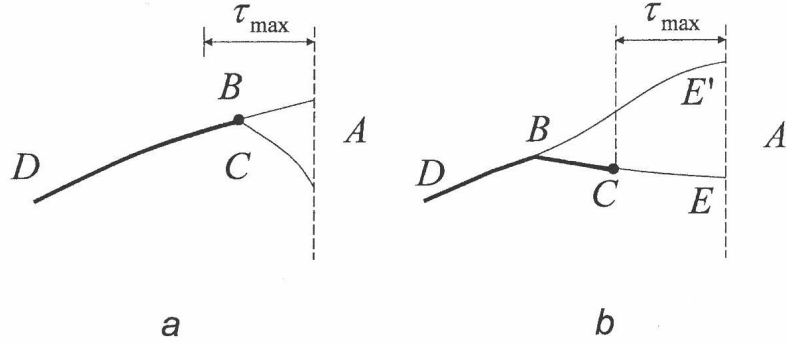
5. The humorous effect

Figure 3: The parameter τ_{max} is the upper bound of the time interval corresponding to delay of point C with respect to front A; (a) $\tau_{AB} < \tau_{max}$, (b) $\tau_{AB} > \tau_{max}$.

Let us discuss the nature of the delay of point C with respect to front A (Fig. 2). At first sight, point C in a reasonably organized system should be always behind point B or coincide with it: it is just the variant we surely choose writing the computer program. But for a human as well as for any biological object such a variant is completely unsatisfactory. The matter is that the delay of point C with respect to front A results in the time interval τ_{AC} during which the information introduced to the brain does not appear in the consciousness (the man sees a bear but he is not aware of this). The prolongation of the interval AC is obviously dangerous while the interval AB can drag out for objective reasons (the man cannot decide what he sees: a bear or a bush shaped like a bear). So the interval AC should have the upper bound τ_{max} on the time scale: if time delay τ_{AB} corresponding to the interval AB is less than τ_{max} then point C coincides with point B (Fig. 3,a); if $\tau_{AB} > \tau_{max}$, then $\tau_{AC} = \tau_{max}$ and point C outruns point B (Fig. 3,b). In the latter case, the most probable version DE is transmitted to the consciousness while competing versions (DE') are conserved in the operative memory (Fig. 3,b) — their deletion is unreasonable because the brain has resources to continue the analysis. If in the course of the subsequent movement of front A the trajectory DE continues to have the maximum probability, then the competing trajectory DE' will be deleted and the time will be saved as a result. If in the course of the movement of front A the probability of DE falls below the probability of DE', then the brain will have a possibility to correct the mistake. In this case, however, the specific malfunction occurs: the fragment BC transmitted to consciousness should be immediately deleted and replaced by the fragment of trajectory BE'. Psychologically this malfunction is perceived as interference of two incompatible versions: version BC fixed by the long-term memory and the newly appeared version BE'. The described specific malfunction can be identified with "a humorous effect".

Indeed, the situation described is exactly reproduced in the course of the interpretation of jocular expressions. For example, in the joke

(14*)   *"My Uncle William has a new cedar chest."*
            "So! Last time I saw him he just had a wooden leg."

two incompatible versions arise in the subconsciousness during the analysis of the first remark: in the first of them (DE) the word "chest" is treated as "box" while in the second (DE') it is treated as "breast". In the context of the given sentence version DE ("box") is more probable and is transmitted to consciousness. The appearance of the word "leg" in the second remark makes version DE less probable and increases the probability of version DE' ("breast"): this gives rise to a humorous effect.

It is essential to emphasize that the existence of a humorous effect is not to any degree unavoidable: nature had a possibility to avoid it in one of the two manners: (1) by delaying the transmission of trajectory DE to consciousness till trajectory DE' is naturally discarded, or (2) by quickening the transmission of DE by deleting DE' simultaneously. However, in the first case the time the information reaches consciousness is delayed and in the second case the brain resources are not completely used: so nature resolves this problem at the cost of psychological confusion.

