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COMMUNICATIVE ACTIVITY OF CHILDREN IN THE STATE OF SUPPRESSED CONSCIOUSNESS AFTER SEVERE TRAUMATIC BRAIN INJURY

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SUMMARY

Background: The aim of the study was to show the consistency and compatibility of a fixed assessment of a patient's suppressed consciousness on the basis of two scales: the SCABL and RLAS-LCF-R, and to reveal the peculiarities of the restoration of signal communication systems in a group of patients without a "clear" consciousness (RLAS < VI).

Material/ Methods: 28 children were taken into the study aged 3-16 who had survived severe traumatic brain injury and who suffered from the consequences of brain hypoxia and arterivenous malformation ruptures. It describes a large number of communicative signals as well as their intensity. The Scale of Communicative Activity by Bykova, Lukianov (SCABL) has an important correlation with the RANCHO LOS AMIGOS MEDICAL CENTER LEVELS OF COGNITIVE FUNCTIONING (RLAS-LCF-R) for the fixation of the consciousness suppression level.

Results: It was found that in Group A the recovery was significantly lower during the first stages than it was in Group B. In Group A the speed of SCABL changes was significantly lower than in Group B. The second objective of this study was to identify the peculiarities of the signal (communication) system recovery in the group of patients with severe injuries and in the group of patients with a clear consciousness. In Group A the dynamics of communication signal recovery had a non-linear dependence. The correlation by Spearman at each time slice in this group was 0.75 ($p<0.05$) on average and covered all of the SCABL parameters. The Kendell concordance ratio for all stages exceeded 0.73, which indicates a correlation for all the signal processes recovery.

Conclusions: The SCABL scale performs a more differentiated and more precise quantitative and qualitative evaluation of the communication signals in children after brain injury of various etiology and may constitute a new objective approach for psychological studies in this group of patients.

Key words: children, severe brain injury, long-lasting consciousness impairments, communication abilities, scale of communication activity (SCABL).

INTRODUCTION

We can live without many things, but not without each other.

Ludwig Börne

The problems of consciousness recovery after brain injury of various etiology are of prime interest for experts from various fields (physicians, psychologists, physiologists, physicists, philosophers) [4,11,15,20,21].

Like other authors who studied consciousness, the authors of the present article do not consider *brain* and *consciousness* to be identical identifications: "… we shouldn't consider different phenomena to be identical simply because we use the same words in their designation" [8]. Nevertheless, attempts to study the damaged brain can help one to understand the nature of this pathology and the possibilities of human communication with such patients.

It should be noted that environment is a structural element of consciousness. Multiple studies have revealed the fact that the accumulation of personal experience through communication leads to significant changes in the brain chemical structure [8]. Such ideas have impelled us to study the process of human communication with the outside world as a phenomenon in which communication plays the role of an adaptive capacity to one's surrounding. [4]

Communication is the process of information transmission from one human being to another caused by the necessity of joint activity and includes: communication (exchange of information), interaction (exchange of actions) and social perception (the sensing and understanding of partners) [7]. Verbal communication includes speech answers and speech intonation.

Non-verbal communication is the process of information exchange without the vocal and language tools which serve as functional supplements, substitution of speech and include:

- body signal – the sign elements of movements of different parts of the body [2]
- vegetative reactions – uncontrolled and involuntary reactions of the body which replace emotions and serve as responses to impetuses from the environment, [17].
- facial gesture – «expressive movements of facial muscles which are one of the forms of expressing human feelings» [3].
- gestures, pose (Latin *gestus* – movements of the body) – a kind of action or movement of the human body or its part, which has a definite meaning or sense [16].
- patient's volume of possible communication manifestations with others (relatives, care-givers, other disabled children and so on) [5,19].

