CONTENTS

PREFACE

This is a review article, or rather a commented summary, of

> L.Ja. Balonov & V.L. Deglin: Slux i reč' dominantnogo i nedominantnogo polušarij (Hearing and speech in the dominant and non-dominant hemispheres). Izd. "Nauka", Leningradskoe otdelenie, Leningrad, 1976.

The deeper I got into this book and the problems it raised, the more aware I became that it demanded an understanding of matters beyond straightforward neurolinguistics. I frequently had to seek professional help for checking details under discussion. The material was not readily available to the layman having only specialist literature at his disposal. In working out the text I have therefore repeatedly had to bother other people in my search for information and references.

Giacomo d'Elia, professor of psychiatry at Linköping University, has been especially helpful. He read the whole manuscript in its first complete draft and made a number of amendments and suggestions. Moreover, he also read an earlier version of the first half of the article and commented extensively at different points. In fact, Section 2 of this review is based primarily on d'Elia's comments. I wish to express my sincerest gratitude not only for his permission to let me include his comments on the earlier draft, but also for his patient and self-sacrificing work in helping the layman to understand a little of what psychiatric medicine really is about.

Sidney Wood, linguist, phonetician and collaborator in another research project of mine, also contributed considerably to the final form of the review in brushing up my English and in advising me on matters of phonetics and neuropsychology.

Barbara Prohovnik, speech pathologist of Jönköping Regional Hospital and formerly assistant of general linguistics at Lund University, participated during the initial stage of outlining the article. Her influence is traceable in many places, above all in sections 7, 8 and 9.

I would also like to thank Robert Bannert, Christina Dravinš, Merle Horne, Mona Lindau-Webb, Anders Löfqvist and Peter Silfverskiöld for assisting me at different points. The article has finally benefitted from comments on presentations of the material I gave at the Linguistics Departments of Göteborg and Lund Universities.

Of course, none of the people mentioned can be held responsible for the way I have used their suggestions and references.

While editing what was intended to be the final version of this article, I was fortunate to get access to Traugott (1979) (on international loan by courtesy of the Lenin Library, Moscow). This book, co-authored by Balonov and Deglin, provides clarifying insights. I have been able to include some of this information in the text, but lack of time prevented me from making further amendments. For this reason some minor inconsistencies may appear now and then.

The theory, practice and ethics of electroconvulsive therapy (ECT) are discussed in later sections. For the meantime, the following definitions will be useful. In ECT, an electrical stimulation is applied to the brain in order to induce an epileptic seizure (an uncontrolled discharge of epileptic activity through the neurons of the brain). It is used in the treatment of depression and schizophrenia. The stimulation may be bilateral (to seizure the entire brain) or unilateral (either to seizure one hemisphere, as Balonov and Deglin obviously have aimed at, or to initiate a seizure that spreads to the entire brain, as in Western psychiatric practice). A grand mal is a global or generalized seizure that affects the entire brain. A focal seizure is limited to a local area of the brain only. Petit mal seizures are very brief and not followed by muscular convulsions. An abortive seizure is epileptic activity that subsides without building up to seizure level.

1. FUNCTIONAL SPECIALIZATION AND EXPERIMENTAL METHODS

It is nowadays generally accepted that functional specialization of the hemispheres is one of the most important principles underlying the organization of the activity of the human brain. The last decades have presented us with a number of studies concerning the question of lateralization in relation to different aspects of thinking and behaviour. Such studies have been carried out by scientists from a wide range of disciplines - not only neuropsychology, psychology, and psychiatry, but also linguistics, sociology, and education. The main focus in most of these studies has been the role of the dominant vs. the non-dominant hemisphere in speech production and, not least, speech perception. Worth mentioning is research on hearing in brain damage (Buffery 1974), on the results of stimulation and extirpation of structures of the left and right hemispheres (Penfield & Roberts 1959), experimentation with dichotic listening techniques (Kimura 1967; Studdert-Kennedy 1974 & 1975), work with "split-brain" patients (Sperry 1964, 1966; Gazzaniga & LeDoux 1978; Zaidel 1978), Wada technique testing (Wada & Rasmussen 1960) and various studies of the bioelectrical activity of the human brain (Galin & Ornstein 1972).

These investigations, together with experience from work with aphasics, have given us a relatively good picture of the specializations of the hemispheres with regard to different linguistic functions. But it should still be kept in mind that our understanding of brain functioning and our knowledge of neurological correlates to cognitive functions is very fragile.

The recent investigations of the roles of the dominant and the non-dominant hemispheres in speech and hearing by the Soviet psychiatrists Lev Jakovlevič Balonov and Vadim L'vovič Deglin is an interesting and challenging contribution to this field, partly because of its content but above all because of the unusual technique used for collecting data. In many ways the book reports phenomena that are, at least <u>prima facie</u>, sensational. In addition there are numerous intriguing proposals regarding linguistic functions and their neurological correlates that are worthy of discussion. Unfortunately, the authors are often very parsimonious in reporting their primary data. Consequently, it is not always easy to check the credibility of their claims and statements, which have to be taken at face value. And even if they are, one is left with many questions unanswered - e.g. how reliable are the conclusions, how can overinterpretation of the data be detected, how can suspicions of dishonest improvement of the results be rejected, are the authors at times ignorant of other recent research findings or are they evading certain issues? It is possible that Roman Jakobson (Jakobson & Waugh 1979, 32; Jakobson 1980) has exaggerated the importance of Balonov's and Deglin's research by claiming that it has given us "the deepest and most consistent insight into the speech and hearing capacities of the two hemispheres" (Jakobson & Waugh 1979, 32). On the other hand, since such approval has been accorded to this work, it is only right to take a closer look at it.

Balonov's and Deglin's book presents the results of a decade of systematic research on the respective abilities of the hemispheres of the brain to process auditory stimuli independently of each other. The authors are psychiatrists at the Skvorcov-Stepanov Psychiatric Hospital in Leningrad. As routine medical treatment they have administered unilateral electroconvulsive therapy (ECT). This method has replaced the older bilateral therapy in the last 10-15 years, because it lessens undesirable side-effects. One consequence of unilateral ECT observed by Balonov and Deglin is that after the treatment the patient regularly exhibits behavioural symptoms resembling symptoms in patients suffering from brain damage. According to the authors the affected hemisphere is so to speak switched off for up to 30 minutes after unilateral ECT while the contralateral hemisphere remains conscious. Such observations would not have been possible in the West, where ECT is only administered in order to produce an epileptic seizure of the grand mal type and where, furthermore, the treatment is not carried out without premedication and general anaesthesia. Balonov and Deglin, on the other hand, apparently induce focal or unilateral seizures, which are considered to have lower therapeutic efficacy, at least in the treatment of depressive states. From an ethical point of view this is therefore a dubious enterprise. Moreover, ECT treatment without general anaesthesia may cause the patients traumatic sensations of a very dreadful kind. The ethical question apart (to be discussed more thoroughly in Section 2), such switching off of one of the hemispheres for a period of time does seem to be a possible undertaking. It is evident that this in turn provides a unique opportunity to check aspects of lateralized functional specializations of the brain.

What Balonov and Deglin primarily have done is to test a number of hypotheses arising from earlier experimentation as mentioned above. Of these, the experiments with split-brains and the Wada technique are most similar to Balonov's and Deglin's ECT tests. In principle, both approaches assume that the functioning of one hemispere can be studied independently of the other. Given that different linguistic and other higher cognitive functions really are differently represented in the brain, the isolation of one hemisphere should help us to determine more precisely the content of at least certain specific linguistic functions. There are, however, a number of difficulties connected with the aforementioned techniques. Firstly, the patients being tested are ill and often exhibit severe types of brain damage. This means that even if significant results are obtained from the tests, it cannot be taken for granted that they are representative of the healthy, undamaged brain. Balonov's and Deglin's patients, on the other hand, suffer from mental disorders - they are classified as either manic-depressives or schizophrenics. There is nothing to indicate that a mental disorder should affect the very localization of linguistic or other higher functions in the brain, although the disorder itself may be due to localized functional deficits.

Be this as it may, the positive interest allotted to neurosurgical experiments in pharmacological extinction of one of the hemispheres - so-called pharmacological hemispherectomy, cf. Wada & Rasmussen (1960) - is highly exaggerated at least from a linguistic point of view. The Wada technique is a procedure for anaesthetizing a single brain hemisphere by injecting a solution of sodium amytal (amobarbital, barbamile) into one of the carotid arteries, vessels supplying the respective hemispheres with blood. As a result of the injection the patient becomes totally deprived of activity in that hemisphere while retaining normal activity in the non-drugged hemisphere. The technique is used primarily for establishing language dominance prior to neurosurgical intervention. For both this and for ethical reasons it is not used on healthy brains or healthy hemispheres. Actually, the technique is of relatively restricted value for a number of reasons, above all because of the short duration of the anaesthetized state, which normally lasts no more than a minute. The period can be prolonged considerably with a stronger dose, but the danger of incurable damage increases proportionately. Consequently, the possibilities for detailed analysis of any linguistic function are extremely small; the most one can achieve is to check the patient's ability to identify linguistically a few central lexical items.

More interesting to the linguist are the investigations performed on split-brain patients with the aid of dichotic and monaural listening or by exploiting the individual visual fields. Split-brain surgery, or commissurotomy, is a technique for cutting the corpus callosum, a bundle of fibres connecting the two hemispheres, as a treatment for intractable epilepsy. It seems that the patient really is relieved from epileptic attacks without being severely changed in intelligence, personality or general behaviour. However, after the intervention the patient possesses, as it were, two separate and independently functioning brains in place of the former cerebral complex. The investigator can ascertain the lateral specialization of a number of impressive linguistic functions by using dichotic listening experiments to ensure that the subjects receive verbal information in only one hemisphere. However, it should be pointed out from the very beginning that the results obtained from split-brains, just like corresponding data from studies of aphasics, should be accepted with caution. Both epilepsy and brain damage can result in a reorganization of language functions in the brain. It has been reported that split-brain patients reveal linguistic ability in their right hemisphere that we do not usually expect in a normal brain - cf. Gazzaniga & LeDoux (1978). One possible reason for this is that the right hemisphere has developed compensatory functions to replace those lost or damaged as a result of the epilepsy itself or as a consequence of the intervention. For ECT, on the other hand, the likelihood of a compensatory linguistic function appearing in the non-dominant hemisphere is very small.

Our understanding of lateral specialization to date is mainly based upon studies of patients with unilateral lesions and cerebral disconnections. Attempts have been made to repeat the studies on normal brains by measuring electrical activity (Galin & Ornstein 1972) or blood flow intensity (Lassen, Ingvar & Skinhøj 1978). By and large these studies seem to confirm the results obtained from pathological research. It is therefore generally accepted today that the hemispheres are specialized for working with different materials, so that, in typical right-handers, language and arithmetic depend primarily on the left hemisphere, while the right hemisphere is specialized for patterns, spatial relationships and music. This could imply that ultimately the hemispheres differ in cognitive style, the left hemisphere operating in an analytic, logical manner, and the right hemisphere in a holistic, synthetic, gestalt way.

2. ELECTROCONVULSIVE THERAPY

As indicated above the choice of technique for investigating hemispheric lateralization is highly problematic both for ethical and for theoretical (methodological) reasons. In order to properly evaluate the book under review it is therefore necessary to scrutinize electroconvulsive therapy as a technique and as medical treatment.

ECT is a cover term for a variety of separate methods, that differ according to placement and size of the electrodes, amount of electrical energy supplied, voltage and duration of the stimulation, and direction and frequency of the pulses (Weiner 1979). Whatever the method selected the ultimate goal is to induce an epileptic seizure of so-called grand mal type, i.e. a generalized seizure manifested by tonic (continuous) and clonic (intermittent) bilateral fits. It is generally held that it is precisely this generalized seizure that has the benevolent antidepressant effect (Ottosson 1960; d'Elia 1970; Galin 1976; Fink 1979). It is to be observed that chemically induced grand mal seizures also have the same positive therapeutic effect. What makes psychiatrists generally prefer electrically induced seizures seems to be the fact that they are the easiest to administer.

In traditional bilateral ECT large plate or sponge electrodes are placed on the temples at each side of the skull and the current is switched on, the stimulation immediately causing the patient to lose consciousness. At the same time certain parts of the brain, the diencephalon and the hyppocampus, having the lowest seizure threshold, are stimulated to epileptic activity. This spreads very quickly, in a second or less depending on the technique, to the whole brain including the cortex. Muscular convulsions dominate the clinical picture. The convulsions begin with tonic muscular contraction, gradually passing over into clonic spasms decreasing in strength and successively levelling out. The seizure itself, brought about as a direct consequence of the electrical stimulation, lasts for 30-60 seconds, and the two phases, the tonic and the clonic ones, are of approximately the same duration. After such a grand mal seizure the patient is in a comatose state, i.e. he is unconscious to the extent that he does not react to pain, at least not during the first minutes following stimulation. After a while he begins to move his arms and his legs and eventually opens his eyes. Still 10-15 minutes after the treatment the patient is muddled and confused. By the end of this period, 20 minutes after the initial stimulation, the patient is usually capable of understanding questions.

After unilateral stimulation the picture is by and large the same, the outcome being a grand mal, tonic-clonic, bilaterally symmetric seizure just as after bilateral stimulation. However, by placing the electrodes on only one side of the skull a number of advantages appear, e.g. a smaller amount of electrical energy is probably supplied to the brain, the comatic state following the treatment is shallower, and side-effects such as long-term memory impairment, confusion and headache are minimized, especially if the stimulation is given to the non-dominant hemisphere (d´Elia 1970 & 1974; Clyma 1975). Unilateral non-dominant stimulation is therefore, at least in Sweden, recommended as routine convulsive treatment of endogenous depression.

Many patients are apprehensive and anxious before treatment, in part because of the overwhelmingly negative reports of ECT in the lay press. Care is therefore taken to prepare the patient psychologically. He also gets pre-anaesthetic medication about half an hour before the treatment and the treatment itself is performed under anaesthesia. Before the electrical stimulation the patient is given muscular relaxation, and oxygen is administered during the treatment until spontaneous breathing starts again. The amount of current used is kept liminal.

It is evident that unilateral ECT performed in this way cannot be equated with Wada testing as a method for neuropsychological investigation. A global epileptic seizure, no matter whether it has been produced by bilateral or unilateral stimulation, inactivates both hemispheres. It should be added that d´Elia & Perris (1970, 19ff.) found no significant EEG differences in post-seizure activity between the two kinds of treatment. There was, however, a higher integrated voltage on the stimulated side during the first minutes after the end of the seizure. The stimulated side also showed a slight tendency to be more disorganized in unilateral treatments. Otherwise the abnormality of post-seizure activity was equal for the two hemispheres in all treatment methods.

Unfortunately Balonov and Deglin give very scanty information about their own stimulation methods. Their description of bilateral treatment is by and large in agreement with what can be found in d'Elia (1970) and Fink (1979), the main sources for what has been outlined above. With regard to unilateral treatment, on the other hand, the description is different.

The clinical picture of Balonov's and Deglin's unilateral treatment has the following characteristics. The coma is shallower than in bilateral treatment. Respiratory arrest is considerably less frequent in unilateral treatment - 20% of the cases as opposed to 70% in bilateral treatment. Spontaneous breathing starts again usually already during the clonic phase. Most likely oxygen is not given during the treatment. This is a guess, which is, however, indirectly confirmed by Traugott (1979, 150), where the respiratory arrest following unilateral ECT is not considered to constitute a complication of the treatment: spontaneous breathing will usually be regained by itself or can otherwise be easily restored with the aid of manual or "mouth-to-mouth" artificial respiration.

Brain stem reflexes are less suppressed in unilateral treatment and return more quickly than in bilateral ECT; some brain stem reflexes do not become suppressed at all. The suppression disappears somewhat more slowly after left than after right hemisphere stimulation.

The convulsive muscular movments are less outspoken than in bilateral treatment. In 70% of the cases they occur mainly on the contralateral side of the body. This information suggests that incomplete seizures were induced (cf. Weiner 1979, 1514). Rudimentary spinal reflexes do not occur at all. Immediately after the end of the seizure hemiplegia can be observed, which is quickly transformed into transient hemiparesis of the extremities contralateral to the stimulated side of the brain.

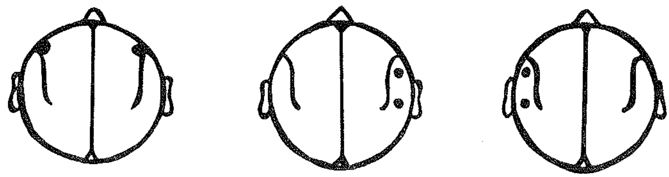
Consciousness is usually lost at the moment when the current is switched on. After right-sided treatment it returns more easily and is completely restored earlier than after left-sided stimulation. Sometimes consciousness can persist even during the beginning of the seizure, with adversion of the patient's head at the culmination of the seizure but often returns again before the end of the clonic phase. According to d'Elia (personal communication) this description is compatible with so-called dissociated seizures, which from a medical point of view are highly undesirable and, in the West, usually avoided with great success.

Orientation is regained in 42% of all right-sided treatments within 5 minutes of the end of the convulsions. In left-sided treatment, on the other hand, consciousness is lost already before or simultaneously with the start of the convulsions, and never returns before the end of the convulsions. Quickly regained formal orientation, i.e. within 5 minutes of the end of the seizure, is observed only in 4% of the left-sided treatments.

A course normally consisted of 8-12 treatments, three times a week with an interval of 48 hours between the treatments. No psychopharmacological medication was given from the day before treatment and no anaesthesia before ECT. All this means that Balonov's and Deglin's seizures cannot be compared with Western experience, where the use of premedication, anaesthesia, muscle relaxation and oxygenation provide radically different conditions.

Nothing is said about the ECT apparatus. The only information given is that the electric stimulations were administered with the aid of metal electrodes two centimetres in diameter. d'Elia (personal communication) points out that these electrodes are rather small. The smaller the electrodes are, the greater is the risk of inducing a focal seizure, i.e. a seizure localized to a restricted part of the cortex and not followed by a generalized seizure. However, it is apparent from Traugott (1979) that Soviet psychiatric practice, contrary to Western practice, actually aims to induce hemispheric, focal seizures rather than generalized bilateral seizures. The authors of Traugott (1979, 13) explicitly describe how the voltage and duration of the stimulation are individually adjusted for each patient in order to avoid a bilateral seizure.