In the process of evolution the optimal value of τ_{max} is achieved which ensures the compromise between the reliability of information and the speed of its obtaining (people with long τ_{max} will be eaten by a bear, while people with short τ_{max} will confuse every bush with a bear and will be incapable of getting food). For the optimal value of τ_{max} the inequality $\tau_{AB} < \tau_{max}$ is satisfied as a rule, and a humorous effect is rare enough in the natural conditions; but it can be easily produced by specially constructed witticisms and comics.

6. The mechanism of laughter

According to Hopfield model [6], a neural network can be described (in a reasonable approximation) as a system of interacting spins. Two states of a neuron ("excited" and "rest") can be corresponded with two states of a spin ("spin up" and "spin down"); describing these states by Ising variables $\sigma_i = \pm 1$ (spins or neurons are numbering by index i), one can introduce an energy E of the spin system:

$$E = \sum_{ij} J_{ij}\sigma_i\sigma_j$$

where J_{ij} are exchange integrals (for the spin system), or the links between neurons (for a neural network). It is possible to introduce also the "temperature" T, "magnetic field" H, and a rate of dissipation γ (γ^{-1} is a characteristic time of relaxation to a stable state) [5].

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[5] For a neural network, T is determined by the noise level in it, H can be created by a special group of neurons ("magnet"), while γ^{-1} is a relaxation time to one of "written images" (the latter can be identified with stable states in the corresponded "spin glass").

According to Sec. 2, the humorous effect arises in a situation, when some information should be quickly deleted from the consciousness. On the physical language it corresponds to necessity of quick "nullification" of some portion of neural network: all neurons, which become excited in the course of writing certain information, should be transfered to the rest state. Such "nullification" can be carried out by switching a strong magnetic field, which makes a state "spin up" energetically unfavorable: so after a time $\sim \gamma^{-1}$ all spins will come into the state "spin down". It is possible to delete information for a time lesser than γ^{-1}, if (in the presence of the magnetic field) one connect a nullified region with a "reservoir", i.e. large portion of neural network in the rest state. Then an access of neuron energy is throwing out to reservoir. The role of reservoir can be played by portions of neural network, unrelated with a function of thinking (in order not to arise parasitic thoughts), i.e. motor cortex. In this case, deleting of wrong version from consciousness arises contraction of certain muscles, i.e. laughter.

It is easy to notice the similarity with old idea by Spencer [5] that the humorous effect is caused by a release of nervous energy which is transformed into muscular contractions. This idea was suppported by Darwin [3] and Freud [4] but was criticized by subsequent investigators [16] on the grounds that the concept of "nervous energy" was difficult to define. In fact, it is possible to define the "energy" for neural networks only under condition $J_{ij} = J_{ji}$, which is not very realistic for actual neurons; so the concept of "nervous energy" should not be taken too seriously. Nevertheless, the qualitative picture following from the Hopfield model looks rather reasonable, and appears in good correspondence with Spencer's hypothesis: it looks as if the excitation energy of neurons is thrown out into the motor system.

The release of the nervous energy in the humorous situation was argued by Spencer on the basis of the concept of decreasing incongruity — the transition from the high style (state with rich associations) to the low style (state with poor associations). Such treatment of humorous effect is clearly restricted and cannot claim universality. In our scheme "the release of nervous energy" (in the conditional sense discussed above) is connected with the necessity of deleting the false version from consciousness.

Since laughter is treated as an unconditioned reflex to the humorous effect, then an explanation should be given to the well-known exclusions, when laughter is forced out by secondary emotions. For example, laughter can be forced out by indignation (an indecent anecdote was told to a puritan), fear (a bush suddenly appeared to be a bear), pity (a man in front of you has slipped on a melon skin and hurt himself seriously), shame (you have slipped on a melon skin) etc. Spencer's hypothesis accounts for these cases, if we suppose that "released nervous energy" is transmitted not to motor cortex but to other regions of the nervous system (the limbic system) where it is used to excite secondary emotions. The fact, that a joke produces a maximum effect if it is expressed extremely laconically, has an analogous explanation [4]: the laconism reduces the possibility of side associations that can absorb the "nervous energy".

A man can regulate the level of muscular reaction by transmitting the excitation of neurons to different regions of the motor cortex: this can explain the dependence of laughter

on the mood, the psychological motivation, the existence of laughing environment and so on [17].