During his life a man develops (obtains) different psychological functions and mechanisms and becomes familiar with them thus acquiring his individual, personalized structure. Severe brain injuries cause the regression of these functions

deeply altering the state of consciousness (coma, vegetative state and so on). Rehabilitation, as used in this text, serves as an instrument for the recalling of previous communicative experience and for promoting the restoration of a patient's psychological and physical functions as an integral personality.

A. Mindell supposes that during communication a man produces up to 300 communicative signals [12]. After severe brain injury communication as a process of action exchange and social perception comes to a stop, and the number of communication signals reduces. However, a patient's dialogue with the outer world goes on. The authors of this research propose a rating scale of communication signals with 104 parameters. Such a number is determined by the significant deprivation of patient signal abilities after severe brain injury.

In global practice the RANCHO LOS AMIGOS MEDICAL CENTER LEVELS OF COGNITIVE FUNCTIONING (RLAS-LCF-R) scale is used to assess the cognitive abilities of patients after brain injuries [22]. RLAS-LCF-R scale was implemented into clinical practice abroad, while in Russia at the same time the Dobrohotova and Zaitzev's classification of syndromal levels of consciousness suppression was proposed for clinical practice [9, 10]. These scales are generally used by physicians. However, currently there is the necessity to develop a specialized "psychological" scale which would allow one to more precisely fix the possibilities of patient communication activities within the deeply altered state of consciousness (ASC) and which would be consistent with "medical" scales.

The Bykova-Lukyanov Scale of Communication Activity (SCABL) captures multiple signals from different directions (verbal and non-verbal) and serves as a sensitive evaluation tool for patients in a deeply altered state of consciousness (vegetative state, minimal consciousness state and so on).

This scale is used by psychologists working with patients who have a suppressed consciousness. This scale also measures the obtained information in the form of signals.

Purpose of the study

To give an opportunity to medical psychologists to apply the technique of the scale assessment of communication activity (SCABL) for patients with severe brain injury along with other techniques such as patient's observation, interviews and conversations.

Study goals

To show the consistency and compatibility of the fixed assessment of patient's suppressed consciousness on two scales SCABL and RLAS-LCF-R

To reveal peculiarities in the restoration of signal communication systems in a group of patients without a "clear" consciousness (RLAS < VI) and in a group of patients with complete consciousness recovery.

Study design

This research is complex, prospective and cohort.

MATERIALS AND METHODS

28 children aged 3-16 were taken into the study (17 boys and 11 girls). The average age in the whole sample was 12+/-4 years (M± Std). All these children had a severe brain injury of various etiology: severe traumatic brain injury (TBI), hypoxic brain injury, the consequences of arteriovenous malformations rupture. Every child was examined 3-5 times. Checkups were conducted after the stabilizing of the patient's vital functions at the acute recovery stage without drug sedation. The average time between investigations was about a fortnight (14 days). Depending on the degree of consciousness recovery during the first six months after the trauma, the children were divided into two groups. **Group A** included 17 children without clear consciousness during the first six months. **Group B** included 11 children with a clear consciousness recovery.

Study procedure

The primary SCABL filling-in was conducted at the vegetative state stage following brain injury of different etiology (RLAS-II) when the injured child was not under drug sedation. The completion of the SCABL (104 parameters) was done by a medical psychologist. Each response was ranked according to a three-point assessment depending on the presence and frequency of communication signals: "0" – complete lack of communication signals, "1" – "unstable" – sporadic communication signals, "2" – complete recovery and restoration of communication signals.

The total summarized score was calculated using the obtained results and the SCABL scale as well as on the amount of signals (body responses, gestures, vegetative reactions, facial gesture, speech, contact level) in each separate section of the signal systems. In the questionnaire there are four negative statements and nine conditionally negative statements. The higher the total score is, the higher the level of consciousness and the child's ability to communicate with the outer world.