The electrodes were placed on the skull as indicated in Figure 1. Some treatments were administered with other placements as well. The voltage for bilateral stimulation was 157 ± 5 volts for a duration of 0.59 ± 0.03 seconds, and 165 ± 2



A B C

Figure 1

Standard placement of electrodes: (A) bilateral treatment, (B) unilateral right treatment, (C) unilateral left treatment.

volts for unilateral stimulation for a duration of 0.73 ± 0.02 seconds (all figures are mean values). Continuous EEG monitoring showed that the seizured hemisphere was non-functioning and that the non-seizured hemisphere was functioning normally. This is an important point, since it cannot be interpreted otherwise than that the authors deliberately produce focal or unilateral (hemispheric) seizures. Further evidence can be found in Traugott (1979, 67), where we are told that disturbances of consciousness after the induced unilateral seizure are compatible with those following focal epilepsy.

The distance between the electrodes was 10-12 centimetres, rather close according to d'Elia (personal communication). Weiner (1979, 1514) points out that placing the electrodes too close may result in a higher seizure threshold and skin burns.

Western psychiatrists emphasize that in their view the main disadvantage of unilateral ECT is that it heightens the risk of inducing focal seizures, which they insist have little or no therapeutic value. Another disadvantage, alarming in this connection, is the fact that unilateral stimulation is more likely than bilateral stimulation to result in a "missed" seizure, i.e. the electric stimulation is not followed by any epileptogenic cerebral activity. Balonov and Deglin explicitly report that they had "missed" seizures.

Unfortunately they do not say anything about what happened to these cases subsequently. We do not even know if these patients were included in the investigations. It is to be assumed, however, that they were not. A missed seizure is a dreadful experience for the patients with pain, fear, and panic; "following such an experience, they can rarely be induced to have another treatment" (Fink 1979, 49). This is one of the reasons why ECT without anaesthesia is considered unethical by Western psychiatrists. The panic and the terror of the patients subjected to missed seizures without anaesthesia can even lead to death from heart failure (cf. Engel 1976 and Dimsdale 1977).

The information given in the book regarding the treatment methods is not complete enough to allow a definite evaluation of the investigations. Judging from the indications referred to above and from Traugott (1979) it does nevertheless seem safe to conclude that Balonov and Deglin really have induced dissociated, focal or unilateral seizures. Whether the brain activity of their patients after such treatment can be equated with that of Wada-tested patients cannot be checked. The authors claim that the stimulated hemisphere was totally incapacitated during the 15 to 25 minutes following the convulsions, while the untreated hemisphere was fully conscious during the same period. This was when investigations were mainly carried out. It might be added that Traugott (1979) reports that about 20% of the unilateral stimulations performed in Leningrad result in an abortive seizure, i.e. epileptogenic activity starts but fades away again without developing even to just a focal seizure. The clinical picture of such an abortive seizure is characterized, according to Traugott (1979, 99), by not being followed by any muscular convulsions or by only weak muscular fits.

Whatever the final evaluation of their work may turn out to be, it is more than likely that Balonov and Deglin have caused their patients much unnecessary suffering during the experiments.

3. THE SUBJECTS

As a whole, Balonov's and Deglin's study is ambitiously executed. They first aim to determine which aspects of the human perception of sound that are lateralized and which are not. They then go on to map the specific role of the left (dominant) hemisphere in the perception of speech sounds. The next step is to depict the right (non-dominant) hemisphere and its role in speech. After having studied aspects of the neural organization of the left hemisphere, they present an ingenious picture of the collaboration between the hemispheres with regard to their perceptual functions. Finally they discuss psycho-acoustic syndromes of the dominant vs. the non-dominant hemispheres.

The investigation is based upon a total of 1044 electrically induced seizures: 534 right-sided, 432 left-sided, and 78 bilateral. The seizures were administered to 150 subjects (119 female and 31 male) of different ages: 8 less than 20 years of age, 87 between 21-40, 49 between 41-60, and 6 subjects more than 60 years old. 75 of the patients were characterized as depressive, among which 53 were manic-depressive and 22 involutionary. The group as a whole included all types of melancholic, anxious, paranoic, hypochondriac and dysphoric syndromes. The remaining 75 subjects were said to suffer from schizophrenia: 14 from "circular" schizophrenia, 31 hallucinations-paranoia, 8 hebephrenia-catatonia, and 22 from schizophrenia simplex. All schizophrenic patients exhibited secondary symptoms of anxiety or depression, which was the medical motivation for the treatment with ECT.

All patients were clearly right-handed. All cases of uncertain or right hemisphere dominance had previously been excluded, primarily using methods described in Subirana (1969) and secondarily on indications drawn from the ECT as such. According to the authors left and dominant hemisphere on the one hand and right and non-dominant hemisphere on the other are therefore synonymous notions with respect to the study under review.

On the whole I believe the results obtained from the investigation are reliable not only as regards the patients investigated but also the generalization to the lateral specialization of individuals not suffering from mental disorders. As indicated above one should not expect any critical differences in lateral specialization between mentally sick and healthy people, but with respect to specific lateralized functions as such one cannot exclude the possibility of significant differences between the two categories. This makes proper evaluation of the study troublesome. I have become especially concerned about two peculiarities in the authors' selection of subjects: the type of syndrome and the sex of the patients.

Balonov and Deglin have divided their subjects into two groups of 75 patients suffering from manic-depressive or schizophrenic syndromes respectively. They do not, however, tell us why they have decided on this division. One reason could have been that they wanted the subjects to be as homogeneous as possible. Another and perhaps more plausible purpose might have been a desire to check for any detectable differences in lateralized cognitive functions between the two groups of patients. For example it has recently been proposed that certain types of manic-depressive syndromes might have their origin in right hemisphere dysfunctions and that schizophrenic syndromes might ultimately depend on left hemisphere deficits (cf. Gruzelier & Flor-Henry 1979 for extensive information and further references). Balonov and Deglin do not comment upon such contingent differences. This can be interpreted in two ways: either they have found no differences or they have found differences but for some reason choose to conceal the results. In either case the failure to comment is disturbing.

In connection with the question of functional brain asymmetry in the regulation of emotion a most surprising outcome of Balonov's and Deglin's experiments must be mentioned. When the patient has regained consciousness (five minutes or so after unilateral ECT) but is still deprived of activity in the treated hemisphere, he is in approximately 50% of the instances after right hemisphere treatment in very good mood, friendly, optimistic, even euphoric, but after left hemisphere treatment bad tempered, dysphoric, anxious or depressed. The fact that different emotions are associated with each hemisphere has been recognized earlier. Different emotional states have been noticed as reactions to brain damage (Gainotti 1972) and in experiments with Wada testing (Terzian 1964). There has been much speculation concerning the grounds (see especially Gruzelier & Flor-Henry 1979), but, as far as I can tell, no ready explanation has ever been given. And, of course, I do not demand a neat explanation from Balonov and Deglin either. But with regard to the general relationship between speech disturbances and states of mind on the one hand and linguistic deficiencies and mental disorders on the other, one would have expected a discussion of the phenomenon. Balonov and Deglin are content with reporting their observations and saying no more.

The second point concerns the sex of the patients. There is a considerable preponderance of women among the subjects, which excludes every possibility of elucidating any difference between the sexes in type or degree of linguistic or other higher cognitive lateralized functions. The authors seem to be unaware of the significance of the question, in spite of the fact that there are striking dissimilarities between men and women both with regard to mental disorders and to linguistic ability (cf. Taylor & Marsh 1979 and Buffery & Gray 1972). From a linguistic point of view only, one can cite differences in language production. Girls, for example, generally acquire language earlier and more efficiently than boys at all levels of grammar: phonology, syntax and lexicon. Boys and men, on the other hand, are more frequently afflicted by language disturbances, stuttering and dyslexia. Such disturbances could of course be accounted for in terms other than lateral specialization, but there is evidence of anatomical sex differences in left-right asymmetries in support of the first option: the frontal operculum and the temporal plane are consistently larger on the left than the right side in males, and frequently smaller on the left side in females. Wada, Clarke & Hamm (1975) have suggested that this finding might be associated with a right hemisphere speech component in females, which is absent or poorly developed in males. Furthermore, Bradshaw & Gates (1978) have recently found significant right visual field superiority in women with respect to verbal tasks associated with decisions of lexical nature, where phonological and/or graphological criteria are important. It is a serious weakness on the part of Balonov and Deglin that they have not considered this question. On the other hand, their neglect is understandable due to the fact that patients of this type are predominantly female.

4. HOW TO INDUCE APHASIA

As indicated in Section 1 above, the book under review was originally initiated by the authors' observation that their patients often revealed aphasic symptoms as a result of unilateral ECT. In order to map the more particular characteristics of such disturbances Balonov and Deglin studied a great number of patients with regard to linguistic abilities during their recovery from unilateral ECT. No less than 123 subjects were investigated after 785 unilateral electroconvulsive treatments (404 right-sided and 381 left-sided). The behaviour of the patients was described with reference to three distinct periods after the treatment, viz. the period of diffuse oppression of the brain's functioning, the period of inactivation of one of the hemispheres, and, finally, the period of residual features. Such a division is salient, though, of course, the shift from one period to another is not abrupt. Generally unilateral ECT has the following effects.

After left-sided treatment speech is lost immediately the current has been switched on, i.e. even before the seizure has been released and also in such cases where no epileptic activity at all is induced. Immediately after the seizure there is total aphasia, speech and other vocal activities disappear together with the understanding of speech and gestures. The first reactions to verbal address appear some time after the convulsions have passed. Normally they consist in turning the eyes or head when the patient is called. There are, however, no sounds and no signs of understanding. Later, the patient tries to pronounce words but fails, clumsily moving lips and tongue, making smacking noises, helplessly opening and closing the mouth. The first sounds uttered are either unsegmented distorted vowels or repeated syllables (da da da, ta ta ta, mi mi mi). Speechlike behaviour subsequently reappears as an indistinct murmuring where chains of incomprehensible syllables can be discerned. The comprehension of simple instructions and the ability to name objects is still absent. Later, when such abilities are returning, the patient can obey just one instruction or name just one object, whereupon everything goes wrong again. There is no understanding of written words, letters or numbers.

After about 5 minutes and onwards, when the right hemisphere has recovered full activity, global aphasia is very rare. The patient has widened his verbal ability somewhat, utters single words on request, and recognizes where he is. There is still no spontaneous speech or just a few single words, particles or short phrases. The patient pays no attention to the speech around him, does not react immediately on address, has to be reminded repeatedly to stick to the conversation and yet loses the thread. He has access to words only with difficulty and exertion, and pronounces them with effort, in bursts. Comprehension of verbal commands and naming ability are dramatically impaired. His speech is characterized by perseverations, echolalia, obscenities and verbal paraphasias.

On the whole the picture of the patient's condition when the left hemisphere is functionally incapacitated resembles a mixed motor and sensory aphasia. As recovery progresses the patients often exhibit purer symptoms of one or the other type of aphasia. These may persist for as long as 30-40 minutes after the treatment. As a rule the disturbances disappear completely during the residual period, though features of sensory-amnesic aphasia are present now and then.

After right-sided ECT the speech difficulties are fewer and different compared to left-sided treatment. Occasionally speech is maintained even during the convulsions and disappears only at the culmination of the seizure. A total absence of speech and vocal reactions lasts for a relatively brief period of time. Sensory and motor aphasic symptoms are rare and when they occur they are weakly expressed. It happens that the patients try to answer questions or name objects when the trismus of the masticatory muscles still remains and clonic spasms are still being repeated.

The most characteristic features of the disturbances after a right-sided seizure comprise changes in voice timbre and intonation. Aphonia, different forms of dysphonia and phonasthenia are often present. Some patients exhibit a dull or hoarse voice, others are disrupted, breathless or shrill, yet others acquire a nasal twang in the voice that lends their speech a characteristic snuffling. The rhythmic and melodic features of the speech are disturbed: the voice is alternately now dull and low, now exaggeratedly high-pitched and whining. Some patients stutter and pronounce the words with forced exhalation. Word stresses (note that word stress in Russian is highly phonemic) and phrase accents are often assigned to non-stressed syllables, and intonational contours, emotional figures and logical accents are misused. The speech is generally indistinct and monotonous. On the other hand the verbal activity is high, even heightened as compared to the normal behaviour of the patient. Immediately after the seizure there is a tendency to echolalia and verbose perseverations.

Right-sided ECT is often accompanied by an inability to localize the source of sounds in space. The patients desperately turn their heads to find where the sound is coming from. No matter where the source in fact is, the patient invariably ends up with locating it to the side of the incapacitated hemisphere, thus ignoring the left aural field. It is interesting to notice that a similar disregard of the left visual field has been observed in patients with organic brain damage in the right hemisphere. The orientation impairment normally lasts only a couple of minutes.

The disturbances after right hemisphere treatment reported so far all refer to the period of diffuse oppression of the brain. Once the left half-cerebrum has regained full activity there are usually no aphasic symptoms. Most tasks such as naming objects and understanding instructions are sustained without any particular difficulties. Speech activity is markedly strengthened, though it does not lead to logorrhoea as is frequently the case after left hemisphere seizures. The patient is much more talkative than under normal circumstances, and his speech abounds in comments and wordy effusions. For example a patient presented with a spoon for identification answered: "You think I don't know what it is, but I'll tell you that that thing is a spoon, it's a tea-spoon, a little spoon you use to stir the tea". The patients are exaggeratedly social, butt into conversations without invitation, comment upon the behaviour of other people present, ask questions and offer advice without being asked for it. At the same time the voice is still intonationally deviant: snuffling, nasal or phonasthenic. During the residual period the intensified talkativity fades away. The voice can, however, still be monotonous with a slight note of nasality.

The picture given above refers to a single unilateral seizure. The pattern of recovery changes, however, with repeated treatment. The motor aphasia and dyskinesia symptoms increase markedly in relation to the fluent aphasic symptoms after repeated left-sided stimulations. If the series is continued long enough, prosody is impaired as well. A series of ten treatments is sufficient to produce long-lasting aphasic impairments, usually almost exclusively of the motor type. Right-sided stimulations also produce a different pattern when repeated. The distortions of voice timbre and intonation grow worse at the same time as aphasic disturbances appear more frequently. After ten treatments in succession 50% of the patients exhibit aphasic symptoms, usually grave dyskinesia, even if the seizures have been administered exclusively to the right hemisphere.

5. HEMISPHERIC VERBAL DISTURBANCES

An unspecified number of the experiments designed to map verbal disturbances following the inactivation of one hemisphere were carried out with a different placement of the electrodes as compared to the routine procedure (Figure 1). One electrode was placed anteriorly on the temple and the other one just in front of the ear as indicated in Figure 2. Evidently the placement of the electrodes was chosen primarily to affect Broca's area, thus checking whether aphasic disturbances would accordingly change in character. Indeed, they did. Symptoms of verbal apraxia and dyskinesia increased dramatically in frequency after left-sided ECT, while symptoms of sensory aphasia decreased almost as much. The frequency of motor aphasia, on the other hand, was approximately the same as before. Combined with this different pattern the patients' condition was generally worse than otherwise. The development of akinesic disturbances was evident already during the period of diffuse changes. The patients were completely passivized, did not react to addressing of any kind, nor did they change their posture or countenance. First after a long interval and after repeated and urgent addressing was the patient able to give single answers to questions, but with a low voice and without looking at the interlocutor. Words were pronounced without moving the lips and with minimal tongue movements, which gave a slurred tone to the voice. The speech was slow with long pauses between the phrases, but the words within the phrases were nevertheless pronounced smoothly. In spite of the obstruction of the speech muscles the speech as such sounded fairly clear. There was no sign of paraphasia, but single words and, especially, phrases were often perseverated. The patients typically exhibited a peculiar kind of echolalia, beginning a reply with a repetition of the last words in the question or transforming the question into a declarative utterance. Syndromes of verbal akinesia lasted for a considerably long period and continued also during the residual stage, the patients being motionless, incollaborative and taciturn.

The syndrome of verbal akinesia was intimately connected with general motor disturbances. In addition to this, a peculiar chronological regression was seen, which never

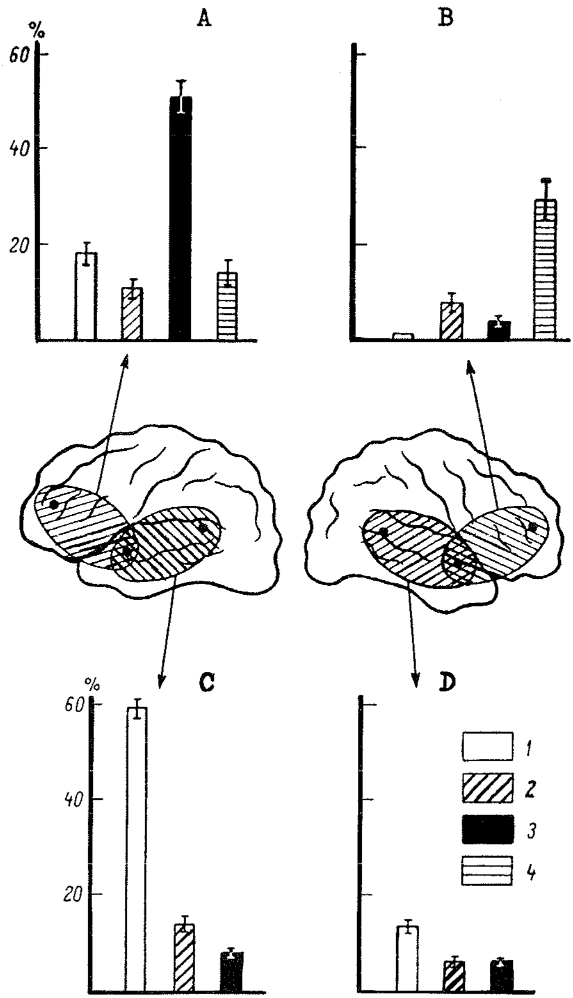


Figure 2

Frequency of aphasic disturbances after unilateral ECT with different placement of electrodes. (A) forehead-temple left, (B) forehead-temple right, (C) temple-temple left, (D) temple-temple right. Shaded areas indicate zones of cortex maximally affected by the current. Symptoms: (1) sensory aphasia, (2) motor aphasia, (3) verbal akinesia, (4) chronological regression.

occurred when both electrodes were applied to the temple. The patient seemed to go back in time. As an example, the two records for the patient Ž. are reproduced below.

Patient Ž. 38-year old male engineer, diagnosed as mild schizophrenic. Symptoms after left ECT, fronto-temporal electrode location:

Time in minutes after seizure	Verbal behaviour
10	No spontaneous speech. Laconic replies to questions. Names objects and carries out instructions with no difficulty. When asked where he works and what his occupation is he says he is 23 years old and works as a carpenter-assembler in the Elektrosila factory.
14	Situation-bound speech is free. To the same question he now replies that he is 25 years old, works as a carpenter at Elektrosila and is taking an extramural course at the Moscow Polytechnic Institute. The year is 1964 or 1967 and the people present are teachers of the Institute.
19	Converses freely. He says he is 33 years old and works as an engineer at the Svetlana factory.
35	At the physician's request he now gives his correct biography: He is 38 years old; he took employment at the age of 18 at Elektrosila and later studied at the Moscow Polytechnic Institute while continuing to work. On completing his studies he took a job as an engineer at Svetlana. He has not worked the last

two years because of illness. He categorically denies what he said a few minutes earlier about his employment at Elektrosila. "I didn't say that. I worked at that factory in 1957, before the Institute."