7. Some consequences

The model described accounts for a number of well-known facts.

Absense of a humorous effect from a hackneyed joke is a consequence of the fact that a man knows of the existence of two incompatible versions beforehand and avoids the transmission of the clearly false version to consciousness (for example, knowing that in joke (14*) the "chest" turns out to be a "breast" he is not tempted to interpret it as "box").

The role of intonation in telling jokes is connected mainly with timing (tempo, arrangement and duration of pauses, etc), which can be taken into account by incorporating an appropriate number of "gaps" in succession A_n. The quick pace of telling does not give time for the false version to be transmitted to consciousness and interval BC (Fig. 3) turns out small or absent. The slow pace of telling increases the lengths of trajectories due to "gaps" and the competing trajectory BE' (Fig. 3) is deleted from the operative memory; so the swithing of versions becomes impossible.

Different susceptibility of people to humour[6] is connected (in case of the equal intellectual level) with the differences in the delay τ_{max}. People with large τ_{max} seldom laugh because point C seldom outruns point B. Conversely, people with small τ_{max} are aware of a humorous effect even in cases that most people do not see as funny. Supposedly, τ_{max} is diminished by alcohol and this is a cause of the unmotivated gaiety. At fixed τ_{max} the susceptibility to humour correlates with the volume of the operative memory, which determines the average length of the interval AB (Fig. 2).

Nervous laughter. If a variety of unpleasant impressions rushes at a man and there is danger of the overstrain of the nervous system then the organism forcibly deletes the unpleasant information and replaces it by neutral: this gives rise to the reflectory laughter.

8. The higher levels of the information processing

In principle, the proposed scheme explains all types of humour considered above if we do not specify the nature of the symbols A_n. However, if practical modelling of the sense of humour is intended, then it is convenient to consider symbols A_n as usual words. In this case the preceeding consideration gives us an explanation only for jokes based on the

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[6] We have in mind the principal susceptibility to humour without regard to the cases when individual peculiarities give rise to inadequate reaction to a concrete joke. The examples are failure to understand a joke due to the absence in memory of a necessary image, peculiar view of the "norm" while perceiving the comic, the forcing out of laughter by side emotions (Sec. 6) and so on.
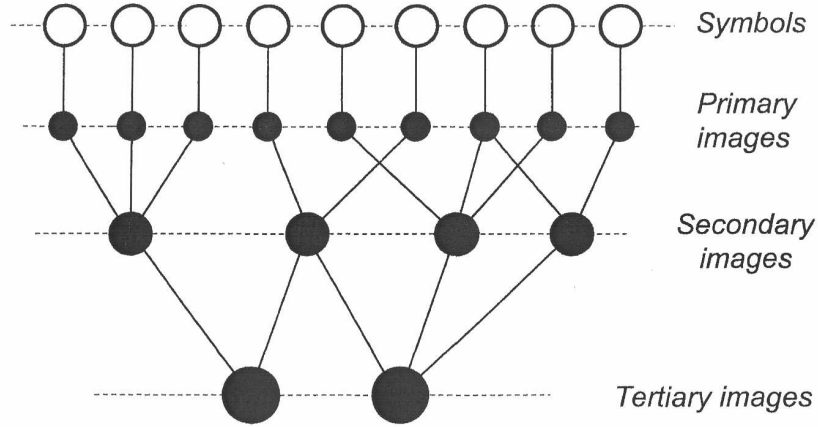
Figure 4: Higher levels of information processing.

switching of meanings of a separate word (example 14*). In order to explain more complex types of jokes it is necessary to consider the higher levels of the information processing.

At the first level of processing the succession of primary images is put in correspondence to a succession of symbols A_n. Suppose that besides the first level a second level exists where the succession of larger (secondary) images is put in correspondence to the succession of primary images. On the third level even larger (tertiary) images are constructed and so on (Fig. 4). The obtained images are transmitted to consciousness in such a way that images of each level go to a special channel. The whole information is perceived on several levels simultaneously ("stereoscopically"). The principal algorithm of transition from level k to level $(k + 1)$ consists in the following. Each image stored in memory (e. g. "cow") is associatively connected with the smaller images ("horns", "hoofs") as well as the larger ("herd") and the more abstract ("animal") images. Suppose A_n is a primary image and the set $\{B_n\}$ of images associated with A_n contains only larger or more abstract images than A_n. Then the problem of constructing the secondary version consists in choosing the appropriate image $B_n^{i_n}$ and is analogous to the problem of the primary processing[7]. If in a primary succession A_n several images are contained (e. g. "horns", "hoofs", "tail"), which are parts of a larger image ("cow") then the latter will be contained in each of the corresponding sets $\{B_n\}$ (Fig. 5); the most connected version will contain repetition of this image; after excluding repetition the latter takes its place in the secondary succession

