

An Internet System of Partner-Learning Special Type

Oleg P. Skljarov

Research Institute of Ear, Throat, Nose & Speech

198013, St.Petersburg, Bronnitskaja, 9, Russia, fax:7-(812)-316-79-11;e-mail:skljarov@admiral.ru

and

Alexander N. Porosin

Northwest branch of International University

e-mail: anp@narod.ru

ABSTRACT

Internet system of "partner" type principles are offered. Model of "trainee" and "learning" in this system is Feigenbaum scenario of route to chaos for dynamical regimes of trainee's speech rhythm as result of both learning (education) and/or an external feed-back of various type. In our paper dynamics of speech rate and rhythm are traced during its self-correction by trainee in accordance with various methods exposed in our Internet system. The system estimates the efficacy of various strategy of self-correction in dependence of deviation of trainee's rate and rhythm from norm. This system allows to implement process of stuttering self-correction. Dynamics of rate and rhythm traced in speech during correction of a stuttering is submitted in this paper. The various strategy of correction of a stuttering in dependence of behavior of rate and rhythm are detected. This trajectory has conforming to a modification of rate and a rhythm during correction. Two basic strategy are a method of "pulled speech" and the method "tunnel passage". Combination of these strategy has allowed to increase efficacy of correction of a stuttering. The outcomes are interpreted in the terms response-contingent feed-back reacting in Hopfield network. Both strategy take the explanation within the framework of the theory of control of dynamic regimes of a rhythm within Feigenbaum scenario of route to chaos.

Keywords: Speech, Rate, Rhythm, Stuttering, Correction, Feedback, Feigenbaum Scenario, Internet.

1. INTRODUCTION

As a result of perennial relative examination of temporal structure of the normal and stuttering carried out in St.-Petersburg Research Institute of ear, throat, nose and speech it was established that duration pattern of V/U-segments (V/U-rhythm) obtained by a principle: "there is a voice - there is no voice" (principle "Voice/Unvoice") adequately characterizes this structure and allows to judge a degree of a deflection of stuttering speech from norm temporal pattern. The mean duration of V-segments

T we have determined as V-rate, and the coefficient of variation std of these duration - V-arrhythmia [2].

The segmentation was executed with the help of the self-acting computer program. On the input of this program there was a speech acoustical signal, and on the output - point on a plane with coordinates $\{T, std\}$. Recording a speech signal in accordance with a course of correction, it is possible to trace a dynamic trajectory of rate and arrhythmia of concrete stutterer.

The analysis of temporal characteristics of speech has shown that the points $\{T, std\}$ corresponding to the patients with normal speech, form compact range with coordinates in limits: $0.80 \pm 0.10 < std < 0.90 \pm 0.10$ and 150 ± 25 milliseconds $< T < 250 \pm 25$ milliseconds. The tool errors were calculated in paper [3]. The points corresponding to stutterers occupy extensive range at values $std > 1.0$ and in all diapason of change T (in limits from 600-700 milliseconds (for the persons with prolonged speech; skills of this speech frequently are inoculated to stutterers with the purpose of a primary reduction of speech disfluencies) down to 50 milliseconds (in a case of the explicitly expressed tachylalia). The cases of complete temporal disorganization of speech (prolonging convulsive pauses, sometimes, in especially severe cases - complete speech stupor) are featured by parameter std about 1.7-3.0. In accordance with decrease of this parameter the degree of manifestation of a stuttering is reduced.

From the analytical point of view the value of a coefficient of variation std testifies to as far as the deviations in duration of segments (in root-mean-square sense) are declined from mean duration. At so-called «lacerated», arrhythmic speech there are or very short and/or very long «voice» segments typical for «cluttering» pronouncing and/or convulsive segments for «real stuttering» pronouncing of vowels or voice consonants or, for example, very long «unvoice» segments typical, for example, for "pulled, real stuttering form» of pronouncing of a whistling sound «c», or, for example, for big intervals of pure silence, connecting, as

a rule, with hypotaxia of respiration and articulation at the patient. All enumerated features are characteristic for severe forms of a stuttering. These defects of speech fluency specify the speech is accepted as speech with extremely large arrhythmia.

2. METHODS

With the help of the program of segmentation was established that at use of traditional procedure of correction of a stuttering when the skill of "pulled" speech is inoculated to stuttering subject, with the purpose of a reduction speech disfluencies, the often cases of "reversion" take place. We perceive this term the following circumstance: to middle of a course of correction the patient practically has not disfluencies (coefficient std is low), but the rate very much time-lapses (T is great). At attempt to return the patient to normal rate frequently there is a return of a trajectory of a point $\{T, std\}$ in stuttering range of plane (T, std) (see Table 1).