After right hemisphere treatment:

6 Situation-bound speech is free. Names without difficulty, carries out instructions correctly. Says he is studing at the Polytechnic. Is at the Institute now and is conversing with the lecturers.

15 Speaks willingly and with no difficulty. To the question he now says that he is a pupil at School 472. Volunteers the address of the school. The persons present are teachers. He identifies one of the physicians as his own teacher.

30 Correct orientation in time and space. He knows that he is in hospital, recognizes the physicians and names them correctly. He does not recall and denies that he just took them for lecturers of the Moscow Polytechnic Institute and school teachers respectively.

This type of chronological regression occurs more frequently after right hemisphere seizure than after treatment on the left side. According to Balonov and Deglin the phenomenon is not simply a matter of remembering an earlier period of life. The regression includes also the stock of knowledge, values, opinions and general intellectual orientation of the patient. The syndrome is different from a certain type of retrograde amnesia that can also develop after ECT. In such cases a chunk of time, it may be some hours or even a couple of days immediately preceding the treatment, disappears from memory but the patient never loses the awareness of his own age. Moreover, a patient suffering from retrograde amnesia is quite conscious of his deficit. In the chronological regression depicted above the patient winds back to an earlier period in time.

Furthermore, Balonov and Deglin claim that this chronological regression is something intrinsically different from the type of "flash-backs" reported in Penfield & Roberts (1959). This seems to be a more dubious conclusion. Penfield obtained his flash-back responses as follows. Since the brain itself does not contain pain receptors, it is possible to remove part of the skull under local anaesthesia and electrically stimulate the cortex, while the patient remains fully conscious. When an electrode is inserted about one centimetre into the cortex of the superior surface of the temporal lobe and a gentle current is switched on, the patient may experience something very similar to Balonov's and Deglin's chronological regression. He returns to the past; some long ago experienced situation is recalled to consciousness and relived as it were here and now. When interviewed afterwards the patients assure that this kind of reliving has no resemblance to remembering. "Instead of that it is a hearing-again and seeing-again - a living-through moments of past time" (Penfield & Roberts 1959, 52). At the same time the patient is fully aware of the current situation, lying strapped to the operating table and separated from the surgeon by a tent of surgical drapes. The patient thus has double consciousness. "He enters the stream of past and it is the same as it was in the past, but when he looks at the banks of the stream he is aware of the present as well", as Penfield puts it with a reference to Heraclitus (Penfield & Roberts 1959, 43). This double consciousness, according to Balonov and Deglin, is one of the decisive features differentiating the Penfield flash-backs as qualitatively different from the chronological regression they themselves observed. If we assume, however, that the loss of awareness of the present in the latter case is a result of the ECT, there is no difficulty in recognizing the similarity of the two reactions. An alternative interpretation of Balonov's and Deglin's observation is then possible. It could very well be that the superficial layers of the cortex, being more affected by the current than deeper structures, remain numb while the deeper structures regain their activity. This would be consistent with similar phenomena in senile dementia and under hypnosis in psychotherapy. It would also be easier to understand why Penfield's patients are surprised, even emotionally upset, by their experience, whereas Balonov's and Deglin's patients remain indifferent. This indifference is brought forward by Balonov and Deglin in support of their non-identity hypothesis. However, if their patients are deprived of awareness of the actual present, why should they find the only available reality remarkable? On the other hand, Penfield's patients relive the past at the same time as they perceive the present, and this must be an exceptionable experience. Note also that Penfield's patients but not Balonov's and Deglin's remember the sensation: the former but not the latter have active superficial cortex where the sensation can be imprinted anew.

There are more differences, but one might suspect that they can all be referred to the different techniques used to provoke the responses. The very fact that Penfield stimulated one limited locality in the cortex with a small electric potential, whereas ECT disrupts the whole brain should lead us to expect the seemingly different reactions. If indeed the two kinds of chronological regression are of basically similar origin, implying that once imprinted past experiences are never totally wiped out but rather become overlayed with later recordings, then Balonov's and Deglin's findings are more interesting than the authors themselves seem to realize. They could ultimately lead to better understanding not only of awareness as such but also of higher cognitive functions in general - including language.

6. HOW EFFECTIVELY IS THE TREATED HEMISPHERE INACTIVATED BY ECT?

If the hypothesis put forward here, viz. that the chronological regression after ECT is due to activity reappearing in the deeper structures of the cortex while the surface is still numbed, then a number of difficulties arise with regard to the general evaluation of Balonov's and Deglin's research. As noted in Section 2 Balonov and Deglin consider the treated hemisphere to be totally incapacitated for a period of approximately 15 minutes after right-sided ECT and 25 minutes after left-sided ECT. In fact, they refer to this period as a state of "temporary hemispherectomy" with reservation for possible spreading of the seizure to the untreated hemisphere. However, their only evidence for this claim is their interpretation of the EEG recordings. The question then arises: is it really possible to draw such far-reaching conclusions from the EEG alone?

It is true that about five minutes after unilateral ECT the EEG resembles normal alpha-rhythm (waves of 8-13 cps) on the untreated side, while there is high amplitude and low frequency on the stimulated side, a waveform that is typical of deep coma. It does not necessarily follow from this, however, that the treated hemisphere is completely inactivated. For one thing, EEG primarily records electrical activity in the cortical surface. It is impossible to tell to what degree the activity of deeper structures, say 3-4 centimetres down in the cortex, is efficiently recorded. Fink (1979, 79) reports that a recognizable visual evoked response is elicited after ECT in subjects with typical petit mal episodes in the EEG (a petit mal is a very brief seizure followed by unconsciousness but not convulsions). Fink's observation suggests that not all cortical neurons participate in seizure activity.

Moreover, the fact that different electrode locations produce different reactions also indicates that the effect of ECT is a matter of degree of deactivation rather than of complete temporary hemispherectomy. It should be observed that such differences were reflected in the EEG as well and, furthermore, that still other distinct reactions were provoked with a temporal-occipital location of the electrodes. In this case, aside from sensory aphasia there were also symptoms of alexia, agraphia and visual agnosia. The side of the brain treated also played a role. For example, after left-sided stimulation the ability to write words and numbers becomes obstructed, while the patient can still draw given figures such as a circle or a square. With a temporal-occipital location of the electrodes on the left side of the skull the ability to draw figures may also be lost, while the ability to write letters and numbers remains unaffected. It might be added that, according to Fink (1979, 113ff.), different electrode locations provoke different long-lasting memory deficits without affecting the antidepressant efficacy of ECT. This fact is interpreted as evidence against the hypothesis that the therapeutic effect of the ECT might be a secondary phenomenon arising from the amnesia induced by the seizure.

It is thus clear that the location of the insult is of significance with respect to different responses to hemispheric ECT. This is consistent with results obtained from studies of aphasics. However, aphasics are normally not considered as being technically hemispherectomized. On the other hand it is not settled whether the patient makes use of the non-dominant hemisphere or of undamaged structures of the dominant hemisphere when language is reestablished after global aphasia. There is evidence for both options. Be this as it may, had hemispheric ECT caused a total blockage of the cortical activity in the treated hemisphere, we should not have expected any differences correlated to alternative locations of the electrodes. It must therefore be concluded that a certain level of activity remains in the affected hemisphere during the entire oppression stage.

A further problem arises when we consider the nature of the insult caused to the brain by ECT. In aphasia the disturbances are primarily caused by fairly localized damage to the cortex, while other areas remain organically though not necessarily functionally intact. Disturbances induced by ECT, on the other hand, come from two sources: biochemical sequelae of the epileptic seizure and the electric current as such. We know from Balonov and Deglin that the current alone is responsible for the initial loss of linguistic functions. As noted in Section 4 this occurs prior to the seizure and also in cases of a "missed" seizure. Unfortunately, Balonov and Deglin do not tell us if these patients regained language after the current had been switched off or if the disturbances persisted. It should be observed that Penfield, when stimulating certain points in the speech cortex, induced aphasia, but that speech returned as soon as the electrode was removed (Penfield 1966, 229ff.).

Since the amount of current administered to the brain in ECT is of quite another order than the gentle stimulation given by Penfield, we cannot be sure whether the disturbances produced by ECT are primarily caused by the current or the seizure. With respect to the striking similarities to aphasia generally one would expect the current to be the main factor contributing to the dysfunctions. If so, however, chemically induced seizures would give a different picture. In fact, the residual deficits in memory and language production in such cases are of the same type as those following electrically induced seizures, which seems to indicate the contrary, viz. that the seizure as such is a sufficient source for the disturbances. However, other factors, such as higher blood tension and hypoxia, i.e. low content of oxygen in the blood, have also to be considered. Further, it must be remembered that the global seizures induced in Western psychiatric practice probably are not directly comparable with the hemispheric seizures induced by Balonov and Deglin.

It is at least plausible that the specific deficits following from different electrode locations are caused by the current. In other words, the electrically induced local irritation is comparable to local brain damage in ordinary aphasia. This would explain the similarity in behaviour between aphasics and ECT-treated patients. On the other hand, even though certain activity in those parts of the brain not directly affected by the current cannot be excluded, the seizure itself produces such a dramatic molestation of the brain's functioning, that anything resembling normal cognitive behaviour is unlikely. Balonov and Deglin are therefore no doubt correct in interpreting the dominant delta-rhythm in the EEG as indicating a temporary inactivation of the treated hemisphere. Any residual neural activity in the cortex is too slight to account for more than negligible linguistic activity after a left hemisphere seizure. This puts us into a dilemma, because we would expect the ECT-treated patients to exhibit symptoms more similar to commissurotomies than to aphasics. The miserable state of matters is that the right (non-dominant) hemisphere of the split-brain patient is mute. Normally the disconnected right hemisphere has no ability at all to produce appropriate speech, no matter how well developed its capacity in language comprehension may be. Even Gazzaniga's and LeDoux's patient P.S., who was able, while arranging letter cards, to spell the names of objects flashed to his right hemisphere via his left visual field, could not pronounce a single word under the same circumstances (Gazzaniga & LeDoux, 1978). Therefore we should not expect any capacity of that kind in Balonov's and Deglin's patients either, and yet they speak. Often with difficulty, it is true, but they speak.

In a most comprehensive comparative study of split-brains, hemispherectomies, aphasics, children of different ages and normal adults Zaidel (1978) found the same gross pattern of language abilities in all populations. In brain damage there is evidence that the right hemisphere may take over language processing to a certain degree, but reluctantly. It is only in early massive unilateral lesions that the non-dominant hemisphere takes over all language functions (Zaidel 1978, 265). It is interesting to note that Zaidel's subject R.S., a 15 year old girl hemispherectomized at the age of 10 with no indication of linguistic transfer to the right hemisphere before surgery, had severe difficulties in language production, but her deficits did not resemble any of the clinically identifiable types of aphasia (Zaidel 1978, 266). Whatever this may imply, all data presented so far unanimously suggest that the normal right (non-dominant) hemisphere lacks the ability to deal with speech at a phonetic level, though it has an apparent capacity to understand connected speech, actually a lot more than Gazzaniga (1970) thought.

The assumption of the right hemisphere taking over language production in aphasia originates from a study by Kinsbourne (1971). Since Kinsbourne's investigation bears a certain resemblance to Balonov's and Deglin's research, it is relevant to this dicussion. Kinsbourne examined three right-handed, severely aphasic but far from speechless men. They had become aphasic through acute left hemisphere damage a relatively short time before the investigation and there was no indication whatsoever that any of them was relying on the right half-cerebrum for speech production prior to the injury. All of them were given intracarotid amobarbital injections on the left side, and two were subsequently Wada-tested on the right side of the brain. It turned out that the left-sided injection did not produce the customary speech arrest in any of the cases. Their speech ability was largely unaffected by the injection. The two right-sided injections, on the other hand, resulted in a complete loss of vocalization. The subjects remained fully conscious, which could be inferred from motor responses to verbal instructions. Kinsbourne interpreted these results as indicating that the aphasic speech was programmed by the right and previously non-dominant hemisphere. He also offered an explanation, that there is a bihemispheric potentiality for language (the sensorimotor control at the cortical level is complementary on the two sides of the brain), which permits the minor hemisphere to gain some limited control over vocalization when the cortical language area of the major hemisphere has been destroyed.

Applied to Balonov's and Deglin's ECT-treated patients this might mean that the untreated hemisphere temporarily takes over the control of functional specialities from the inactivated hemisphere and then gradually hands it back in pace with the increasing retrieval of the lost capacity. This is a neat explanation of the different behaviour of ECT-tested patients, aphasics and commissurotomies respectively. It is an attractive explanation since it also seems to account for the muteness of the right hemisphere in split-brains. Kinsbourne actually backs up his hypothesis with reference to observed cases of developing language in the disconnected right hemisphere, but as pointed out above this is an extremely rare occurrence. Under normal circumstances the right hemisphere remains mute. On the other hand, there is no urgent need for the split-brain, as opposed to the aphasic, to develop right hemisphere speech. His problem as an individual is not centred in an absolute inability to speak - at least not once he has recovered from the acute disabilities that follow from the intervention - but rather a question of how to transfer information from the one half of the brain to the other. As Sperry, Gazzaniga and others have repeatedly pointed out there are numerous other means for doing this.

Morover, it is only in controlled investigations that a single hemisphere can be presented information not available to the contralateral hemisphere. The occasions when a split-brain patient really needs access to speech in his right hemisphere are consequently very rare.

Though this model is quite acceptable from a general point of view, the absolute muteness of the right hemisphere in commissurectomy contrasted with the relative ease of transfer of vocal control to the right hemisphere in aphasia (and in ECT-treated subjects if the above hypothesis is correct) still constitutes a problem. A further complication arises from the fact that the possibility of the right hemisphere taking over speech in aphasia is very much dependent upon the severity of the damage, the age of the patient and the locus of the lesion. This seems to indicate that there must be some inhibitory factor involved as well. In view of the behaviour of the split-brains, the functioning of the main commissure, the corpus callosum, seems to be a good candidate. The corpus callosum might be likened to the chain of a bicycle or the drive shaft of a car. No matter how well the pedals or the engine are functioning, the wheels of the vehicle will not turn, if the driving link is cut. It is the same with speech. Without a link between the two hemispheres there will be no speech initiated in the right hemisphere since speech as such is located to the left hemisphere. Observe that this does not mean that speech control is exclusively a matter of the left hemisphere. Although the performance of speech might imply such an all-or-none hemispheric specialization, the non-performing hemisphere may well posssess a knowledge of the way the performing hemisphere functions, a knowledge that makes it possible for it to decide not only what the performing hemisphere has to convey vocally but also how to do it. Such knowledge could ultimately provide the right (non-dominant) hemisphere with the capacity to control speech directly in case of disturbances in the performing hemisphere. If this is the case we can understand why Balonov's and Deglin's patients react so differently to hemispheric ECT - from practically no traceable deficits at all to global aphasia or total disorientation and amusia respectively. It will always be a question of how well equipped the complementary cortical structures of the non-specialized hemisphere are to "understand" the functioning of the specialized structures of the opposite hemisphere.

In passing, it is tempting to assume that such non-dominant hemisphere control could be a major factor underlying second language production for most people. That is to say, when speaking a foreign language we have acquired as adults, we may largely rely on patterns imprinted in the right hemisphere and limit left hemisphere control to such structures as are either universal (i.e. common to all languages) or directly transferable from the first (native) language to the second language. Failures in second language production would then come from either badly or incorrectly imprinted patterns in the right hemisphere or from patterns controlled by the left hemisphere, mistakenly taken to be common to both the first and the second language (interference proper).

It should finally be underlined that the model proposed here is supported by neurological data. These will not be gone into now. The interested reader is referred to Geschwind (1974) for direct information and extensive further references. The paper "Disconnexion Syndromes in Animals and Man" (Geschwind 1974, 105-236) is especially informative with regard to the specific role of the corpus callosum in language production.

7. HEMISPHERIC SENSITIVITY IN GENERAL AUDITORY DISCRIMINATION

Balonov's and Deglin's first series of neuropsychological experiments was carried out in order to determine the absolute sensitivity of the hemispheres with regard to general auditory discrimination ability. This inquiry was divided into two parts, the first to determine auditory thresholds for pure tones at different frequencies and the second to investigate differential discrimination for various durations of tones. The patients' ears were matched for sensitivity before the experiments, and so were the subjects' discrimination abilities both before the experiments and after bilateral ECT. The thresholds were determined monaurally at each ear. In each individual case the weakest signal level that could be detected with a probability of $\underline{p} = 0.75$ was identified as threshold.

In the first part of the investigation the auditory thresholds of 10 subjects were measured at the frequencies 250, 1000, 3000 and 6000 cps respectively after 5 bilateral, 9 left and 9 right unilateral electroconvulsive treatments. It turned out that bilateral ECT raised the threshold considerably, 13 ± 3 dB at low frequencies and 19 ± 2 dB at high frequencies, while unilateral ECT produced sporadic transient changes immediately after the treatment and only on the contralateral ear. Otherwise there were no differences in sensitivity between the ears. This seems to be consistent with Small's (1973, 393) claim that if one ear has a different threshold to the other, the binaural threshold will be the same as the best ear, i.e. the threshold obtained using both ears is simply that of the better ear. Balonov and Deglin do not offer any interpretation of the sporadic changes on the contralateral ear, but it nevertheless seems evident from the experiments that the sensitivity as such cannot be lateralized.

The second part of the sensitivity test was designed to determine whether the absolute thresholds might be dependent upon the duration of the signal. 10 patients were examined after 5 bilateral, and 11 left and 12 right unilateral ECTs. Pure tones at a frequency of 1000 cps with durations of 2, 5, 10, 50, 100 and 300 msec were presented to the subjects both binaurally and monaurally. Bilateral ECT produced equally higher thresholds for all conditions in both binaural and monaural listening. After unilateral (hemispheric) ECT, however, the discriminatory threshold was raised considerably for the contralateral ear on short durations of the tone (2-10 msec). It was raised for the contralatral ear also at 50 msec but to a lesser degree, whereas tones of longer duration were perceived equally well by both ears. This is more than would be expected, since, according to Small (1973, 376), the binaural threshold in normal subjects is not sensitive to durations longer than 250 msec. Curiously, the thresholds became slightly lower after a while during the residual period but before full recovery. According to Balonov and Deglin this might be explained as a result of an increased sensitivity of the non-specific thalamic pathways, ultimately due to the ECT.