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[7] The secondary version does not necessarily differ from the primary one by enlarging all images without exception; so in real algorithm it is reasonable to include all images associated with A_n into the set $\{B_n\}$ but at the same time to introduce the weighting function which would increase the probability of versions with larger images.
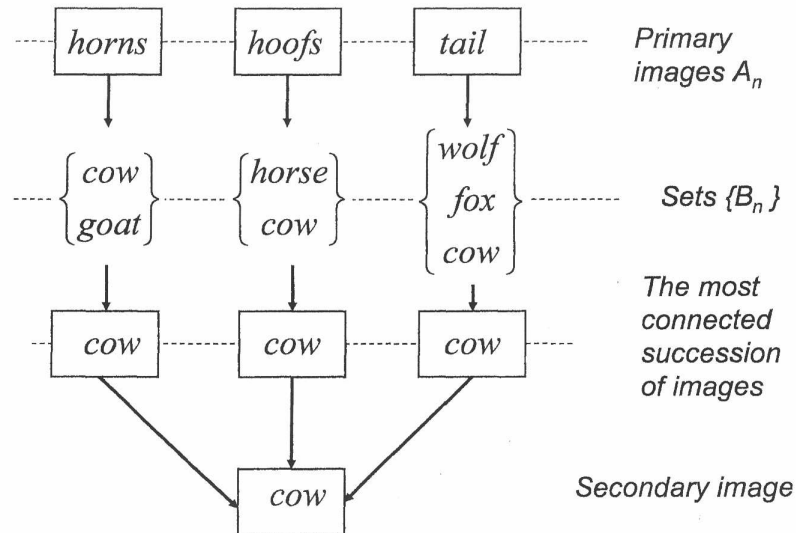
Figure 5: The scheme of enlarging the images.

(Fig. 5).

Evidently, the specific malfunction described above can take place in the process of developing the higher level versions, even if the primary succession is determined uniquely: this explains jokes with commutation of complex images (examples 5*, 6*, 7*, 8*, 9*, 11*). The examples 6*, 7*, 8* shows that emotional estimates constructed according to the described above scheme can become one of the high level images.

9. The ambiguity scheme

Suppose that two versions 1 and 2 exist on the primary level; on the second level the single version $1'$ corresponds to 1 and the single version $2'$ corresponds to 2 (Fig. 6). Consider the case when version 1 is more probable than 2 and version $2'$ is more probable than $1'$. Then "logically" it is impossible to give preference to one of the two possibilities $1 + 1'$ or $2 + 2'$: each of them is "correct" in a certain sense. Such situation takes place in the process of the perception of jokes constructed according to "the ambiguity scheme".