Table 1. Distribution by sample

Groups	Nosology	Recovery of consciousness	Output by RLAS	Age (years)	Number of patients
A	Severe TBI, hypoxic brain injury, malformation rupture	Confusion – inadequacy. Level of dependence – maximum amount of assistance	V stage	Average =11 ±-4.5	17
B	Severe TBI	Automatism – adequacy. Minimal level of dependence, amount of assistance in everyday life	V stage	Average = 13.5±2.5	11

The obtained data were processed with nonparametric statistical techniques using the program Statistica v.6.

Tab. 2. SCABL form

				points
Nonverbal responses	**Body responses (Br)**	**1**	acceleration – slowdown of breathing on request	2
		2	increase and decrease of depth of breathing on request	2
		3	breath-holding	2
		4	finger movements	2
		5	repeated finger movements	1
		6	hand movements	2
		7	repeated hand movements	2
		8	“twitching” of the blanket	1
		9	scratches	1
		10	clenched fists (fist)	2
		11	handshake	2
		12	appearance of hand tremor	1
		13	movements in elbows	2
		14	purposefulness in body movements to be in contact	2
		15	involuntary shoulder movements	2
		16	involuntary bending movements in knees	2
		17	involuntary movements of foots	2
		18	involuntary toe movements	2
		19	repeated leg movements	2
		20	leg tremor	1
		21	changes of body position	2
		22	bending over the body or an attempt to get up	2
		23	swinging movements of the body	1
		24	untargeted head turn	2
		25	head turn to the direction of voice	2
		26	head turn away from the speaker	2
		27	involuntary eye opening	2
		28	eyes opening as a response to conversation	2
		29	eye opening as a response to deep contact	2
		30	fixation of gaze at the speaker	2
		31	withdrawal from contact through eye abduction	2
		32	untargeted motor anxiety	0
		33	body-expressed aggression	0
		34	body-expressed negativism	0
		35	change in common activity during contacts	2
		36	tertiary body signals	2
		37	changes in saliva swallowing frequency	2
		38	voluntary “yes” response using eyes	2
Total score for body responses				**64**

The following form is completed as a conditionally “absolute” standard (191 scores).

So as to compare the SCABL scale equivalent components, the data standardization was conducted. Using standardization results, calculations were made with the equation: **1*Br + 1.5*Fg + 2.9*Vr + 4.3*Gp + 2.9*Co + 2.7*Si = SCABL.**

Tab. 2 (cont.). SCABL form

	Facial gesture and emotions (Fg)	**39**	non-differentiable facial gestures	2
		40	facial paleness	2
		41	blushes on cheeks	2
		42	raising of the eyebrows	2
		43	changes of eye expression during contacts	2
		44	pain/discomfort grimace	2
		45	frustration	2
		46	weeping	2
		47	expression of insult	2
		48	irritation, anger	2
		49	smile	2
		50	laugh	2
		51	fright, fear	2
		52	disappointment	2
		53	other emotional manifestations (lip biting and so on)	2
		54	mimic reactions to relatives	2
		55	adequacy of mimic reactions	2
		56	adequacy of emotional expressions	2
		57	emotional lability	2
		58	connecting emotions with the actual disease situation	2
		59	understandable psychological emotions	2
		60	recognition of other signals during repeated contacts	2
Total score for facial gesture				**44**
	Vegetative reactions (Vr)	**61**	change in skin color on hands	2
		62	change in hand temperature	2
		63	sweating hands	2
		64	change in leg temperature	2
		65	change in leg color	2
		66	redness on body	2
		67	perspiration	1
		68	vegetative excitation (hyperkinesis and so on)	0
		69	change in body temperature	2
		70	changes in the pupil size	2
		71	redness on the face	2
		72	pale face	2
		73	other vegetative occurrences (hiccup, yawning …)	1
Total score for vegetative reactions				**22**

Each signal system had a maximum of 64 points, and the level of “absolute health” (clear consciousness) would be equal to 384 points.