A strange side-effect of hemispheric ECT was also reported. When the signal was presented to the contralateral ear, it did not normally evoke an immediate response: rather the investigators had to direct the patient's attention to the signal. Although the patient could hear the signal, he nevertheless seemed to be unware of its presence. He heard, yet he did not. Furthermore, when the signal was of a short duration, the patient often asserted that there was no sound at all present in the exposed contralateral ear; instead he claimed to hear the signal in the non-exposed ipsilateral ear. It should be observed that these effects of hemispheric ECT were exactly the same for both sides of the brain.

Thus far the overall picture seems to be manifest: though the seizures produce dramatic changes in sensitivity, there is no difference between the hemispheres with respect to threshold detection. There is an interesting parallel to this in Kimura's & Durnford's (1974) investigation of visual fields in normal subjects, where they found no difference in detectability of either verbal or non-verbal material between the hemispheres, though they did find dissimilarities in processing ability. They therefore suggested that it is not a general sensitivity function that distinguishes the right hemisphere from the left. In that respect the two hemispheres are equal mates. Kimura's and Durnford's suggestion is supported by the findings of Balonov and Deglin.

8. HEMISPHERIC SENSITIVITY TO AMPLITUDE DIFFERENCES

The second series of experiments was designed to establish the ability of each hemisphere to detect amplitude changes in sounds. The most efficient way to do this, according to Balonov and Deglin, is to study the effect of masking, i.e. the threshold shift to an auditory stimulus induced by the simultaneous presentation of a second auditory stimulus (Balonov and Deglin do not define the concept; the definition given here is taken from Small 1973, 378). The investigation was as follows: a sinusoid of 1000 cps and 30 msec, the amplitude of which was increased in intervals, was chosen as test stimulus (signal), and as masker was chosen a tone of the same frequency and duration at an amplitude of 80 dB. The subjects had to discriminate the amplitude at which the perception of one tone was replaced by a double tone. This amplitude was subsequently chosen as threshold for the masking, measured at intervals of 33, 60 and 330 msec between the fronts of the masker and the signal. 13 subjects were investigated after 16 right and 14 left unilateral ECTs.

The authors controlled the effect of both forward and backward masking. In both cases a considerable rise in the thresholds for signals presented to the contralateral ear was registered after the ECT. The effect was maximal immediately after the treatment and subsided gradually but differently for forward and backward masking. With forward masking the initial threshold was regained within 10-20 minutes after treatment, whereas differences in thresholds for backward masking were retained for 30-90 minutes after treatment. Incidentally the thresholds were even lowered during the residual period for backward masking. No such effect was noticed for forward masking.

These results might indicate that forward masking is less dependent on non-specific thalamic pathways (cf. Section 7) than backward masking. Balonov and Deglin claim that this really is the case and refer to supporting neuropharmacological data reported in Balonov & Kaufman (1974). It was shown there that drugs increasing the activity of non-specific nuclei of the thalamus diminish the effect of backward masking, while drugs decreasing the activity of these nuclei significantly strengthen it. In forward masking the effects of the same drugs were considerably less operative. Thus forward and backward masking seem to be regulated differently by the non-specific structures of the brain. However, neither of them show any lateralized effects.

9. AUDITORY ADAPTATION

Poststimulus auditory adaptation, defined as an increase in threshold due to the prior presentation of an acoustical stimulus (i.e. what Small (1973, 400) refers to under the heading fatigue), was the object of a further series of experiments. Adaptation varies considerably in connection with certain aural and pathological conditions and as a consequence of psychotic or mental syndromes. Adaptation can also be affected by hypnosis.

Balonov's and Deglin's investigation of adaptation was as follows. After an initial control of adaptation under normal circumstances the subjects were treated with bilateral or unilateral electroconvulsive stimulations and new measurements taken for a period of 2-5 hours. In every single case the threshold for the detection of a tone of 1000 cps was determined. Then an acoustical stimulus of the same tone 90 dB over the preestablished threshold was presented to the subject for a duration of 1.5 minutes (surely this must have been torture!). Immediately after this and again after 30 seconds, 1, 2, 3 and 5 minutes the threshold for the detection of a tone of 1000 cps was determined anew. The measurements were made separately for the right and the left ear. 11 patients were investigated after 28 ECTs (5 bilateral, 10 left and 13 right unilateral treatments).

In the control tests the thresholds increased 15-20 dB and smoothed out in 2-3 minutes. There were no significant differences between the ears.

After bilateral ECT there was a dramatic decrease in auditory adaptation. In most cases it actually became totally nullified on both ears. The same effect could be observed after unilateral ECT too, but only on the ipsilateral ear. In 11 of the 23 tests adaptation disappeared totally and in 10 cases adaptation was vigorously impaired, whereas there were no significant changes on the contralateral ear. The changes in adaptation lasted 2-4 hours after bilateral ECT, and 1-2.5 hours after unilateral ECT. The effects were most manifest during the residual period when high-amplitude activity dominated on EEG, but it was also evident during the period of exalted alpha-rhythm.

In some of the tests the electrodes were placed at the temple and at the back of the head as indicated in Figure 3 instead of the routine location (Figure 1). The placement of the electrodes did not influence changes in auditory adaptation. The results were the same as previously: no change on the contralateral ear and a considerable decrease of the threshold on the ipsilateral ear.

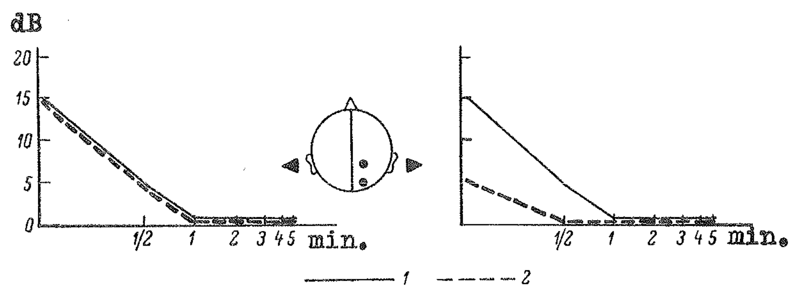


Figure 3

Alternative placement of electrodes for right unilateral ECT and effect on adaptation at left and right ear: (1) before seizure, (2) after seizure.

Balonov's and Deglin's conclusions from the investigations are that adaptation must depend on activation in the reticular activating system and the posterior thalamus. Since changes in auditory adaptation after hemispheric ECT always occur on the ipsilateral ear and not on the contralateral ear, they conclude that central structures not higher than the second neuron of the aural path are responsible for the phenomenon. Had auditory adaptation been dependent on processes higher than the cochlear nuclei, one should have expected changes on the contralateral ear. For the same reason Balonov and Deglin claim, contrary to general opinion, that the non-specific mechanisms regulating adaptation are independent for the two ears.

10. NON-VERBAL CATEGORICAL PERCEPTION: ENVIRONMENTAL SOUNDS

The experiments reviewed so far all unanimously point to the fact that the perception of uncategorized sounds is not lateralized. At the level of categorization, however, one would expect clear differences between the hemispheres. And indeed, they also appeared in Balonov's and Deglin's investigation, providing hardly sensational confirmation of left hemisphere dominance for verbal tasks and right hemisphere dominance for non-verbal tasks.

Traditionally, three different kinds of auditory agnosia are recognized, viz. verbal agnosia or word deafness, non-verbal agnosia or psychic deafness, and amusia or musical deafness. While verbal agnosia is thought to be caused by dysfunctions in the left hemisphere, both non-verbal agnosia and amusia are associated with right hemisphere deficits. The main part of Balonov's and Deglin's book is devoted to testing these hypotheses.

There is a problem involved here. Whereas there is general agreement upon the question of which hemisphere is dominant for specific strategies in interpreting categorized signals, the question of the over-all ability of the respective hemispheres to process data of different kinds is still a moot point. Though Balonov and Deglin explicitly declare that their technique is especially favourable for investigating the capability of each hemisphere to process auditory data independently, they are still more interested in demonstrating the well-known dominance properties than in exploring the question of ability. This is unfortunate, but their inquiry is nevertheless an important contribution to a better understanding of the issue.

The investigation of non-verbal categorized signals consisted of four series, the first of which was designed to check the ability of the hemispheres to correctly identify environmental noises. The subjects were given a recording of 15 or 20 of the following sounds to listen to: the ringing of a bell, birdsong, applause, a locomotive hooter and the sound of a train passing by, laughter, splashing water, a horse neighing, a snowstorm, coughing, a motorcycle, bees buzzing, a lion's roar, a crying child, breaking glass, thunder, a pig's grunting, clinking metal, a rooster's crow, snoring, barking, mooing, the sound of a horn, steps in a corridor followed by the closing of a door, an airplane, the signal and the noise of a tram, a honking goose, the ringing of a telephone, and the sound of waves breaking. The stimuli were presented monaurally and at an amplitude optimized for a correct recognition of the signal - this procedure was also followed in the remaining three non-verbal series. Each signal lasted 2-10 seconds, i.e. long enough to identify the sound without difficulty. 14 patients were investigated after 32 hemispheric seizures (16 right and 16 left).

There was no particular difficulty in identifying the sounds in the control test before ECT. About 80% of the stimuli were correctly identified on both ears and the time lag between the presentation of the stimulus and the response was 4.0 ± 0.2 seconds. There was no noticeable asymmetry between the ears.

When the right hemisphere was inactivated the recognition of environmental sounds was dramatically obstructed. There were fewer correct reponses and more refusals to complete the task. The time lag between stimulus and response increased to 5.7 ± 0.3 seconds. The patients often produced completely inappropriate answers, which never occurred during the control tests. Thus a dog barking was identified as cackling hens, coughs as splashing water, laughter as birdsong or children shouting and applause as "A blacksmith at work". Responses like "I don't know" or "Some kind of noise" were very common. Occasionally patients gave answers like "It's / it isn't an animal" or "It's a kind of work", or they answered with a negative query, e.g. "It couldn't be a dog?". Such responses were not consistent, i.e. a new suggestion was offered for each presentation of the same stimulus.

Attention diminished considerably during the tests. Though the patients were generally talkative and answered questions willingly, they nevertheless seemed to be unaware of the presence of sounds in the earphones; they had to be reminded repeatedly to pay attention and carry out the tasks requested.

The disturbances lasted 1-3 hours. No difference between the ears was established.

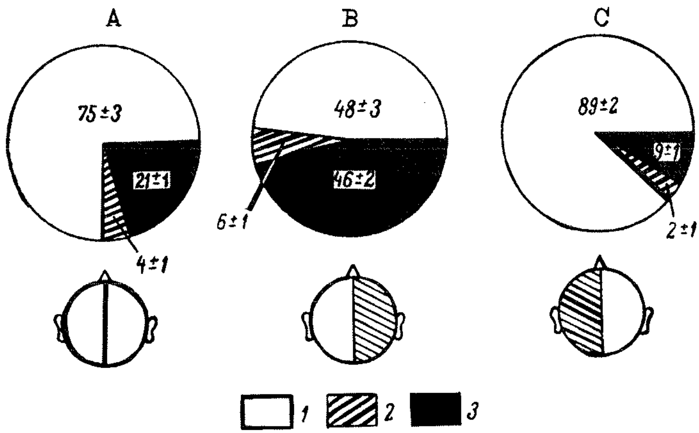


Figure 4

Distribution of different types of responses when identifying environmental sounds: (A) before ECT, (B) with inactivated right hemisphere, (C) with inactivated left hemisphere; (1) percentage identified and correctly named sounds, (2) percentage identified but not named sounds, (3) percentage unidentified sounds.

After left hemisphere treatment the picture was quite different. The ability to recognize environmental sounds was even better than in the control tests. Also the time lag between stimulus and response was significantly shorter, provided the inactivation of the left hemisphere was not accompanied by transient aphasic disturbances. In the latter cases the patients responded slowly and often complained that they had forgotten the proper word. However, they had no difficulty in selecting pictures corresponding to the auditory stimuli. Even so, the identification of the sounds was still better than under normal circumstances, though the answers were often strange, the words distorted and the word combinations unusual: "A horsish voice" (lošadixin golos), "A goaty voice", "A pig chirping". Balonov and Deglin do not comment upon cases such as the last example, but it looks as though a wrong verb is consistently selected when one of the items in a noun-verb string is used inappropriately.

Just as in the case with the inactivated right hemisphere no ear difference was established. This is somewhat surprising since dichotic listening studies on split-brains and normal subjects have established a right ear advantage for verbal material and, conversely, a left ear advantage for environmental sounds (cf. Kimura 1961 and Curry 1967). According to Springer & Deutsch (1981, 70) Wada-tested patients also reveal a typical contralateral ear advantage for both kinds of stimuli. Balonov and Deglin mention Kimura's study and refer to studies with pharmacological hemispherectomy concerning musical stimuli, but they make no comments. As a matter of fact, they are very parsimonious both with comments and data in this chapter. Of the 14 investigated subjects all that is reported is a few selected responses from 5 (!) patients, illustrating considerable difficulties after right hemisphere treatment and better performance after left hemisphere treatment. But what about the remaining 9 subjects? We know from the statistics (cf. Figure 4) that about half of the stimuli yielded correct identifications, in spite of the fact that the right hemisphere was inactivated, and that no less than 90% of the stimuli yielded responses that could be communicated verbally with an inactivated left hemisphere. Such data are actually more interesting than the fact that a statistically significant right hemisphere advantage for non-verbal material is demonstrated. They show that the dominant hemisphere has a remarkable capacity for non-verbal material, and vice versa, that the non-dominant hemisphere has a considerable ability for verbal production. In order to evaluate these results properly, however, one needs information both about the character of the responses and about the patients, their sex, age, educational background, and clinical history. Nothing of the kind is offered, unfortunately.

11. NON-VERBAL CATEGORIZATION: MUSICAL SOUNDS

The remaining three investigations of the lateralization of the perception of non-verbal categorized signals all concerned musical sounds. The first was concerned with frequency modulation of tone signals. 5 patients were investigated before and after 5 right and 5 left unilateral stimulations. They were presented 20 pairs of 1 second tones, the frequency of which was stepped up or down by one octave from the initial 1000 cps. The pairs were presented in random order. The interval between the stimuli within a pair was maximally 0.5 seconds and the interval between pairs 5-10 seconds. The subjects had to determine whether the two stimuli of a pair were alike or different with regard to the direction of the change in frequency.

In general no specific difficulty in performing the task was found, and no difference in detection ability was established in comparison with the control test, neither after right nor left ECT, for either ear.

The second series was designed in order to check the ability of the hemispheres to identify short melodic phrases. The patients were presented 10 pairs of phrases played on the the piano. Every phrase consisted of 4 notes in one bar. In 4 pairs the two phrases were identical while in the other 6 pairs the phrases were different, as indicated in Figure 5. The interval between the phrases within one pair was 1-1.5 seconds and the intervals between the pairs were 10-15 seconds. The subjects had to determine whether the phrases of one pair were identical or not. 8 patients were tested after 17 unilateral ECTs (9 to the right and 8 to the left).

In the control tests before ECT about 80% of the items were correctly identified. No asymmetry between the ears could be established.

After right unilateral ECT the identification ability decreased and the latent period between stimulus and response increased considerably. After left unilateral ECT the identification ability was slightly facilitated and the time lag between stimulus and response was significantly shortened. 40-50% of the responses were correct after right-sided ECT

Figure 5

Pairs of musical phrases presented for identification.

with a small advantage for the right ear. All changes in identification ability lasted for 0.5-2 hours after the seizure.

The last series of experiments with non-verbal categorized sounds concerned the ability to recognize melodies. 18 familiar tunes such as "Stenka Razin", "Kalinka", "Black eyes" were presented without words for so long time as was necessary for identification and with a pause of 7-10 seconds before each new tune. The subjects had to name the song, recall the words and hum the melody. 11 patients were tested after 25 unilateral ECTs (13 right- and 12 left-sided).

In the control tests 80% of the tunes presented were recognized correctly. Most subjects were also able to sing the melody on request.

By and large, the same picture as for environmental sounds was typical also for the recognition of familiar tunes. After left hemisphere ECT the melodies were recognized both with greater ease and with a shorter time lag between stimulus and response than under normal circumstances, while right unilateral ECT produced dramatic disturbances in recognition. Some of the patients totally lost their ability (and yet it should be obsered that 50% of the stimuli were still correctly identified with inactivated right hemisphere). The over-all advantage of the right hemisphere for recognizing tunes is nevertheless clearly confirmed. This is per se sensational. There is, however, another feature in Balonov's and Deglin's investigation that is even more unusual.

Not only do the authors claim that the right hemisphere is preponderant in melody recognition but also that the texts associated with the melodies are reproduced better by the left hemisphere than vice versa. For example, patients who, after right hemisphere seizure, were unsure or completely unable to tell what tune had been presented to them could nevertheless recite the text or, even, could mistakenly start to recite a text used for quite another melody. After left hemisphere treatment, on the other hand, the patient often had more difficulty than in the control test in properly naming the melody or recalling its words. He was actually aware of his difficulty himself and commented upon it with words like "I know it, but I've forgotten the words", and this happened also when he had demonstrated good knowledge in the control test.

These observations are, in fact, very remarkable, since it has been observed that the ability to sing with words is frequently unaffected in patients with severe speech disturbances. For example, the 18th century Swedish essayist Olof von Dalin reported a man who in spite of a total aphasia could sing hymns he had learned before suffering a stroke. The man could even say certain prayers "though as it were marking the beat, with an elevated and shouting voice (men liksom i takt, med en uphögd och ropande röst)" (Dahlin 1745, 114). Similar cases have been reported repeatedly, suggesting not only that the right hemisphere controls music but also the verbal component in singing. Balonov's and Deglin's observations obviously run counter to what might have been expected. None the less, the authors do not refer to such complications and no theoretical implications are discussed. They are content to be able to support Gazzaniga's hypothesis that the right hemisphere handles melodies and the left naming (Gazzaniga & al. 1975) in spite of numerous counter-examples in their own material.

12. PHONEME PERCEPTION

The detailed exposition of difficulties in interpreting Balonov's and Deglin's research in comparison with results obtained from studies of brain damage and from psychiatric practice given in Sections 4-6 was necessary in order to provide a base for evaluating the implications of the authors' investigations of clear-cut linguistic functions in the last four chapters of the book under review (pp. 119-195).

The main purpose of these investigations was to isolate different factors underlying what Luria (1973) called "acoustic word agnosia". Agnosia is generally a failure to recognize familiar things and appreciate their purpose. For example, an agnostic patient may sit down to his meal and look at his knife and his fork without knowing what to do with them. Similarly verbal agnosia is the inability to recognize familiar words such as "knife" and "fork". In acoustic word agnosia the patient does not recognize the minimal phonological units, the phonemes, of his native language.