Thus results of clinical practice show that the logopedic studies on the basis of "pulled speech" method spent with the adults not always lead these characteristics in norm, and only reduce disfluencies. Rather frequently at attempts to normalize rate of speech negative dynamics or "reversion" of an arrhythmia is observed.

Therefore one of most serious problems facing to the logopedist is the choice of such procedure of correction which reduces a level of disfluencies at rate reference for normal speech.

* The digits 1, 2, 3 in the column "Statistician" correspond(meet) to the beginning, middle and ending of a course of correction accordingly.

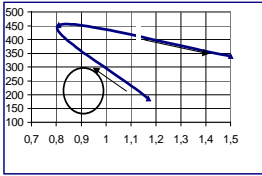
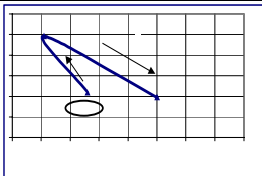
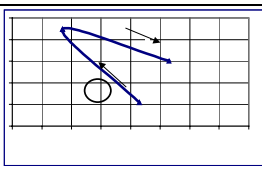
Therefore in offered procedure of logopedic correction of stuttering the following method was stipulated: determination of individual singularities of temporal features of patient's speech, their deflection from norm, and also their dynamics during correction and adduction them up to parameters in accordance with norm.

Really as has shown our study the speech behavior of stutterers can be implemented on any other case in different conditions in dependence on external action. That is the dynamic pattern of possible regimes is mobile and depends on generalized parameter of learning, in other words, from operations of the logopedist.

Methods of response-contingent stimulation, biological, acoustic etc. aspects of a feed-back are proved trusty enough in practice of correctional procedures at elimination of a stuttering [5]. However in a feedback circuit offered us the incorporation of all complex logopedic and psycho-correction actions on a stutterer is possible in dependence on present-day dynamics of temporal characteristics of corrected speech. The efficacy of such action on a dynamic regime of speech production is grounded on fundamental regularities of functioning of a central nervous system and, in particular, of such complex systems as the sensomotor mechanism of perception and production of speech [3].

As examination of mathematical model of complex speech production system has shown that typical case of such dynamic behavior is the existence of the whole panel of possible dynamic regimes, from static regimes (conforming to convulsive disfluencies in case of speech) and rhythms - oscillations (these rhythms are associated by us with disfluencies of the clonic form) up to states with an irregular, chaotic rhythm (this rhythm associated by us with temporal organization of normal speech). The Hopfield's neuron net can serve as model of such behavior [6]. Within the framework of this model it is possible to establish that the external action reduces in change of one dynamic regime on another. These circumstances create scientific - theoretical fundament for organization of a feed-back (learning). This learning must be optimum for reduction of speech of everyone concrete stutterer closer to norm as it is possible (see figure 1). In this case program of segmentation by a principle "Voice/Unvoice" reflecting intrinsic dynamics of speech production neuron ensemble at the presence of external action realizing by the logopedist, plays a role of some kind feed-backs in a system "logopedist-stutterer" [1].

Table 1.

	Reading (trajectory) axes $x-std$, $y-T(msec)$ circle - norm	Statistician			
M			1	2	3
		std	1,2	0,8	1,5
		T	186	452	340
T			1	2	3
		std	1,2	0,8	1,0
		T	294	591	318
S			1	2	3
		std	1,1	0,9	1,2
		T	210	548	402

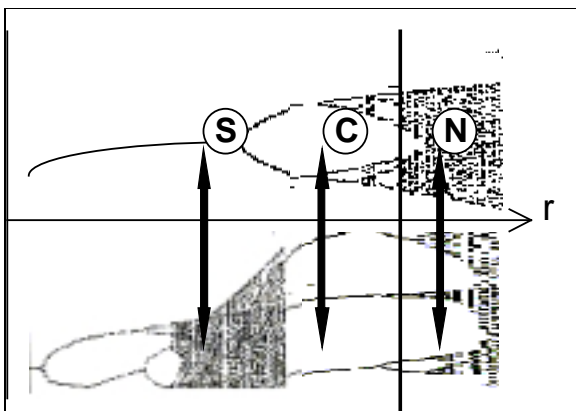


Figure 1. Scenario of route to chaos in a neuron net in a case without a feed-back (Hopfield net - above) and with a global feed-back (McClelland and Rumelhart's net - below). The other explanations are given in the text. "S" in circle indexes zone of real stuttering rhythm, "C" – cluttering rhythm (clonic form of stuttering) and "N" – rhythm of normal fluent speech. The arrows designate passage from zones of Feigenbaum scenario in conjugate zones of that same scenario displaced concerning themselves under action of a feed-back.