Indeed, on the primary level the connection between the images nearest in succession is established (close context) while on the high levels the connection between remote images is established (remote context). It is easy to see that in all examples of Sec. 2, corresponding to the ambiguity scheme, one of the versions is more probable in close context, another — in remote context:
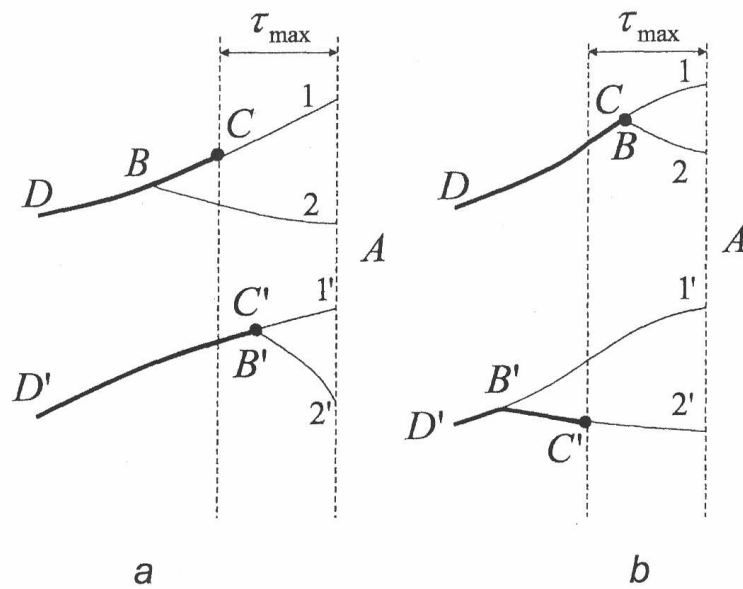
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Figure 6: The situation corresponding to "the ambiguity scheme": the order in which the trajectories are transmitted into consciousness depends on the mutual arrangement of points B and B'.

Example	Close context (or a separate word)	Remote context
1*	treated *familiarly*	Rotshild $-$ *millionaire*
2*	put in *reliable place*	*confidence* (by the analogy) ,
3*	her *virginity*	*guiltlessness* of Dreifus
4*	"*Calcutta roast*"	*roast from Calcutta*
12*	*idealist*	complete *idiot*
13*	chair (for *sitting*)	chair (for *sleeping*)

So the first version corresponds to the variant $1 + 1'$ while the second — to the variant $2 + 2'$.

The uncertainty in the order of the appearance of the two versions is connected with the unevenness of information processing in different channels, namely the mutual arrangement of points B and B' with respect to front A (Fig. 6). If point B goes behind point B' then version 1 is transmitted to the consciousness first (Fig. 6,a); it takes place up to the moment when delay $\tau_{AB'}$ becomes equil to τ_{max} — then version $2'$ is transmtted to consciousness while version 1 as incompatible with $2'$ is deleted and replaced by 2. If point B outruns point B' then version $2'$ is transmitted to consciousness first (Fig. 6,b); when τ_{AB} becomes equil to τ_{max} then the transmission of version 1 begins, while version $2'$ is replaced by 2. Formally, the considered situation is reduced to "the switching scheme" but its psychologycal perception will be different. Indeed, the relative order of following for points B and B' depends on the rates of processing in two channels, which is determined by occasional reasons and can change for the repeated reading of the text. The attempt to fix the order, in which two versions arise, does not lead to a definite result and this order appears to be elusive.

10. Perception of the comic.

A definition of the comic as "deviation from the norm" (Sec. 2) may arouse doubt, since not any deviation from the norm looks funny. However, one should have in mind two circumstances. Firstly, the comic often give rather small humorous effect, which can be easily forced out by side emotions (see Sec. 6). Since some background level of forcing out surely exists, so the comic looks funny when a deviation from the norm exceeds a certain critical level. Secondly, the habitual, oft-repeated deviations do not produce the humorous effect by the same reason as hackneyed jokes (Sec. 7). Theoretically, any deviation from the norm is comical, but practically it should be sufficiently strong and unusual, in order to look funny.

The humorous effect from the comic arises by the same mechanism, as for jokes based on the switching scheme (Sec. 5, 8). In spite to deviation from the norm, the comic still

conserves sufficient likelihood with the norm; so, at one of the higher levels of information processing repeated switching of images "the norm" — "not the norm" occurs.

11. Development of a sense of humour in the process of evolution

Evolution of a sense of humour can be imagined in a following manner. At the first stage of evolution a sense of humour is surely absent, since the algorithm of the information processing should be sufficiently complicated for its existence: e. g. the condition $M > 1$ is necessary for the model of Sec. 3. When the algorithm becomes sufficiently complex and the specific malfuction described in Sec. 5 becomes possible, the second stage of evolution begins: a sense of humour exists, but laughter (as a specific muscular reaction) is still absent. The latter is related with the fact that the main part of the neural network rules the muscle performance and digestion, while thinking occurs in small "islands" of intellect: dumping of nervous energy to the motor cortex occurs in occasional manner, and amount of this energy is rather small. Thus, at this stage the humorous effect is accompanied with only small muscular contractions and is not noticed in the population. The growth of amount of the intellectual activity results in the growth of the released nervous energy, so muscular contractions becomes noticeable: a necessity arises to arrange the discharge of energy, in order to exclude movement of limbs and prevent the animal from falling. As a result, the released nervous energy is transmitted into specific muscular centers and laughter arises as a characteristic muscular reaction to the humorous effect. The third step of evolution starts, when the humour is recognized in the population and begins to play a social role.