It has been assumed that underlying the perception of speech sounds are acoustic cues of some sort. These cues, however, are not characterized by a simple one-to-one sequential correspondence between cue and phoneme. Instead, the acoustic cues of a phoneme are scattered along the utterance so that at any given moment the speech wave is composed of several acoustic cues, simultaneously signalling different phonemes. Consequently, it is impossible to identify speech sounds acoustically in such a way as to make them correspond to discrete sequential phonemes such as we understand them. Moreover, one same acoustic property can give rise to several different possible perceptions and, conversely, different acoustic cues can be perceived as one and the same phoneme.

Liberman & al. (1967) see the restructuring of a discrete phoneme sequence in scattered, overlapping, acoustic cues as the code of the speech wave. This is decoded by a system of parallel processing. Now, it seems that some kinds of phonemes are more directly encoded than others. Thus the vowel formants are direct cues to vowel percepts, while consonants have their cues in the CV formant transitions and in transiental and aperiodic phenomena. These differences in encoding properties between vowels and other speech sounds are quite well known today. With respect to their neurological correlates, however, our knowledge is more restricted. Thanks to dichotic listening experiments on normal subjects (e.g. Shankweiler & Studdert-Kennedy 1967; Haggard 1971) it has nevertheless been possible to establish an over-all right ear advantage for all kinds of speech sounds, which implies left hemisphere processing of the auditory input. Steady-state vowels of 250 msec and more, however, seem to be fit for processing also by the right hemisphere. Godfrey (1974, 329) even reports a slight left-ear advantage for vowels at 300 msec. This seems to indicate that if the vowels are long enough they can be discriminated linguistically also by the right hemisphere - at least in a linguistic context. The different encoding properties of long vowels on the one hand and other speech sounds on the other could therefore be correlated to a difference in lateral specialization.

It should be pointed out that the alleged right hemisphere capacity for processing vowel phonemes is far from undisputed. Furthermore, an ear advantage established by way of dichotic listening experiments is a very doubtful measure for many reasons. First of all it is a matter of a statistic preponderance in favour of one interpretation. Secondly the interpretations are forced. Anyone who has participated in such experiments knows that one hears not one signal but both signals simultaneously. What has to be decided is whether the mixture is more likely to be identified with one of the signals rather than the other. I believe that the dichotic listening technique is too blunt an instrument for use in deciding whether phoneme discrimination is a lateralized specialization. This does not mean that I do not accept that phoneme discrimination is mainly a matter of the dominant hemisphere. But that this is so has not been demonstrated in any decisive way.

It is in this respect that Balonov's and Deglin's experiments provide us with new and partly unforeseen information.

13. WORD AND LOGOTOME IDENTIFICATION

In order to widen and complete the picture of hemispheric capability to discriminate speech sounds independently, Balonov and Deglin performed six separate series of experiments. They first examined the thresholds for recognizing sounds as speech and the discrimination of words in silence. They then went on to investigate the discrimination of syllables, consonantal phonemes and vowel phonemes respectively. Finally they examined the discrimination of words masked with white noise and the discrimination of words presented after high-pass filtering. Each examined item was tested separately before ECT and repeatedly after the treatment. Vocal signals, especially designed in tabular form, were recorded on tape and presented monaurally to both the right and the left ear. All psycho-acoustic changes after the ECT were controlled in the period when speech disturbances due to the treatment had disappeared and the comprehension of speech had been reestablished. No further information is given about the time span between the stimulation and the tests, which indicates that the subjects belonged to the group of patients that exhibited only small or no dysphasic disturbances due to the ECT.

In the first series the authors used as material a list of word groups, said to be "balanced according to their phonemic composition" (sbalansirovannyx po fonematičeskomu sostavu). I do not understand what this means; the reference given (Pokrovskij 1962) has not been available to me, but I would assume that the words were chosen so as to correspond to each other with regard to number of syllables and syllabic structure. The words were presented to the informants at intervals of 5 seconds. 16 patients were investigated after 41 unilateral stimulations (22 left and 19 right) and their discrimination ability was measured. The threshold was defined as that intensity level where the subject could tell that he was listening to speech though without being able to discriminate single words. The intensity level of the signal was subsequently increased in steps to 10, 20, 40, 60, and 80 dB above this threshold, and at each level the discrimination ability was measured with respect to the percentage of correct responses to a set of 20 items totally. The tests were done on each ear separately, so that each patient had his discrimination ability measured for both ears at least once at each intensity level. In addition 24 patients were investigated after 50 treatments (26 left and 24 right) at only 40 dB above the threshold. In all, 40 patients were investigated before and after 91 unilateral ECTs (48 on the left side and 43 on the right side).

In the control tests prior to ECT the maximum discriminating capability was found to lie in the range 40-60 dB above the threshold. In this range the discrimination of words amounted to 70-80% correct responses which is equivalent to what has been observed in normal subjects under normal conditions. No asymmetry in discrimination between the ears was established.

After left-sided ECT, and during the period of left hemisphere inactivation, there was a significant rise in the threshold for recognizing the signal as speech, and a decline in the number of correctly identified words, as indicated in Figure 6. The threshold rise occurred for both ears and amounted to 8 ± 2 dB in 80% of the subjects. The decline in discrimination ability was the same on both sides and was observed at all intensity levels. It was, however, most outspoken in the optimal range for speech perception, i.e. 20-60 dB above the threshold. At a level 40 dB above the threshold there was a fall in word discrimination of 15% for the left ear, and 17% for the right ear. This bilateral decline occurred in 38 of the 48 experiments, i.e. in 79% of the cases.

This deterioration in word discrimination had two manifestations: either the patient did not understand or did not catch the presented item, or he failed to give an interpretable response to the stimulus. Most typically such failures consisted in a meaningless but phonetically related response. For example the word vólja 'will' was identified as bónja (a non-existing Russian word) or figúra 'figure' was identified as timúra (also non-existing though recorded as a proper noun). Thus it seems the patient had a certain idea of the gestalt of the stimulus, but that he could not connect this gestalt with a proper semantic representation.

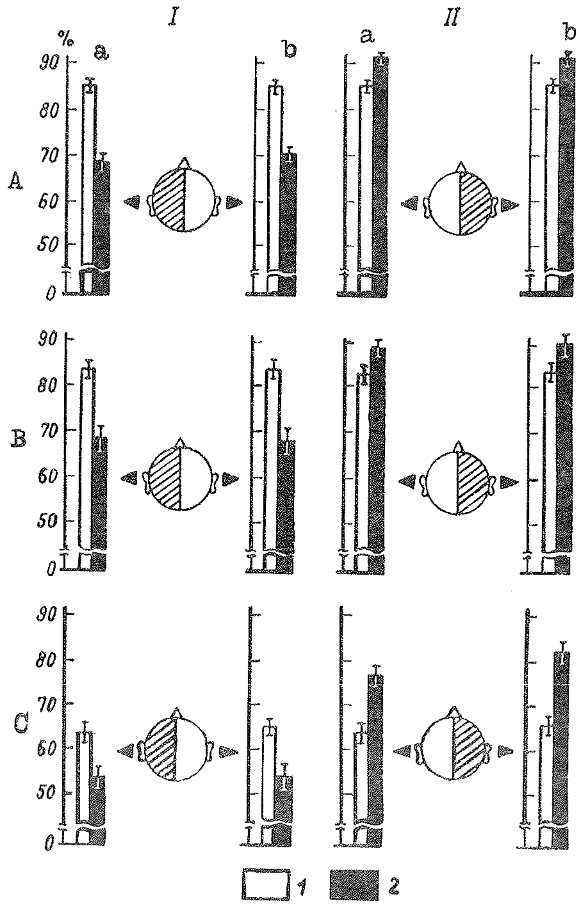


Figure 6

Recognition of words (A), logotomes (B), and consonantal phonemes (C) after unilateral ECT. (I) In the period of inactivation of the left hemisphere, and (II) the right hemisphere. (1) Discrimination of speech sounds (%) before ECT, and (2) in the period of inactivation. Left ear (a) and right ear (b).

Another feature typical of the patients' behaviour was a prolongation of the latent period between stimulus and response. Furthermore the patient answered lethargically, for which reason the pauses between the presentations of the stimuli had to be lengthened considerably. In addition to general inattention to the experiments the patients often resorted to perseveration - after having identified a number of words correctly, the patient would begin to respond with one and the same word for every stimulus word presented. Paraphasias often persisted in the test situation, though such phenomena had totally disappeared from the spontaneous speech.

The disturbances were worse at the beginning of the test period. Changes in threshold and discrimination seldom survived the state of left hemisphere inactivation. During the residual period discrimination ability was even better than in the control investigations. Such an improvement can of course be explained as a training effect, though Balonov and Deglin seem to believe the ECT to be the ultimate source of the phenomenon.

When the right hemisphere was inactivated the threshold sank and the discrimination ability was facilitated. A small threshold drop was observed in 60% of the cases (5 ± 2 dB on the right ear and 3 ± 2 dB on the left). There was no instance of a threshold rise after right hemisphere treatment. The increased ability in word discrimination was bilateral and occurred at all intensity levels, the maximum effect occuring in the range 60-80 dB above the threshold. At a level 40 dB above the threshold there was a facilitation of 6 ± 1% for both ears in 32 of the 43 cases.

As reported in Section 4 the patient often became exaggeratedly talkative while the right hemisphere was non-functioning. Balonov and Deglin find it remarkable that the patients' continuous commenting and speaking about other things did not interfere with the testing. After all, they did better than in the control tests.

Failures were infrequent and of another type than with the left hemisphere inactivated. Phonemes and accents were changed, but the outcome was always an existing word. So pensionér 'pensioner' became terpénie 'patience', kusók 'piece' yielded perrón 'platform', and máma 'mother' was identified as lámpa 'lamp'.

The second series of experiments concerning speech discrimination had so-called logotomes as its object. By logotomes Balonov and Deglin understand such mono- or bisyllabic combinations of phonemes as are phonotactically allowed in Russian but do not convey any lexicalized meaning. The subjects were presented 20 (in some cases 40) such logotomes monaurally to both ears and at an intensity level of 40 dB above the preestablished threshold. The percentage of correctly identified logotomes was taken as a measure of the discrimination ability. Discrimination curves were made for two subjects. 12 patients were investigated after 25 unilateral treatments (12 on the left side and 13 on the right side).

By and large the same types of differences as in the case of word recognition were observed in logotome identification. The number of misinterpreted consonants increased significantly after left hemisphere treatment, whereas vowel identification was the same as in the control tests. This happened at all intensity levels and in 10 of the 12 treatments. After right unilateral ECT all phonemes were identified with the same accuracy as in the control tests or even better (in 11 of the 13 treatments). Failures in the latter case were also of another nature: the patients made significantly more incorrect accentuations and they tried to find a meaning in the stimulus, reinterpreting the presented item as a similar structure having a semantic content.

No significant differences between the ears could be established neither for word nor for logotome identification.

14. CONSONANT AND VOWEL DISCRIMINATION

The final four investigations of speech discrimination are partly of questionable value. Some interesting observations are made, it is true, but now and then the authors are unnecessarily amateurish. This is particulary so in the series construed in order to examine the discrimination of what the authors call "consonantal phonemes". Six stops, differing with regard to place of articulation and voice, i.e. [p, b, t, d, k, g] were presented in a CV frame, where C was the stop and V allegedly the vowel [e]. The syllables varied in length 390-650 msec. Every individual stimulus was presented 5 times in random order at an intensity level 20 dB above the threshold, established as in the preceding experiments. 8 patients were tested before and after 17 unilateral stimulations (8 on the left and 9 on the right).

Nothing is said about how the stimuli were produced. I assume that they were recorded orally on tape, judging from the extreme length and the variation in length of the segments. If so, the vowel in question has certainly not been [e] but [ɛ], i.e. a vowel with a somewhat higher first formant and a lower second formant than [e], because sequences such as [pe, te] are phonotactically prohibited in Russian. A certain A.V. Baku assisted in the experiments (the surname is not Russian), and if she was the speaker (and of non-Russian origin) she might of course have articulated [pe] without palatalization, but she is hardly likely to have presented the stimuli in a non-Russian way to Russian informants. But we do not know whether Baku or someone else was the speaker. We do not even know if the stimuli were produced by a man or a woman. In addition, it is clear from the vowel charts in the book that the authors are not well acquainted with the IPA system of phonetic transcription. So when all is said and done it is most likely that the authors, far from having investigated the discrimination of stops, have instead compared the ability of the patients to distinguish the spoken names of the Cyrillic letters п, б, т, д, ґ, and the substitute [kɛ] for [ka] = к.

No information is given about the burst, the frequency and the duration of the occlusion, the locus and the duration of the formant transitions, the duration of the vowel steady state, or the frequencies of the first harmonic and the vowel formants. The fact that the patients did very badly already in the control tests - only 60% correct responses - could also indicate deficient recording quality. The observation that the discrimination ability was worse with inactivated left hemisphere and, conversely, better with inactivated right hemisphere is therefore of no significance.

The next two series of experiments, examining different vowels of two exactly defined durations, 100 msec and 60 msec respectively, are better designed and probably more reliable than the consonant experiments. Nevertheless, there are technical difficulties involved in these experiments as well. Nothing is said in this case either about how the stimuli were produced. However, if they had been produced by synthesis, we would no doubt have been informed. I assume therefore that the vowels in question have been produced naturally and recorded on tape. The problem of producing oral test vowels of an exact length is that the only way to limit the duration exactly is to cut the recording either at the beginning or at the end. This can be done physically with a knife or electronically with a gate. Presumably Balonov and Deglin have proceeded in this way. The problem is to avoid stimuli with an abrupt onset or conclusion. Since a vowel in natural speech always starts and ends smoothly, an abrupt cut will typically be perceived by a listener as a stop consonant, usually as a kind of [b]. This is due to the role of the burst as a cue for stop identification. According to Liberman & al. (1952) a burst just above the second formant is perceived as /k/, while a burst in a position above 3000 cps is perceived as /t/. Other bursts below 2000 cps are perceived as labial stops. The latter case resembles the transient properties of an abrupt cut. This means that a listener to a spliced or gated test vowel is very likely to interpret an abrupt start or ending as a labial burst. Together with the presence of a fundamental this equals a /bV/, /Vb/, or /bVb/ percept. In reality therefore Balonov's and Deglin's stimuli may have been sequences such as [ba, bi, ab, ib, bab, bib] etc. rather than isolated vowels, all depending upon where and how abrupt the cut or the cuts were made.

Just as in the preceding experiments with consonants, nothing is said about the formant frequencies of the test vowels. According to the text the vowels concerned were the following: [ɑ, e, i, u, o]. However, there is good reason to believe that what has really been recorded are the names of the Cyrillic letters а́, э, ы, у, о, which under normal circumstances would yield the stimuli [a] (a symbol actually used in a couple of places in the book as an alternative to [ɑ]), [ɛ, ɨ, u, o]. Of these at least [ɛ] and [o] could very well have been diphthongized. There is thus good reason for caution with regard to the vowel experiments too. However, since the subjects were instructed to say what <u>vowels</u> they perceived, they may well have concentrated on vowel perception and disregarded features of the stimuli not relevant to the identification task. Therefore the results cannot be rejected a priori but should be considered significant - though with due respect to the objections made here.

First, the discrimination of vowel stimuli of a duration of 100 msec was investigated for 13 patients after 30 unilateral treatments (16 left and 14 right). From now on the symbols /i/, /e/, /u/, /o/, and /a/ will be used to indicate those palatal, velar, and pharyngeal vowel sounds that have probably been utilized as stimuli. In the control tests before the treatment more than 80% of the stimuli were correctly identified. Of these /a/ and /i/ were recognized most easily, while /u/ was somewhat more difficult to discriminate. No asymmetry between the ears could be established.

In the period of left hemisphere inactivation there was a considerable decline in discrimination ability on both ears (cf. Figure 7). This effect was observed in 11 of the 16 treatments. However, it was, only the nonlow vowels that were affected and this in a most peculiar way. The close vowels /i/ and /u/ and the open vowels /e/ and /o/ were to a very high degree confused, though more in the direction nonvelar to velar (front to back) than vice versa. As can be seen from Figure 8 such confusions were also made in the control tests before treatment but then exclusively in the direction nonvelar to velar. The vowel /a/, on the other hand, was just as well distinguished as before. This was actually a consistent feature of all the investigations. Thus even when the stimulus was shortened down to 60 msec /a/ was still correctly identified.

After right hemisphere inactivation the discrimination ability was facilitated in 10 of the 14 treatments. In this case a slight right ear advantage was noticed.

The experiments were repeated with vowel stimuli of 60 msec and once again 13 patients were investigated before and after 30 unilateral ECTs (16 on the left and 14 on the right). As could be expected the vowel interpretations became more confused already in the control tests, though once again only with respect to the parameter velar to nonvelar. Misinterpretations concerning the height of the vowel stimulus occurred only after ECT. Quite generally, however, the differences in discrimination ability before and after ECT were small and barely significant. The same holds good for differences between the ears, though it could be shown that after left hemisphere inactivation the decline in discrimination ability only occurred on the contralateral ear. similarly a facilitation was observed on the ipsilateral ear after right hemisphere stimulation.

Balonov's and Deglin's interpretion of these results is that short vowels and consonants (reference is made to Baku's experiments discussed above) are processed by the left hemisphere. I would rather simply say that their results do not contradict this hypothesis. In reality the statistical relations are too small to allow any decisive conclusions. Furthermore it could be questioned if a vowel signal of a duration of 100 msec really is an appropriate test stimulus. True, this is an optimal duration for a stressed vowel in natural speech. However, the fact that this holds good of vowels in a linguistic context, does not make 100 msec vowels optimal stimuli <u>without</u> context. Context-free vowels usually extend to 200 or 300 msec. Kimura (1973) claims that the left hemisphere advantage in analyzing CV syllables gets lost when the stimuli are reduced to 150-200 msec. It is also noteworthy that Shankweiler & Studdert-Kennedy (1967), the study that most likely served as a model for Balonov's and Deglin's experiment, actually used synthetically produced vowel stimuli of a duration of 300 msec.