Tab. 2 (cont.). SCABL form

	Gestures and pose (Gp)	**74**	gestures while answering	2
		75	gestures indicating own intentions (indications and others)	2
		76	change of body pose during contacts	2
		77	crossed arms on the chest	2
		78	crossed legs	2
		79	closed pose	2
		80	fear during body contacts	1
		81	pose of contact desire	2
Total score for gestures				**15**
	contact with the outer world (Co)	**82**	adequate understanding of the fact of interaction with other person	2
		83	contact with one important adult (parent, nurse…)	2
		84	activation during contacts with small children	2
		85	contacts with other disabled young patients	2
		86	contacts with healthy children	2
		87	adequacy of contacts	2
		88	depth of contacts	2
		89	motivation to the emotions of others	2
		90	sufficient involvement in contacts with others	2
		91	the congruence of various own body signals when contacting with others	2
		92	understanding humor	2
Total score for contact				**22**
Verbal answers	**Speech and intonation (Si)**	**93**	optimal speed of responses	2
		94	regularity of answers	2
		95	notional adequacy of responses	2
		96	the congruence of verbal responses to nonverbal signals	2
		97	tone coloring of speech	2
		98	variability in speech volume	2
		99	timbre variability	2
		100	adequacy of intonation coloring to statement meaning (intent)	2
		101	adequate pauses in speech	2
		102	emotional adequacy in speech	2
		103	adequacy of emotional expression in verbal responses	2
		104	opportunity to talk	2
Total score for speech				**24**
Absolute score				**191**

RESEARCH RESULTS

The first objective of this research was to find out the consistency and compatibility of the assessment of consciousness suppression levels in injured patients using two scales RLAS and SCABL.

Figures 1 and 2 show the dynamics of changes in the average parameter values obtained by RLAS and SCABL for Groups A and B, respectively.

In Group A one can see a high significant positive correlation ($r \sim 0.80$, $p<0.05$ by Spearman) at all time stages.

In Group B the Spearman correlation is significant and positive only for the first three stages.

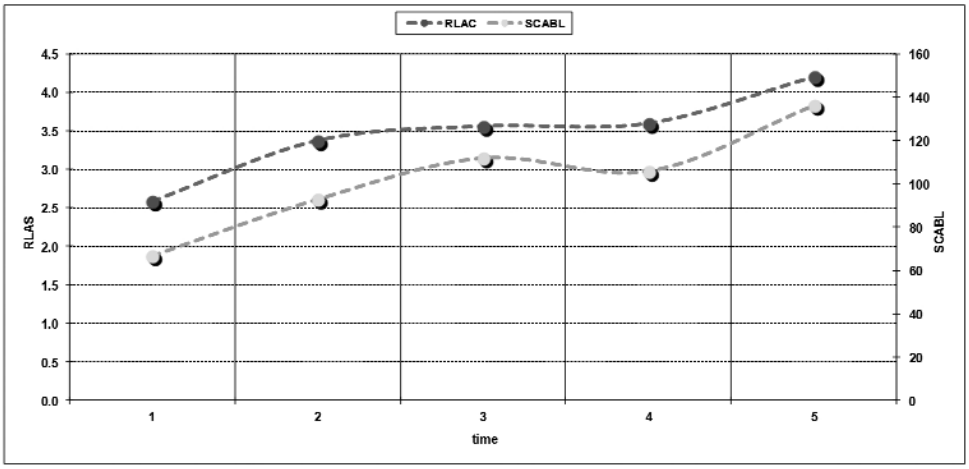


Fig. 1. Dynamics of the RLAS and SCABL average value parameter changes in Group A