Some of psychologists, and in particular Freud [4], consider the pleasure obtained from laughter as the main cause of the existence of a sense of humour: a man discovers the possibility of extracting pleasure from the psychical process and begins subconsciously and then consciously to exploit it. Our viewpoint is the opposite: a sense of humour is biologically conditioned by the necessity to quicken the transmission of information to consciousness and of a more effective use of brain resources: so the pleasure obtained from laughter is not an essential factor (similarly, the two reflexes — sneezing and coughing — exist regardless of the pleasure afforded by the first and the displeasure caused by the second, because they are dictated by the biological necessity of cleaning out the respiratory system). Of course, if laughter afforded displeasure the social function of humour would change: the society would try to get rid of it by censorship, prosecution of witty people and so on.

12. Indeed, can a computer laugh?

In the previous sections, we have demonstrated the principal possibility to endow a computer by a sense of humour. But is it really possible to create a computer program

which will "laugh" in the same cases as a man? From our viewpoint, it is quite possible if we restrict ourselves to a primary level of information processing, i. e. to the simplest types of jokes based on switching of meanings of individual words (example 14*). The corresponding program will have approximately the same level of comlexity, as the average program for machine translation [12, 13, 14] and its creation is possible as a result of work of the whole group of researches during several years. However, it should be noted that such activity is a natural next step in the machine translation researches: in the case of ambiguity, the existing programs suggest several variants for a choice of consumer, while the proper treatment of ambiguity is crucial for registration of the humorous effect. Development of "a computer with humour" should be naturally based on existing programs for machine translation.

As for teaching a computer to react on the more complex samples of humour related with the higher levels of information processing, it looks incredible at the present time. In order to do it, one should reveal a complete set of images the average human brain contains and to establish the correct associative links between these images. This would require many years of work of psychologists and programmers.

References

[1] I.M.Suslov, Biofizika SSSR **37**, 318 (1992) [Biophysics **37**, 242 (1992)]; arXiv:0711.2058.

[2] I.M.Suslov, Biofizika SSSR **37**, 325 (1992) [Biophysics **37**, 249 (1992)]; arXiv:0711.2061.

[3] Darwin, C. The expressions of emotions in man and animals (Murray, London, 1872).

[4] Freud, S. Jokes and their relation to the unconscious (Norton, New York, 1960).

[5] Spencer, H. The physiology of laughter. McMillan's Magazine, **1**, 395–402 (1860).

[6] Hopfield, J.J. Proc. Nat. Acad. Sci. USA, **79**, 2554–2558 (1982) .

[7] Luk, A.N. A sense of humour and wit (Iskusstvo, Moscow, 1968).

[8] Beattie, J. Essays (William Creech, Edinburg, 1776).

[9] Nash, W. The language of humour (Longman, New York, 1985).

[10] Paulos, J.A. Mathematics ana Humor (Univ. of Chicago Press, Chicago, 1980).

[11] McGhee, P.E. and Goldstein, J.H. (eds). Handbook of Humor Research (Springer, New York etc., 1983).

[12] Hays, D.G. Research procedures in machine translation (RAND Corp., Santa Monica, 1961).

[13] Lawson, V. (ed.) Practical experience of machine transslation (North-Holland, 1982).

[14] Hutchins, W.J. In Maxwell, D., Shubert, K., Witkam, A.P. (eds) New directions in machine translation (Foris publ., Budapest, 1988).

[15] Simonov, P.V. Emotional brain (Nauka, Moscow, 1981).

[16] Berlyne, D.E. In Goldstein, J.H., McGhee, P.E (eds) Psychology of Humor (Acad. Press, New York, 1972).

[17] Levental, H. Journ. of Communication, **26**, 190–204 (1976).