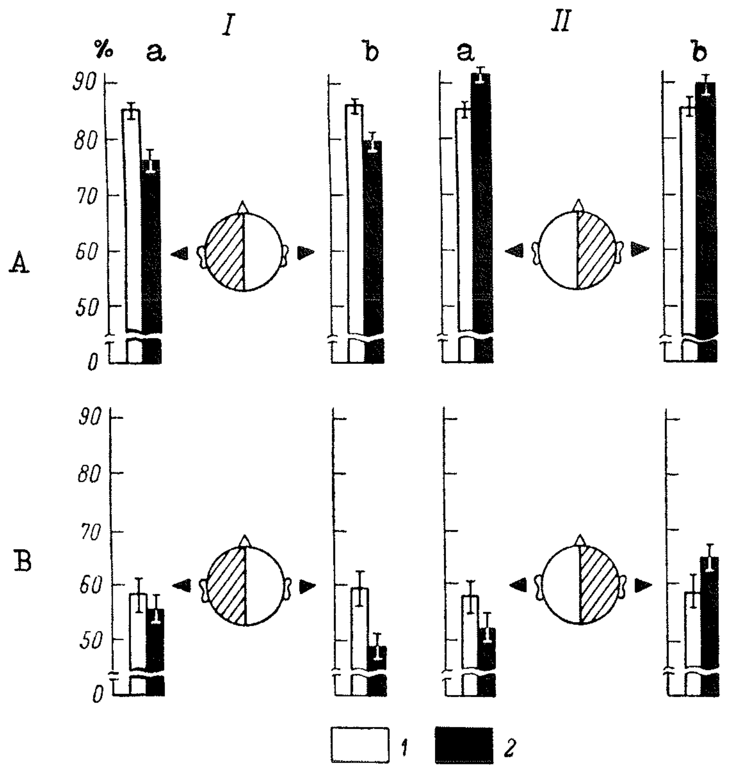


Figure 7

Recognition of vowel sounds of 100 msec duration (A) and 60 msec (B) before and after unilateral ECT. In the period of inactivation of the left (I) and right hemisphere (II). Recognition of vowel sounds (%) before treatment (1), and in the period of inactivation (2). Changes on the left ear (a) and right ear (b) respectively.

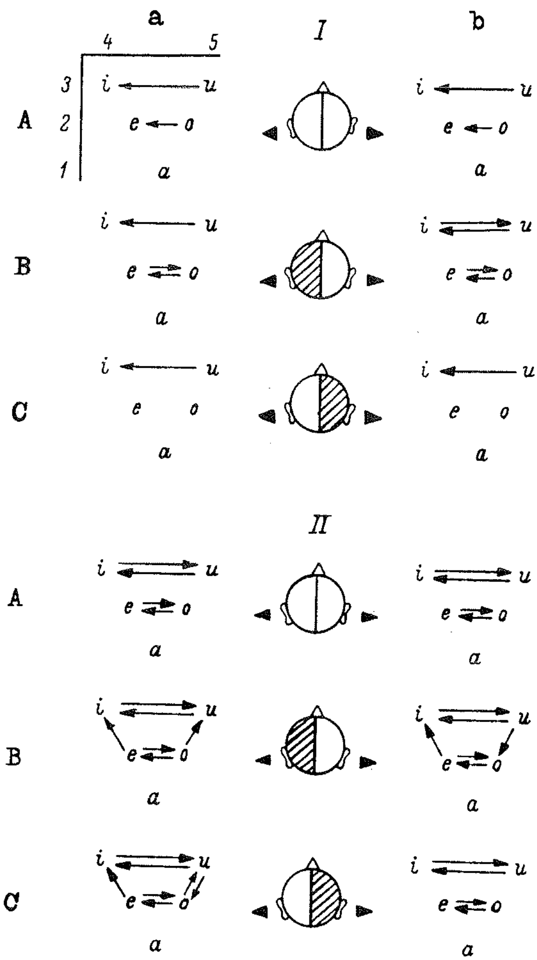


Figure 8

Failures in recognition of vowel sounds of 100 msec duration (I) and 60 msec (II) after unilateral ECT. Most frequent types. (A) Before treatment, (B) after left hemisphere inactivation, (C) after right hemisphere inactivation. Changes on the left ear (a), and right ear (b) respectively. Low (1), mid (2), high (3), front (4), and back vowels (5).

As regards the most remarkable finding in these experiments, viz. that there is a systematic confusion of vowels of the same height in the direction velar to nonvelar, I am inclined to be sceptical. I can see no immediate explanation of the phenomenon. It may be due to poor recordings or circumstances surrounding the presentation of the stimuli, but the reason could possibly also be traced to some hitherto unknown property, acoustic or psychological, connected with vowel height. The issue therefore merits further study.

In the very last chapter of the book Balonov and Deglin suggest an evolutionary explanation, which runs approximately as follows. They claim that all higher mammals are equipped with an innate ability to discriminate vocal sounds as long as the quality in question depends upon the position of the first formant. Man, however, is unique in possessing the ability to discriminate sounds that are identical with respect to the position of the first formant but different with respect to the position of the second formant. The authors suggest that, after ECT, the brain reverts to an infrahuman state and the ability to interpret the significance of the second formant is lost. Hence, they conclude, the reported confusion of vowels of the same height.

I want to question the validity of this explanation. Actually, I query that man is unique in discriminating sounds distinguished by F2 and above all I query the assumption that results obtained from ECT can be used as a means for detecting hidden traces of evolution in the human brain.

15. DISCRIMINATION OF MASKED AND FILTERED WORDS

As a complement to the investigations reviewed in Section 13 Balonov and Deglin designed tests in order to study the effect of white noise and filtering on word discrimination.

For the first of these experiments the discrimination of words in silence was measured at the levels 60 and 80 dB above the threshold. Then the measurements were repeated with white noise added 50 dB above its individual threshold. The difference between the discrimination in silence and noise was taken to be the effect of the masking. The thresholds for discrimination of speech in noise were also determined. 9 subjects were investigated before and after 19 unilateral ECTs (10 to the left and 9 to the right).

In the control tests there was only a small effect from the masking - less than 10% - and no significant differences between the ears. After left hemisphere treatment the picture was by and large the same as in the control. After right hemisphere treatment on the other hand the discrimination ability decreased dramatically on both ears (cf. Figure 9). It is to be observed that this change cannot be explained as a shift in general discrimination ability, since the thresholds remain the same (cf. Section 7).

In the second experiment the discrimination of words was measured at a level 60 dB above the threshold. The word stimuli were then filtered at the frequencies 750 and 1600 cps. The loudness of the resulting signals was adapted to that of the original non-filtered stimulus. The difference in discrimination ability between the two kinds of signal was taken to be the effect of the filtering. 10 patients were investigated after 24 unilateral ECTs (12 left and 12 right).

It turned out that filtering at 750 cps generally had only slight effect. The differences between the hemispheres were also only slight and not significant. When a signal filtered at 1600 cps was used the outcome was different. In this case filtering produced considerable effects already before ECT. The effect was however smaller after left-sided treatment than in the control test, whereas the inactivation of the right hemisphere led to a considerable decrease in discrimination ability. In both cases the effects were significant ($\underline{p} > 0.05$) and there were no differences between the ears.

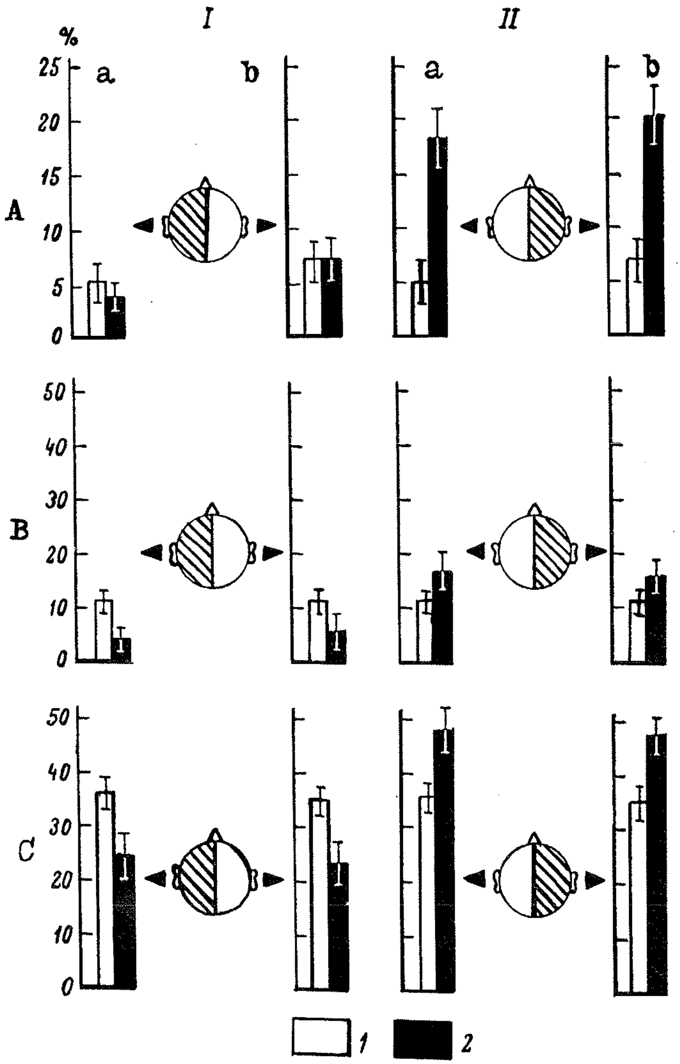


Figure 9

Effects of masking with white noise (A), bandpass filtering at 750 cps (B), bandpass filtering at 1600 cps (C), by magnitude of the impairment (%). Other symbols as in Fig. 7.

On the basis of these experiments together with the experiments reviewed in the two preceding sections Balonov and Deglin draw the general conclusion that all linguistic materials (words, syllables, and phonemes, consonants as well as vowels) are processed by the left hemisphere. This conclusion is drawn from the fact that the understanding of such items is impaired only by left hemisphere inactivation. On the other hand, failures due to "semanticizing" - a tendency to guess or to adapt the response to probability - decrease considerably when the left hemisphere is non-functioning. This was taken to indicate that there may be a certain homeostatic mechanism, regulating the functioning of the hemispheres in perceiving linguistic material. Since the inactivation of the left hemisphere, they argue, leads to a loss or impairment of analytic ability, it follows that the mechanism allowing the individual to make use of the statistic laws of his mother tongue also gets lost. Conversely, right hemisphere inactivation will lead to an exaggerated use of statistic laws, since the individual now has been deprived of the ability to make a proper synthesis. Accordingly, the number of "semanticizing" failures will rise, and in fact it does.

This is an attractive hypothesis, and it is compatible with the model proposed in Section 6 above. In addition it explains why white noise and filtering radically reduce the discrimination ability. Balonov and Deglin are of the opinion that the right non-dominant hemisphere actually has a dual role in speech perception. On the one hand it regulates the extension of the signal, gives the signal its gestalt so to speak. On the other hand it also seems to play a specific role in foregrounding the linguistic message and backgrounding disturbances. As a matter of fact, the hypothesis encompasses, in a very appealing way, the so-called cocktail party effect. Masking experiments in synthetic speech perception (Liberman & Studdert-Kennedy 1977) indicate that the receiver system as a whole has an ability to extract data of relevance from the signal and ignore non-relevant information (cf. Spliid & Andersen 1980, 3). If this ability of the brain to single out relevant categorical information really is to be referred to lateralized functions, then a step forward is made in our understanding of the neurology of cognitive functions. Ultimately this view entails that linguistic processing is a complex of two modes of cognition, an analytic and foregrounding (dominant) mode on the one hand and a synthetic and backgrounding (non-dominant) mode on the other. The general theory of the different cognitive styles of the two hemispheres now follows plainly without need for further explication.

16. FORMANT FREQUENCY CUES FOR VOWEL PERCEPTION

Numerous psycholinguistic experiments have shown that we are very apt to discriminate speech sounds with respect to category boundaries determined by our native language, whereas there is a clear tendency for us to ignore sound differences within language-specific categories. Miyawaki & al. (1975) demonstrated, for example, that stimuli that varied in small steps from [ra] to [la] were perceived relatively categorically as /ra/-/la/ by English-speaking subjects, whereas Japanese speakers' performance at the [r-l]-boundary was almost as poor as that of the English-speaking subjects within their /r/ and /l/ categories respectively. Thus it is clear that the native language and its categories has a tremendous influence on our perception. On the other hand, it is also evident that we are able to and to a certain extent actually do categorize sound differences within the language specific categories. As a matter of fact, many languages reflect such redundant categorical discrimination in their spelling system.

Russian is such a language. Traditionally Russian is said to have five vowel phonemes in stressed positions. Each of these phonemes has several allophones, many of which the native speaker is completely unaware of. The five phonemes are rendered orthographically with 9 separate letters (10 different paired letters in a restricted set of texts). The distribution of allophones with respect to the paired vowel letters is, by and large, equal with one exception: the pair ы - и, both representing the phoneme /i/. The letter ы always represents the allophone [ɨ], while и with some few exceptions represents the allophone [i]. The two sounds, the palatal [i] and the velar [ɨ], both high and unrounded, are true allophones in complementary distribution, [ɨ] being used after a non-palatal consonant and [i] otherwise. Nevertheless the two variants are perceived as categorically different vowels. That is to say, a Russian native speaker easily discriminates the two variants from each other and has no difficulty in using the two orthographic signs correctly as a response to, for example, the spoken names of the letters in question. This means that the two sounds are psychologically salient categories without having a linguistically independent status.

Balonov and Deglin are evidently fully aware of Studdert-Kennedy's (1974) four stages of perception. In fact, it could be argued that the author's aim when designing the experiments and writing the book was to relate this model to the hemispheric lateralization of different cognitive functions. Thus the first part of the book (chapters 2-4, reviewed in Sections 7-9 above) gives evidence for an auditory analysis of the signal. Perception at this level is not lateralized. The second part of the book (chapters 5-7, reviewed in Sections 10-15 above) identifies a phonetic stage of perception, where the listener puts the acoustic cues together and classifies the percepts as being categorical, i.e. either linguistic or non-linguistic. The phonetic stage is therefore the level of at least partly lateralized categorical perception. At the third stage, that of phonological perception, the listener uses the statistical laws of his native language and adjusts the phonetic perception arrived at in the phonetic stage to conform to the constraints imposed by the language specific categories. How this phonological stage of perception is related to the functional specialization of the brain is the main issue treated in the final part of the book (chapters 8 and 9). The fourth stage of analysis in Studdert-Kennedy's model, that of grammar generally (lexicon, syntax, semantics), is not covered by any part of Balonov's and Deglin's work.

In Traugott (1979, 72ff.), an experiment, performed by Balonov, Deglin and I.B. Dolinina, is reported. Its outcome amounts to saying that the left hemisphere alone performs syntactic operations with a higher degree of "syntactic depth" (counted in terms of attributive complements or embeddings to a given syntactic structure) than the two hemispheres in cooperation. The single right hemisphere, on the other hand, is said to do significantly worse in this respect. Since no information is given about how the "syntactic depth" was measured and no examples or other data are presented, it is impossible to evaluate the experiment here.

In tackling the issue Balonov and Deglin first draw a distinction between what they call "linguistic" and "psychological" phonemes, corresponding to units of the phonological and phonetic stages of analysis respectively, i.e. what is usually referred to as phonemes and allophones in ordinary linguistic jargon. Support for such a distinction is taken from Bondarko & al. (1966), where it is shown that Russian native speakers are able to discriminate no fewer than 18 distinct vowel qualities. The reason for this is that the listener can infer from the vowel quality as such whether the preceding and/or following consonants are palatalized or not. This fact, however, does not mean that the boundaries between different "psychological phonemes" are just as clear-cut as the boundaries between phonemes established by a linguistic procedure. In fact, they are not. Rather, discrimination within the limits of a linguistically determined vowel category would probably be just as poor as that of Japanese speakers judging liquids, if there is no indication of context at all. Such cases are possible to devise. A general phonotactic constraint of Russian prohibits a word from beginning with the allophone [ɨ]. Nevertheless Russians tend to pronounce certain geographical names of non-Russian origin with this allophone as the initial sound. So Irtyš is often pronounced [ɨr'tɨš] as opposed to Irkutsk, which is normally pronounced [ir'kutsk] with the palatal variant. I do not know of any psycholinguistic study using such pairs as material, so I cannot judge what status such variation has psychologically. A fair guess, however, is that a Russian speaker, presented with the first syllable of any of these words for identification of the whole word, would not be able to fulfill the task properly.

Be this as it may be. No doubt the distinction between psychological and language specific categories is clear enough. The question now arises, what specific properties are typical of the language specific categories as opposed to the psychological ones. As regards vowels, Balonov and Deglin claim one such property to be hidden in the well-established significance of the relation between the first two formants.

Investigating this hypothesis, they used 46 synthesized vowel-like stimuli, 400 msec long, with constant F3 and F4 at 2200 and 3250 cps respectively and a F0 rising linearly from 100 to 125 cps. The stimuli were spread over the spectral area as indicated in Figure 10B. Originally they were produced by the Laboratory of Cybernetic Acoustics of the Polish Academy of Sciences and previously used for psycholinguistic investigations by Slepokurova (1972) -

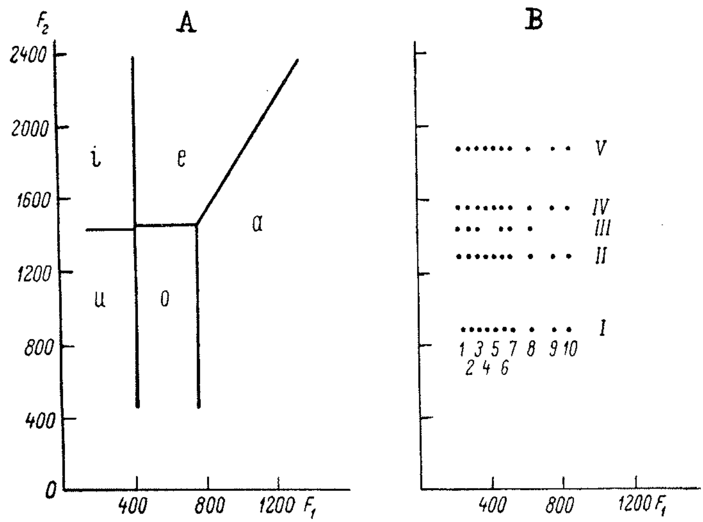


Figure 10

(A) Phoneme boundaries for spectral areas of Russian vowel phonemes defined by the first two formants according to Slepokurova (1972). (B) Set of stimuli used in Balonov & Deglin for investigating phoneme boundaries. Horizontally F1 and vertically F2 frequency in cps. Numbers (Roman and Arabic) indicate the place in the spectral area for each stimulus used.

unfortunately it was impossible for me to get access to this book. By systematically varying F1 with a fixed F2 and F2 with a fixed F1 they were able to determine the phoneme boundaries for the five linguistic vowel phonemes of Russian as follows. The subjects had to classify each presented stimulus as one of the five phonemes. The 50% intersection between phoneme decisions was subsequently taken to be the boundary between the spectral areas of the phonemes in question. The F1 boundary between /i/ and /e/ on the one hand and /u/ and /o/ on the other was thus determined to be 420 cps for both pairs, the F1 boundary between /o/ and /a/ 600 cps, and the F2 boundary between /o/ and /e/ 1090 cps. No value is given for the F2 boundary between /i/ and /u/, but the plotting charts indicate that it was approximately 1050 cps.