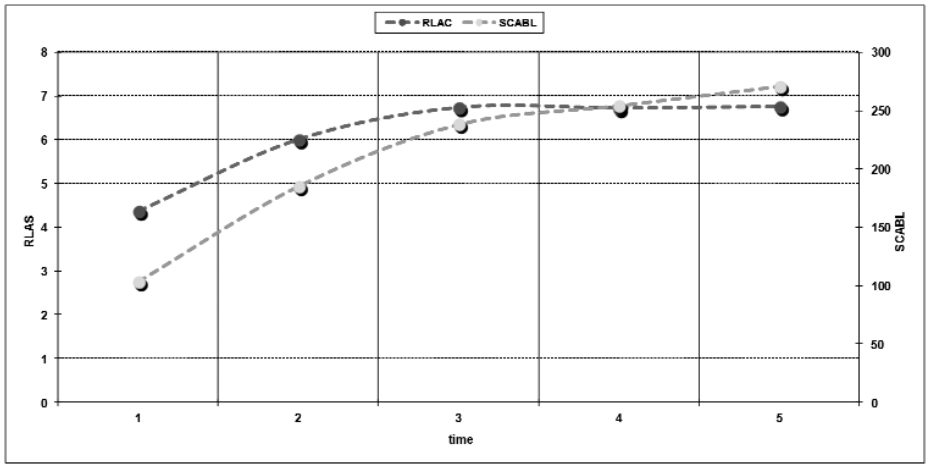


Fig. 2. Dynamics of the RLAS and SCABL average value parameter changes in Group B

To assess the dynamics of the SCABL changes over the course of time, we used Friedman's dispersing analysis, ANOVA. Figures 3 and 4 show the destribution of the average time values in the two groups A and B with +/- 95% CI.

The above figures illustrate the peculiarities of the dynamics of SCABL changes for Groups A and B. The figures are shown in different scales to enable a better view and understanding. The X-axis indicates the time slices of the measured parameters, while the Y-axis indicates SCABL parameters in scores.

There are statistically significant differences in the SCABL scale dynamics for Groups A and B.

We used the Sign Test in order to have a more detailed picture of these differences.