Due to this unit of a feed-back chain we during perennial examination detected a possibility of adequate action on temporal speech characteristics of stutterer with the purpose to bring them as it is possible closer to norm. It was achieved at the expense of differentiated selection optimum logo- and psycho- correction complex of actions to everyone stutterer in dependence on his individual speech changes.

The group of inspected subjects is formed by 60 men (minus the persons, whose temporal characteristics were practically in norm) so it is possible to consider that the presence of a generalized feed-back in a system "logopedist - stutterer" (under this term we mean present in view the constructive count by the logopedist of changes of temporal characteristics traced during a course of correction) gives a parameter of efficacy at a level 62 %. The efficacy of traditional methods compounds 38 % [3] and thus, it is possible to state that the constructive count of changes of temporal characteristics leads to arising of efficacy of correctional measures a minimum on 24 %. That is well correlated with the data on efficacy of the count of changes of rate and rhythm cited in [3].

3. DISCUSSION

The analysis of results of evolution of temporal structure of sequence of V/U-segments' duration or, differently, of rhythm at various stages of logo- correction process executed with the persons suffering by chronic stuttering has shown a heterogeneity of correction process needed for reaching of norm.

As it has appeared there were following three subgroups: For the first subgroup characteristic feature is gradual ("step by step") modification of rate and rhythm of speech. Another feature is dropping down to a level of normal values of std ($std < 1.0$) and rate T ($150 < T <$

300 milliseconds). In this subgroup 37 men have been included, that is 53 % from common number of the participants of experiment.

The second subgroup has found inappreciable deflections of temporal speech characteristics from range of normal values and these parameters a little bit varied during correctional work, not going out from a close neighborhood of the indicated range. 26 men have come in this subgroup, that is 30 %.

The third subgroup has found sharp deterioration of speech rhythm (parameter std increased sharply) at practically normal rate in middle of a course of correction. This subgroup has found considerable enriching of this rhythm parameter frequently reaching range of normal values at the end of a course of correction. 22 men have come in this subgroup, that is 26,5 %.

At realization of relative analysis of temporal speech characteristics of stutterers during experiment we have found that high enough percent (26,5 %) of the persons is, at which "strange" tempo- rhythmic behavior is observed - instead of enriching of temporal speech characteristics step by step they in middle of a course sharply worsen a rhythmicity of the speech, and at the end of a course reduce the indicated characteristics in norm. It has forced us to reflect on sense of descending modifications. Early, within the framework of traditional procedure with use of delayed speech, in middle of a course we scored sharp enriching of a rhythm, and at the end of a course - deterioration frequently exceeding primary disorder. This effect we have termed as "a reversion of an arrhythmia".

Such observations have leaded us in abandoning of total application of procedure of delayed speech at correction of a stuttering. And, apparently, paradoxical modification of behavior 26, 5 % of stutterers at the first stage of correction has reduced in outcome in augmentation of efficacy of rehabilitational measures at 24 %. On parameters of rate and arrhythmia of speech the given subgroup has exceeded in range of normal values at the end of a course of correction and is stable retained these characteristics after an extract from a hospital (cases of a remission registered by us last from 1 month till 1,5 years).

4. INTERPRETATION

As we already have specified in the beginning of paper, the Hopfield's net is neuron analog of dynamics in accordance with which trajectory of point with coordinates $\{T, std\}$ obtained with the help of the program of segmentation due to a principle "Voice/Unvoice" evaluated [2]. In this neuron net "modification of total synaptic weight" (analog of segments' duration [3]) can have the Feigenbaum diagram of states in dependence on parameter of learning r (see figure 1).

This diagram spills light on a phenomenon of "reversion" of stutterers with "pulled" speech, namely, having achieved zone of chaos on the upper branch (see upper of a drawing, left-hand zone of bifurcation) at a modification of control parameter (i.e. having achieved zone of fluent speech [3, 4]), system have was present some short time in a borderline field between zone of bifurcation and zone of chaos. Then this system submitted to itself will be rolled by virtue of irreversibility of dynamics(changes) again on the left in range of disfluencies or in bifurcation's zone (see fig. 1, above).