The angle for the boundary between /a/ and /e/ was determined as 34°. As can be seen from Figure 10A these values are quite different from those of Slepokurova (1972). Balonov and Deglin suggest the reason for the difference is that while Slepokurova presented the stimuli to her subjects in random order, they proceeded themselves systematically towards the boundaries. The authors also point out that their subjects might have been influenced by the boundaries of the psychological phonemes.

Before reviewing the experiments a few comments on the authors' choice of targets must be made. According to the text the following segments were presented to the subjects as targets for phoneme identification: [u, o, ɑ, i, e], i.e. the same vowels as those allegedly used as stimuli for the perception tests reviewed in Section 13 above. In reality the stimuli were the spoken names of the Cyrillic letters у, о, а, э and ы (i.e. [u, o, a, ɛ, ɨ]). This can be seen from the plotting charts, where these very letters are used to signify the responses. No formant values for the target vowels are given. To provide the reader with an approximate conception of the vowel qualities concerned I give here the frequencies for F1 and F2 as reported by Fant (1970, 109) and Jones in Halle (1959, 151 ff.):

	F1	F2	
[u] = у	300	625	(Fant)
[o] = о	535	780	(Fant)
[a] = а	750	1300	(Jones - context /at/)
[ɨ] = ы	300	1480	(Fant)
[ɛ] = э	450	1625	(Jones - context /ep/)

Of the above figures, Fant's values refer to one speaker whereas Jones' figures are means for three speakers and calculated for the context indicated. Fant's values for the vowels [ɑ, i, e] - N.B. not used as targets by Balonov and Deglin - are for F1 700, 240, 440 cps and for F2 1080, 2250, 1800 cps respectively. The principal implementations of the phonemes concerned are according to Jones [u, o, a, i, e]. It should be observed that Bondarko & al. (1966) in the above quoted paper claim Russian to possess six linguistic vowel phonemes, though without explanation or explicitly stating which they are. Presumably they found the [i] and the [ɨ] variants so salient as to motivate their status as independent phonemes even linguistically. Balonov's and Deglin's choice of the [ɨ] and [ɛ] variants as prototypical targets is therefore highly questionable and may have had a negative influence on the results eventually obtained from the investigation.

12 patients were used as subjects for the experiments. They were tested before and after 27 unilateral ECTs, 13 on the left and 14 on the right side of the brain. The 46 stimuli were recorded on tape and presented monaurally to the subjects with an interval of 2 seconds between each item at a level of 40 dB above the threshold.

The control tests revealed the same general regularities as already observed in investigations on normal subjects by Čistovič and her colleagues (Koževnikov & Čistovič 1965; Čistovič 1972). The phoneme boundaries turned out to be rectilinear and largely parallel to the F1 and F2 axes, and common to different pairs of phonemes (cf. Figures 10 and 11). There was some variation in phoneme boundaries, both interindividually and intraindividually. Normally this variability did not exceed 100 cps, though in some cases the variation for the F2 boundaries could be more than 200 cps. This variation, however, is commonly encountered in normal subjects both with respect to the perceptual areas and the specific formant frequencies of different vowels.

Neither left nor right hemisphere inactivation affected the average formant positions. On the other hand there occurred remarkable differences with regard to the magnitude of uncertainty. Thus after left hemisphere treatment both the uncertainty of formant perception and the range of the areas of uncertainty grew considerably. The fluctuations were random and multidirectional, and their amplitude rose considerably as compared with the control tests. They were most outspoken in the regions close to F2. Such differences were noticed both for the group as a whole and individually. The fluctuations were typical also of individuals who did not show noticeable inconsistencies in the control tests before the treatment. Another peculiarity observed with dysfunctional left hemisphere was the character of the responses. Quite generally the patients had difficulties in identifying the stimuli as representatives of specific phonemes. This happened very frequently with stimuli close to the phoneme boundaries and often led to the subject's refusal to fulfill the task. Instead he tried to imitate the stimulus and, it should be observed, was generally successful in his imitation.

Such information is intriguing. However, it does not make the evaluation of the authors' propositions any easier. For if a large proportion of the subjects actually refused to answer properly or did not understand the task, then the indeterminacy alleged to follow from left hemisphere inactivation might come from the investigators themselves and not necessarily from the investigated subjects. The failure to complete the task satisfactorily could just as well be explained with reference to reduced ability to interpret the experimenters' verbal instructions as from reduced ability in categorical discrimination. Moreover, if the imitations have been included in the data as instances of uncertainty and the authors thus themselves have determined the identification by interpreting the imitation, then the claim that the phoneme boundaries become less sharp as the areas of uncertainty increase after left hemisphere treatment could well be erroneous. Unfortunately, the authors do not tell us how they classified such responses.

After right hemisphere treatment the picture was quite different. The phoneme boundaries became clear-cut for different subjects, and the individual boundaries fluctuated less. The majority of the subjects did not reveal any fluctuations at all. Many of the stimuli yielded identical responses from all investigated subjects. In some cases there was no overlap at all between categories as can be seen from Figure 11. There was no tendency to imitate and those patients who had tried to imitate the quality of the stimulus after left ECT now classified the stimuli as representatives of specific linguistic phonemes without hesitation, ignoring qualitative differences between the stimuli.

No significant differences between the ears were observed, neither in the control tests, nor after ECT on either side.

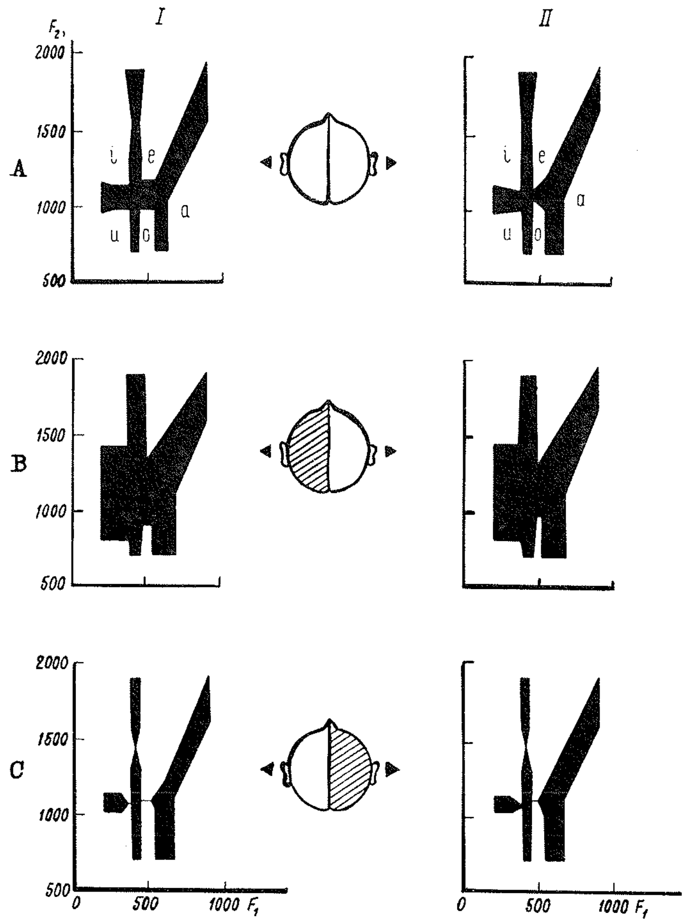


Figure 11

Zones of uncertainty ($\bar{x} \pm \sigma$) in the regions of phoneme boundaries after unilateral ECT. (A) Before treatment, (B) and (C) during inactivation of the left and the right hemisphere respectively. (I) and (II) Performance by the left and the right ear respectively.

There is reason to be cautious in evaluating these experiments, since the authors' claims are not backed up by any published data. The only results given are the plotting charts, recording different responses by the group of subjects as a whole, charts of the average phoneme boundaries, charts of areas of uncertainty (Figure 11), and an identification curve for the F1 of the phoneme /e/, claiming 100% correct identification within the F1 range 450-600 cps after right hemisphere inactivation, approximately 90% correct identification in the same frequency range before treatment and a continually rising curve for correct identification after left hemisphere inactivation with a maximum at around 80% positive responses at a frequency of 600 cps. However, it is impossible to judge whether these charts were correctly designed. Nor are the plotting charts and the areas of uncertainty compatible, as far as I can tell. The authors' interpretation may be well founded but since no individual data are presented, no decisive conclusions can be drawn. There is no way of checking whether or not Balonov and Deglin have read too much into their results or have let their initial hypotheses (concerning possible mechanisms underlying the functions of linguistic as opposed to psychological phonemes) influence the interpretation of the results.

Their first conclusion is that phoneme boundaries can be seen as acoustic correlates to perceptually differentiating features of the vowels: F1 closely correlated to the dimension high-low and F2 to the dimension front-back. This observation is not sensational and has been generally agreed upon at least since Joos (1948). Balonov and Deglin, however, go on to claim that F2 position is a more salient feature than F1, since F2 discrimination is a species specific cue (cf. Section 14). I doubt that this really is so, but the data available do not permit any kind of control. The issue should therefore be subjected to future research.

Balonov's and Deglin's second conclusion is equally challenging but more interesting. Since the average positions of the phoneme boundaries remained unchanged under all circumstances, while the areas of uncertainty widened or narrowed after left and right hemisphere ECT respectively, they suggest that the ability to distinguish between different vowel stimuli at the transitions between specific spectral maxima is a function neither of the right nor of the left hemisphere. That is to say, this is a non-lateralized feature of speech perception. They suggest that man is born with an innate, prefabricated mental net of phoneme boundaries that is tighter than that of any particular language and common to all languages. The meshes of this innate net are responsible for the psychological phonemes, whereas the contours of the linguistic phonemes result from some kind of fusion of the innate meshes according to the pattern or gauge typical of the specific language. The formation of a system of linguistic phonemes would then equate a procedure allotting definite values to some of the innate categories to the exclusion of giving linguistic significance to others. Subsequently, this would lead to the ability to ignore qualitative variance within linguistically defined and determined categories.

They find support for this hypothesis in Stevens & al. (1969). One might also cite categorical perception experiments suggesting uniformity in the voice onset time that infants can attend to (such as Eimas & al. 1971, Eimas 1975, Morse 1974) for further support for an innate universal language mechanism. The hypothesis further implies that the right hemisphere retains an ability to attend to and perhaps direct the rest of the brain's attention to features of speech that are not language-specific, whereas the left hemisphere is responsible for processing language-specific distinctions. In other words, the right hemisphere "knows" what distinctions are relevant for human language, but the left hemisphere chooses and learns the parameters that must be fixed for the specific language being used.

Although Balonov's and Deglin's conclusions are speculative, they do conform with Kinsbourne's (1971) proposal of a bihemispheric potentiality for language while simultaneously adding a new dimension. Not only do they account for right hemisphere take-over of linguistic functions in aphasia, they also explain the apparently greater ease with which the right hemisphere takes over semantic as opposed to syntactic and phonological functions when the left hemisphere is damaged. Indeed, there is evidence that semantic functions may be less language-specific than phonological and grammatical functions.

17. PARALINGUISTIC AND PROSODIC PERCEPTION

The concluding experiments reported in the book were designed in order to investigate the roles of the two hemispheres in decoding prosodic features in the speech signal. The experiments were divided into two series, the first of which was arranged so ignorantly that nothing whatsoever can be benefitted from it. Four stimuli, allegedly taken to represent a male and a female pronunciation of the phonemes /a/ and /i/ respectively, were produced synthetically with the following fundamental and formant frequencies: 120, 700, 1080, 3000 (male /a/), 120, 250, 2300, 3000 (male /i/), 240, 820, 1165, 3300 (female /a/), and 240, 300, 2900, 3300 (female /i/), (F0, F1, F2, F3 respectively). The stimuli were presented to the subjects monaurally at a level 40 dB above the threshold with two different durations: 30 and 75 msec, each stimulus being repeated three times. The subjects had to determine whether the stimuli could be recognized as realizations of the phonemes /a/ or /i/ pronounced by a male or a female voice. 7 patients were investigated before and after 14 unilateral electroconvulsive stimulations (7 on each side).

Vowels of durations 30 and 75 msec occur only in a sequence of several syllables, and can hardly be examples of speech sounds in isolation. Nevertheless the quality and the pitch of such signals are recognizable as "dull"/"light" and "low"/"high" respectively. Thus if one requires a subject to translate these subjective qualities to the parameters /a/-/i/ and male-female, then, of course, the subject is quite capable of giving seemingly consistent responses. However, such forced responses do not indicate that the subjects in any factual meaning really identify the stimuli with speech sounds and male and female voices. Besides, there are more differences between a typical male and a typical female voice than those produced by pitch and formant frequencies.

The authours - assisted by the same A.V. Baku mentioned in Section 14 - claim that very significant differences occurred with dysfunctional left vs. right hemisphere with respect to the above mentioned qualities. Thus after left-sided unilateral ECT the subjects are said to be unable to distinguish along the dimension dull-light, whereas after right-sided ECT they can no longer recognize the difference in pitch. It is impossible to conclude logically from such data that the right hemisphere is unable to recall linguistic categories, while the left hemisphere cannot hear the difference between male and female voices. None the less, this is the ridiculous conclusion drawn by the authors.

The second series of prosodic experiments is primitive from a linguistic point of view. When investigating prosodic features of the speech signal, the natural thing to do is to take linguistic theories as a point of departure. Since the investigated language is Russian, one should therefore expect references to e.g. Bryzgunova (1969). The authors seem quite unaware of the existence of linguistic research in the realm of prosodics, and consequently they base their experiments on random guesses as to which features of the intonational pattern of an utterance are linguistically relevant and which are not. This does not mean, however, that this series of experiments is quite as useless as the first series. But it still does not attain the standard of other experiments reported in the book.

The experiments were designed as follows. Two sequences of meaningless syllables - [an ťɛr f'ɨr soł] and [ɛk mɛs šo zu] - were recorded on tape and spoken with exaggerated intonations, rendering on the one hand emotional moods (anger, joy, surprise, irritation), on the other grammatical meanings (interrogative, imperative, and declarative intonations). Now it is questionable whether imperatives in Russian are accompained by an obligatory phonologically salient intonational pattern. As for interrogatives, however, there are intonation differences for yes-no questions. There are, actually, two types of such interrogatives in Russian, the one being morphologically marked and indicating that the speaker expects a positive reply to a positive question and a negative reply to a negative question, the other one being signalled only by intonation and without implying such prior expectations. A total of 20 stimuli were recorded in random order. For each phrase the subject had to determine what kind of paralinguistic or grammatical content was conveyed by the intonation. The task turned out to be too difficult in many cases. Therefore, when no conclusive response could be obtained at the first try, the investigators put a more specific question, e.g. "Is this phrase pronounced in an angry, joyful, or surprised way?". If this was not successful either, a plain yes-no question was put: "Is there surprise in this phrase?", "Is there a question in this phrase?", and so on. The responses were counted separately for correct answers, independent answers, answers to alternative and to straight questions, and also refusals ("I don't know", "I don't understand"). Simultaneously the latency of the correct answers was measured. In some of the experiments the patients also had to imitate the stimulus. A total of 9 subjects were investigated before and after 18 unilateral ECTs (9 on each side).

Neither the control nor the post-seizure tests revealed any significant differences between the ears. In all conditions it turned out that imitation of intonational contours was considerably harder than identification. In the control tests the patients managed to imitate correctly about half of the examples.

With dysfunctional right hemisphere the identification of intonational patterns decreased considerably (from 77 ± 2 to $47 \pm 4\%$ correct identifications). No individual figures are given. However, it should be observed that an unspecified number of patients were not affected by the treatment, whereas other patients who had had no difficulties in fulfilling the tasks in the control tests now became totally disorientated and lost their identification ability. They listened carefully to the "phrases", but ended up with shrugging their shoulders and expressing utter ignorance. They answered typically with utterances like "Very hard to say", "I don't know", "I don't understand", "Difficult to catch", and so on. Very often they simply declared that they could not find any differences between the stimuli. They all sounded alike.

The deterioration also showed up in a dramatic decline in the number of independent responses. Even with help the patients delivered their answers with hesitation and uncertainty. The ability to imitate the stimuli also decreased considerably. Usually the patients simply refused to try to imitate. In the few instances where they eventually made an attempt, they failed without exception. That is to say, even if they could make a correct identification, they still lacked the accurate control of the motor mechanisms needed for producing intonational contours.

With dysfunctioning left hemisphere, the identification ability was better than in the control test and rose to 90% correct identifications. The subjects even began to recognize intonation types that they could not identify before the treatment. There was no difference between the ears and practically no refusals occurred. The improvement was observed in 6 of the 9 cases.

In the initial stages, the responses were hampered by dysphasic disturbances, but once these had passed over the patients began to give independent and correct identifications. In addition the latency of the responses decreased as compared with that of the control tests.

Grammatical intonations were generally identified better than emotional intonations both before and after ECT and independently of which side of the brain that was inactivated. The decline in identification ability was by and large the same for the two types of stimuli. Only with regard to the number of spontaneous, independent responses was there a significant difference after right hemisphere treatment in favour of grammatical intonations, but all types of responses taken together yield the same result: there was no difference in overall ability between the two hemispheres in interpreting intonations conveying primarily emotive connotations or expressing linguistic distinctions. The authors conclude from this specific experiment that the right hemisphere alone is somewhat better in identifying intonations than the two hemispheres in cooperation, and, vice versa, that the left hemisphere is inferior to the right one in intonation identification.

This is a little surprising, since we would have expected intonations rendering grammatical functions to be less affected by right hemisphere ECT than those signalling moods. All available data - including other research by Balonov and Deglin - unequivocally point to the fact that it is language, rather than the acoustic stimulus alone, that is lateralized. For certain kinds of grammatical information it seems that pitch and tone modulation are just as effectively handled by the left half-cerebrum as "segmental" properties of the speech signal. For example, Haggard & Parkinson (1971), using dichotic listening techniques, showed that when pitch was used linguistically to distinguish voiceless consonants from voiced ones, a right ear advantage resulted. Similarly Van Lancker & Fromkin (1973) found that recognition by the right ear was superior for Thai words when pitch was the important cue (Thai is a tone language), while hummed pitches corresponding to the same words showed no ear difference.

It is possible that Balonov's and Deglin's failure to find lateralized differences between grammatical and emotive intonations is due to the clumsy design of their experiments. On the other hand, the results are consistent with previous investigations of sentence intonation. In two excellently designed dichotic listening experiments, Blumstein & Cooper (1974) found a left ear advantage for intonation contours serving linguistic function. They found the explanation for this phenomenon, as constrasted to the contrary observation of Van Lancker & Fromkin (1973), in the nature of word accent and sentence intonation contours in the linguistic message. Accent contours distinguish individual words, whereas intonation contours distinguish different sentence types (Blumstein & Cooper 1974, 155f.). They therefore conclude that the right hemisphere is directly involved in the perception of intonation contours, and that normal language perception involves the active participation of both hemispheres.

This is also Balonov's and Deglin's conclusion. They claim that prosodic features of speech are especially connected with the activity of the right hemisphere. This applies both to the perception and production of prosody, since right hemisphere inactivation typically produces dysprosodic disturbances - dysphonia and even global aphonia. For this reason they find it justifiable to speak of a specific prosodic component of grammar, using a different channel and, consequently, having a different neurological foundation from the verbal component.

18. CONCLUSIONS

The final chapter of Balonov's and Deglin's book summarizes the content of the previous chapters, highlighting the most important findings and hypotheses. More specifically they linger upon the role of the right hemisphere in speech perception as a filter or a back-grounding device, which at the same time puts the linguistic percept into focus and interferes with or inhibits the efficacy of the left hemisphere in its work as a speech analyst. However, since I have discussed this model fairly exhaustively above, I will conclude my review with some personal comments of my own.

My initial purpose in writing this review was simply to give linguist colleagues a survey of a piece of neuropsychological work I considered relevant for linguistic research. As I penetrated different issues, more and more details turned out to be problematic in a way that I could not foresee from the very beginning.

Firstly, I became concerned over the ethical question. Let me say at once that already after the first reading of the book I felt uneasy about the authors' ethical standards. My initial suspicions were at first the expression of the layman's usual aversion to ECT as medical treatment rather than the result of rational considerations. I accepted, however, the authors' assertion that the treatment was necessary and medically motivated. Then while I was considering the aphasic disturbances following from unilateral ECT I realized that I had to study the seizure technique and its ethics more thoroughly. Having done so, I became aware of the difference between Western and Soviet practice and that unilateral electrocovulsive treatments not followed by generalized, bilateral cerebral epileptic seizures are of doubtful therapeutic value. It is not clear from the book whether the authors have deliberately sought to limit the seizure to one hemisphere only, but that this is probably the case is implicit in indirect evidence given by Traugott (1979). Balonov and Deglin ought therefore explain factually, step by step, exactly how they proceeded. Otherwise they cannot be cleared from the suspicion of performing unethical experiments on human beings.

My second problem concerns the reliability of ECT as a method for selectively inactivating one hemisphere. Although it is technically possible to produce unilateral (hemispheric) or focal seizures, this does not necessarily imply that one can get such distinct differences between the hemispheres as Balonov and Deglin claim to have obtained. At least d'Elia (personal communication) does not believe it to be possible, and other psychiatrists have expressed their scepticism. They criticize especially the allegedly induced aphasia (Sections 4-5). They point out that even though transient aphasia may occur after ECT, this is only one component in a more complex phenomenon that they simply label as post-seizure confusion. They insist it is practically impossible to distinguish dysphasic disturbances from impairment of consciousness and conceptual disorder. All features are hopelessly intermingled (cf. d'Elia 1970, 83). Moreover, incoherent language occurs during sleep or following intoxication by drugs or alcohol, without the same person being classified as aphasic. So why should the same not be true of patients knocked out by electrical current? With regard to the so-called chronological regression (Section 5) d'Elia queries whether the patient simply isn't dizzy, half asleep and confused rather than inflicted by a distinct pathological syndrome. I am inclined to believe in the inherent correctness of Balonov's and Deglin's observations, but I admit that there are difficulties and that they should be kept in mind.

The two points just considered, the ethical question and the question of the reliability of the results made me doubt the value of publishing this review at all. I am faced with a moral dilemma, because whichever way I turn, I will be an accessory party. Moreover, my initial purpose in writing the review has barely been fulfilled. It now deals more with neuropsychology and less with linguistics than I originally intended.

The reason why I have nevertheless decided to publish are the following. I have done my best to give an unbiassed presentation without excluding praise or embarrassing criticism. I am convinced the review gives a true picture of the content of the book and the initiated reader should be able to take a personal stand on what is presented. In addition I have contrasted and compared the results and the discussions with other data drawn from a wide cross section of works in neuropsychology, psychopathology, and psycholinguistics. Hopefully, this complementary information might contribute to a better understanding of the relations between cerebral structures and language.

In spite of the neuropsychological bias in the review, I consider the topics treated above to be highly relevant for linguistics proper. I say this because it is quite meaningless to construct linguistic theories without taking neuropsychology, psychopathology, and, it should be added, neurology into due consideration. It is a common vice of modern linguistics, even among such representatives as claim linguistics to be a branch of biology, that considerations of this kind are not entertained.

At the same time, neuropsychology is, in many respects, quite as immature and speculative a science as linguistics ever has been. It is important not to take neuropsychological assumptions or hypotheses to represent some kind of truth or even indisputable scientific facts. Consider how uncritically a linguistic concept such as "deep structure" has been transposed into psychology, psychoanalysis and education, where it takes on a new meaning, only to be brought back into linguistics in the guise of a "proof" for the alleged existence of the animal in question. The danger that this could happen to neurolinguistics is always imminent. The neuropsychologist must learn to distinguish which linguistic structures really are possible or relevant, before starting to test neurological correlates of linguistic concepts. Conversely, the linguist must learn something of what neuropsychology really is about in order to help the neuropsychologist pose meaningful questions about biologically determined features of language. Not least important, the linguist himself must learn what questions and propositions are reasonable, given the present state of knowledge of the human brain.

REFERENCES

Balonov L.Ja. & Kaufman D.A. (1974). O vlijanii nespecifičeskix sistem mozga na ėffekty predšestvujuščej maskirovki. 25-e soveščanie po problemam vysšej nervnoj dejatel'nosti, posvjaščennoe 125-letiju so dnja roždenija I.P. Pavlova. Materialy sekcij i zasedanij. Moskva: 37-38

Blumstein S. & Cooper W.E. (1974). Hemispheric processing of intonation contours. Cortex 10:2: 146-158

Bondarko L.V., Verbickaja L.A., Zinder L.R. & Pavlova L.P. (1966). Različaemye zvukovye edinicy russkoj reči. Geršuni G.V. (otv.red.). Mexanizmy rečeobrazovanija i vosprijatija složnyx zvukov. Nauka, Moskva & Leningrad: 165-179

Bradshaw J.L. & Gates E.A. (1978). Visual field differences in verbal tasks: Effects of task familiarity and sex of subjects. Brain and Language 5: 166-187

Bryzgunova E.A. (1969). Zvuki i intonacija russkoj reči. Nauka, Moskva

Buffery A.W.H. (1974). Asymmetrical lateralisation of cerebral functions and the effects of unilateral brain surgery in epileptic patients. In Dimond & Beaumont: 204-234

Buffery A.W.H. & Gray J.A. (1972). Sex differences in the development of spatial and linguistic skills. Ounsted C. & Taylor D.C. (Eds.). Gender differences: Their ontogeny and significance. Churchill Livingstone, London: 123-151

Čistovič L.A. (1972). Modeli i metody psixoakustičeskogo ėksperimenta. Fiziologija sensornyx sistem. Čast' 2. Nauka, Leningrad: 311-317

Clyma E. (1975). Unilateral electroconvulsive therapy: How to determine which hemisphere is dominant. British Journal of Psychiatry 126: 372-379

Curry W.K. (1967). A comparison of left-handed and right-handed subjects on verbal and non-verbal dichotic tasks. Cortex 3: 343-352

Dahlin O. (O. von Dalin) (1745). Berättelse om en DUMBE, som kan siunga. Kongl. Swenska Wetenskaps Academiens Handlingar, för månaderne Aprilis, Majus ock Junius, 1745. Vol. VI. Stockholm: 114-115

Dimond S.J. & Beaumont J.G. (Eds.) (1974). Hemisphere function in the human brain. Elek Science, London

Dimsdale J.E. (1977). Emotional causes of sudden death. American Journal of Psychiatry 134: 1361-1366

Eccles J.C. (Ed.) (1966). Brain and conscious experience. Springer-Verlag, Berlin

Eimas P.D. (1975). Speech perception in early infancy. Cohen L.B. & Salapatek P. (Eds.). Infant perception: From sensation to cognition. Volume II. Perception of space, speech, and sound. Academic Press, New York: 193-232

Eimas P.D., Siqueland E.R., Jusczyk P. & Vigorito J. (1971). Speech perception in infants. Science 171: 303-306

d'Elia G. (Ed.) (1970). Unilateral electroconvulsive therapy. (=Acta Psychiatrica Scandinavica. Supplementum 215). Munksgaard, Copenhagen

d'Elia G. (1974). Unilateral electroconvulsive therapy. A review of current clinical issues. Fink M., Kety S., McGaugh J. & Williams T.A. (Eds.). Psychobiology of convulsive therapy. Winston V.H. & Sons, Washington, D.C: 21-34

d'Elia G. & Perris C. (1970). Seizure and post-seizure electroencephalographic pattern. d'Elia G. (Ed.). Unilateral electroconvulsive therapy. Munksgaard, Copenhagen: 9-29

Engel G.L. (1976). Psychologic factors in instantaneous cardiac death. New England Journal of Medicine 294: 664-665

Fant G. (1970). Acoustic theory of speech production. With calculations based on X-ray studies of Russian articulations. Mouton, The Hague & Paris

Fink M. (1979). Convulsive therapy: Theory and practice. Raven Press, New York

Gainotti G. (1972). Emotional behavior and hemispheric side of the lesion. Cortex 8:1: 41-55

Galin D. (1976). Hemispheric specialization: Implications for psychiatry. Grenell R.G. & Gabay S. (Eds.). Biological foundations of psychiatry. Raven Press, New York: 145-176

Galin D. & Ornstein R. (1972). Lateral specialization of cognitive mode: An EEG study. Psychophysiology 9: 412-418

Gazzaniga M.S. (1970). The bisected brain. Appleton-Century-Crofts, New York

Gazzaniga M.S. & LeDoux J.E. (1978). The integrated mind. Plenum Press, New York & London

Gazzaniga M.S., Risse G.L., Springer S.P., Clark E. & Wilson D.H. (1975). Psychologic and neurologic consequences of partial and complete cerebral commissurotomy. Neurology 25: 10-15

Gazzaniga M.S, Volpe B., Smylie C., Wilson D.H. & LeDoux J.E. (1979). Plasticity in speech organization following commissurotomy. Brain 102: 805-816

Geschwind N. (1974). Selected papers on language and the brain. Reidel, Dordrecht & Boston (=Synthese Library Volume 68)

Godfrey J.J. (1974). Perceptual difficulty and the right ear advantage for vowels. Brain and Language 1: 323-335

Gruzelier J. & Flor-Henry P. (Eds.) (1979). Hemisphere asymmetries of function and psychopathology. Elsevier, Amsterdam. (=Developments in Psychiatry. Volume 3)

Haggard M.P. (1971). Encoding and the REA for speech signals. Quarterly Journal of Experimental Psychology 23: 34-45

Haggard M. & Parkinson A. (1971). Stimulus and task factors as determinants of ear advantage. Quarterly Journal of Experimental Psychology 23: 168-177

Halle M. (1959). The sound pattern of Russian. A linguistic and acoustical investigation with an excursus on the contextual variants of the Russian vowels by Lawrence G. Jones. Mouton, 's-Gravenhage

Heilman K.M., Scholes R. & Watson R.T. (1975). Auditory affective agnosia. Journal of Neurological and Neurosurgical Psychiatry 38: 69-72

Jakobson R. (1980). With the assistance of K. Santilli. Brain and Language. Cerebral hemispheres and linguistic structure in mutual light. Slavica Publishers, Columbus, Ohio

Jakobson R. & Waugh L. (1979). The sound shape of language. Harvester Press, Brighton

Joos M. (1948). Acoustic phonetics. Language Monograph No. 23. Supplement to Language 24

Kimura D. (1961). Cerebral dominance and the perception of verbal stimuli. Canadian Journal of Psychology 15: 166-171

Kimura D. (1967). Functional asymmetry of the brain in dichotic listening. Cortex 3: 163-178

Kimura D. (1973). The asymmetry of the human brain. Scientific American 228: 70-78

Kimura D. & Durnford M. (1974). Normal studies on the function of the right hemisphere in vision. In Dimond & Beaumont: 25-47

Kinsbourne M. (1971). The minor hemisphere as a source of aphasic speech. Archives of Neurology 25: 302-306

Koževnikov V.A. & Čistovič L.A. (1965). Reč'. Artikuljacija i vosprijatie. Nauka, Moskva-Leningrad. Translated into English as Speech. Articulation and perception. Clearinghouse for Federal Scientific and Technical Information, JPRS, Washington, D.C., 1965: 30-543. (Only the English translation was available)

Lassen N.A., Ingvar D.H. & Skinhøj E. (1978). Brain function and blood flow. Scientific American 239: 62-71

Liberman A.M., Cooper F.S., Shankweiler D.P. & Studdert-Kennedy M. (1967). Perception of the speech code. Journal of Experimental Psychology 74: 431-461

Liberman A.M., Delattre P.C. & Cooper F.S. (1952). The role of selected stimulus-variables in the perception of the unvoiced stop consonants. American Journal of Psychology 65: 497-516

Liberman A.M., Harris K.S., Hoffman H.S. & Griffith B.C. (1957). The discrimination of speech sounds within and across phoneme boundaries. Journal of Experimental Psychology 54: 358-368

Liberman A.M. & Studdert-Kennedy M. (1977). Phonetic perception. Haskins Laboratories: Status report on speech perception. SR-50: 21-60

Luria A.P. (A.P. Lurija) (1973). Osnovy nejropsixologii. Izd. MGU, Moskva

Miller E. (1967). Psychological theories of E.C.T: A review. British Journal of Psychiatry 113: 301-311

Miyawaki K., Strange W., Verbrugge R., Liberman A.M., Jenkins J.J. & Fujimura O. (1975). An effect of linguistic experience: The discrimination of [r] and [l] by native speakers of Japanese and English. Perception and Psychophysics 18: 331-340

Morse P.A. (1974). Infant speech perception: a preliminary model and review of the literature. Schiefelbusch R.L. & Lloyd L. (Eds.). Language perspectives - acquisition, retardation, and intervention. University Park Press, Baltimore: 19-54

Ottosson J.-O. (Ed.) (1960). Experimental studies of the mode of action of electroconvulsive therapy (= Acta Psychiatrica Scandinavica. Supplementum 145). Munksgaard, Copenhagen

Penfield W. (1966). Speech, perception and the uncommitted cortex. In Eccles: 217-237

Penfield W. & Roberts L. (1959). Speech and brain mechanisms.

Princeton University Press, Princeton, N.J.

Pokrovskij N.B. (1962). Rasčet i izmerenie razborčivosti reči. Svjaz'izdat, Moskva

Shankweiler D. & Studdert-Kennedy M. (1967). Identification of consonants and vowels presented to left and right ears. Quarterly Journal of Experimental Psychology 19: 59-69

Slepokurova N.A. (1972). Issledovanie vosprijatija stacionarnyx sintetičeskix glasnyx. Kand.dis. Leningrad

Small A.M. (1973). Psychoacoustics. Minifie F.D., Hixon T.J. & Williams F. (Eds.). Normal aspects of speech, hearing, and language. Prentice Hall, Englewood Cliffs, N.J: 343-420

Sperry R.W. (1964). The great cerebral commissure. Scientific American 210: 42-52

Sperry R.W. (1966). Brain bisection and mechanism of consciousness. In Eccles: 298-313

Spliid P.E. & Andersen E. (1980). Invariant relations in the speech signal (=Working Papers, 1980, No. 1, The Language Center, University of Aarhus, Denmark), Århus

Springer S.P. & Deutsch G. (1981). Left brain, right brain. W.H. Freeman, San Francisco

Stevens K.N., Liberman A.M., Studdert-Kennedy M. & Öhman S.E.G. (1969). Crosslanguage study of vowel perception. Language and Speech 12: 1-23

Studdert-Kennedy M. (1974). The perception of speech. Sebeok T.A. (Ed.). Current trends in linguistics. Volume 12: Linguistics and adjacent arts and sciences. Mouton, The Hague & Paris: 2349-2385

Studdert-Kennedy M. (Ed.) (1974 & 1975). Dichotic Studies I, Dichotic Studies II (=Brain and Language 1:4, 1974 & 2:2, 1975)

Subirana A. (1969). Handedness and cerebral dominance. Vinken P.J. and Bruyn G.W. Handbook of Clinical Neurology, Vol. IV. North-Holland Publishing Co., Amsterdam: 248-272

Taylor D.C. & Marsh S. (1979). The influence of sex and side of operation on personality questionnaire responses after temporal lobectomy. In Gruzelier & Flor-Henry: 391-400

Terzian H. (1964). Behavioural and EEG effects of intracarotid sodium amytal injections. Acta Neurochirurgica 12: 230-240

Traugott N.N. (Ed.) (1979). Unilateral'nyj ėlektrosudorožnyj pripadok (Nejrofiziologija, klinika, lečebnoe dejstvie pri psixozax). Nauka, Leningrad (Authors: L.Ja. Balonov, D.V. Barkan, V.L. Deglin, D.A. Kaufman, N.N. Nikolaenko, R.G. Savaranskaja, O.P. Tračenko)

Tucker D.M., Watson R.T. & Heilman K.M. (1977). Discrimination and evocation of affectively intoned speech in patients with right parietal disease. Neurology 27: 947-950

Van Lancker D. & Fromkin V.A. (1973). Hemispheric specialization for pitch and "tone": Evidence from Thai. Journal of Phonetics 1: 101-109

Wada J.A., Clarke R. & Hamm A. (1975). Cerebral hemispheric asymmetry in humans. Archives of Neurology 32: 239-246

Wada J. & Rasmussen Th. (1960). Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Journal of Neurosurgery 17: 266-282

Weiner R.D. (1979). The psychiatric use of electrically induced seizures. American Journal of Psychiatry 136:12: 1507-1517

Zaidel E. (1978). Auditory language comprehension in the right hemisphere following cerebral commissurotomy and hemispherectomy: A comparison with child language and aphasia. Caramazza A. & Zurif E.B: Language acquisition and language breakdown. Parallels and divergencies. John Hopkins University Press, Baltimore & London: 229-275

INDEX