The abandoning of total use of procedure of pulled speech has forced us to apply a so-called method " of tunnel effect ", when in middle of a course the temporal characteristics like would be worsened in comparison with initial characteristics (the system fall in unfavorable zone to the right of chaos, there is as though "a tunnel passage " through zone of chaos).

To interpret it it is possible so. As a result of a feed-back in a system "logopedist - stutterer" speech production dynamics fall from zone of Feigenbaum's bifurcation of doubling of period in even more composite range of Hopf's bifurcation on the displaced diagram (see central arrow in a fig 1). But by virtue of irreversibility the system being returned to its in a static regime (extreme left-hand states on the diagram) fall in extensive zone of chaos inherent to fluent normal speech. Due to this extensiveness, in contrary of being in a borderline field at a method of "pulled" speech, duration of a remission also is increased. Duration of remission has amounting some weeks or even some days earlier, at a method of "pulled" speech. At a new method with conservation of natural rate of speech this duration has amounting at least, 12-18 months. Use of this procedure of "tunnel effect", as we already have told above, has allowed to increase efficacy of logo- and psycho- correction approximately by 24 %.

5. CONCLUSION

The results of our study carried out by us can be formulated as the following basic outcomes:

It is established that for tempo- rhythmical characteristics of speech of the adults stutterers the deflections from norm are peculiar. These characteristic can be detected at objective tool registration of temporal structure of speech.

The data on singularities of these characteristics of stutterers' speech have allowed to spot meaning of these singularities in correctional work.

As these temporal speech characteristics are connected to functioning of different components of speech, the work above these characteristics allows to activate and to rank all components of speech, and, hence, speech as a whole during correction of stuttering.

The information about singularities of a modification of temporal speech characteristics enable to modify procedure of overcoming of a stuttering at the adults

stutterers in dependence on individual singularities of their speech. These experiments proved our theory of control of dynamic regimes of the rhythm within Feigenbaum scenario of route to chaos.

Internet system of "partner" type principles an are offered. Model of "trainee" and "learning" in this system is Feigenbaum scenario of route to chaos for dynamical regimes of trainee's speech rhythm as result of both learning (education) and/or an external feed-back of various type. In our paper dynamics of speech rate and rhythm are traced during its self-correction by trainee in accordance with various methods exposed in our Internet system. The system estimates the efficacy of various strategy of self-correction in dependence of deviation of trainee's rate and rhythm from norm. This system allows to implement process of stuttering self-correction.

6. REFERENCES

- [1]. I.A. Povarova, O.P. Skljarov, T.N. Skljarova, "A Computer Feed-Back in a System "Logopedist - stutterer" on the Basis of Neuron Model of a Speech Rhythm," In Proc. of 8-th Int. Conference "Mathematicians, Computer, Education", Puschino, Institute of Biophysics, 2001, pp. 155-156 (in Russian).
- [2] O.P. Skljarov, "The Program of Segmentation of a Speech Signal as an Objective Resort of Scheduling of Correctional Measures at a Stuttering", News of Otolaryngology and Speech Pathology, №2(14), 1998, pp. 61-65 (in Russian).
- [3] O.P. Skljarov. Elements of the Theory of a Speech Rhythm on the Basis of Physical Phenomenology of its Disorders. Doctor Thesis, St.-Petersburg, St. Petersburg State University (in Russian).
- [4] O.P. Skljarov, "Neurodynamical Route to Chaos and Normal Speech vs. Stuttering". «Control of Oscillations and Chaos», Proceedings of the 2000 2nd Int. Conf. (Eds. F.L. Chernousko, A.L. Fradkov) - July 5-7, St. Petersburg, Russia. The Inst. for Problems of Mech. Eng.-2000.- pp.449-452.
- [5]. O. Bloodstein, A handbook on stuttering, Fifth ed, San Diego; London: Singular Publ. Group, Inc., 1995.
- [6]. H.L. van der Maas, P.F. Vershure, P.C. Molenaar, "A Note on Chaotic Behavior in Simple Neural Networks", Neural Networks, Vol. 3, 1990, pp.119-122.
- [7]. O.P. Skljarov, A.N. Porosin. Expert System For Researching and Correction of Speech Disorders. Proc. of the Int. Conf. "Region Informatica-2002", SPIIRAN, St.-Petersburg, 2002.