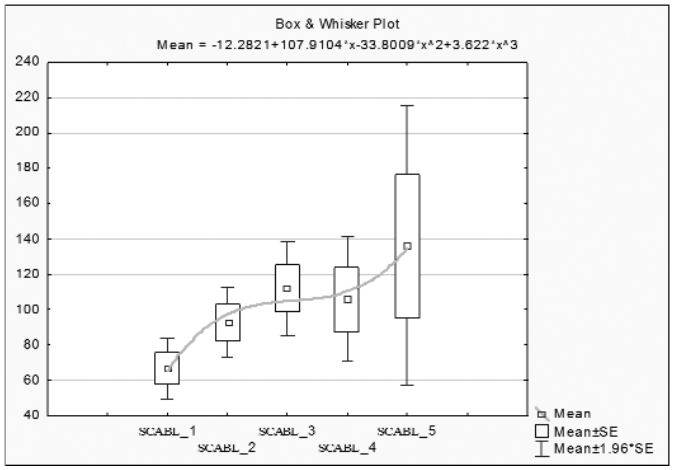


Fig. 3. Assessment of the dynamics of SCABL time changes for Group A

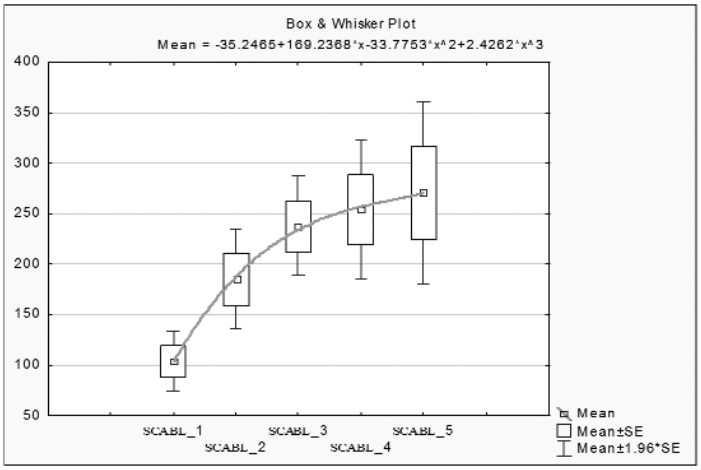


Fig. 4. Assessment of the dynamics of SCABL time changes for Group B

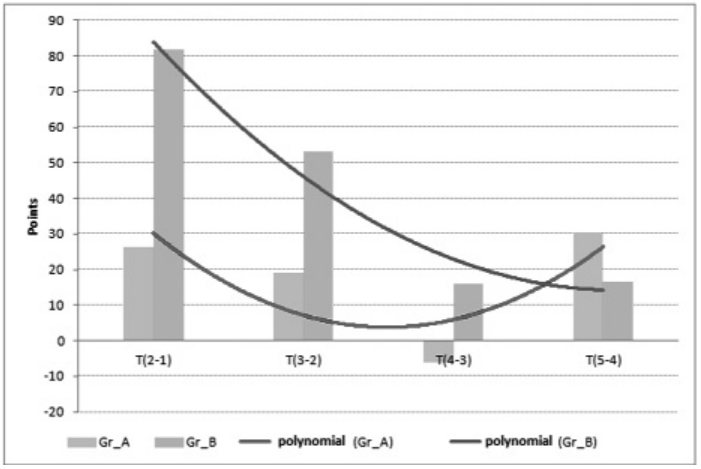


Fig. 5. Dynamics of SCABL speed changes in Groups A and B

For Groups A and B a statistically significant difference ($p < 0.5$) is typical for the first, second and third phases.

To assess the SCABL scale sensitivity in Groups A and B, the dependence of the rate of the parameter score changes per time unit was recorded: **speed = (average value (i) – average value (i- 1)) / time unit**. In our research, a time unit represented about 14 days (a fortnight). The results of our calculations are shown in Figure 5.

It is noteworthy, that in Group B the recovery (the speed of changes according to the SCABL scale findings) was significantly higher during the first stages than was the case in Group A. By the fourth time slice the speed of the parameter changes had stabilized.

In Group A the speed of the SCABL changes was significantly lower than in group B. In general, it remained constant except for a “downward excursion” in the fourth time slice.

All of the abovementioned applies to the differential analysis of the individual groups (A and B). Below, the overall distribution into two groups will be discussed.

Figure 6 shows that the linear dependence of SCABL values on RLAS values lies within the range of 2-5 stages.

To assess the peculiarities of the studied groups with the RLAS scale (6-7 stages), the Fisher’s F test was used for comparing the dispersions of the SCABL with RLAS group (2-5 stages)

A statistically significant difference in variances is associated with another internal structure of the group or with the incorrect usage of the SCABL scale at the level of clear consciousness (purposeful behavior, full orientation in time and space and assessment of one’s state, integration into society).

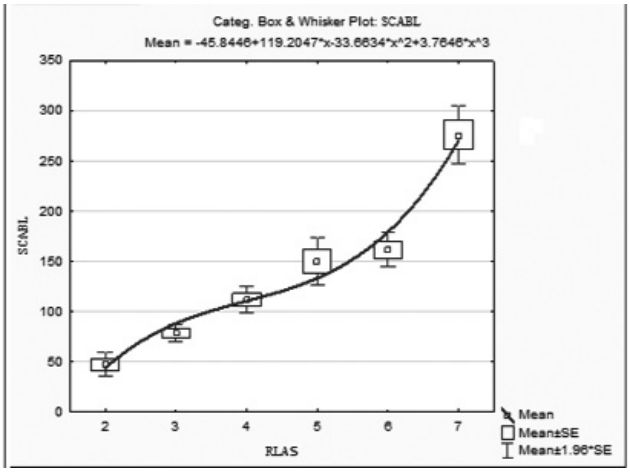


Fig. 6. Overall distribution of two scales via the whole sample

Table 3. Two-sample F-tests for the dispersion

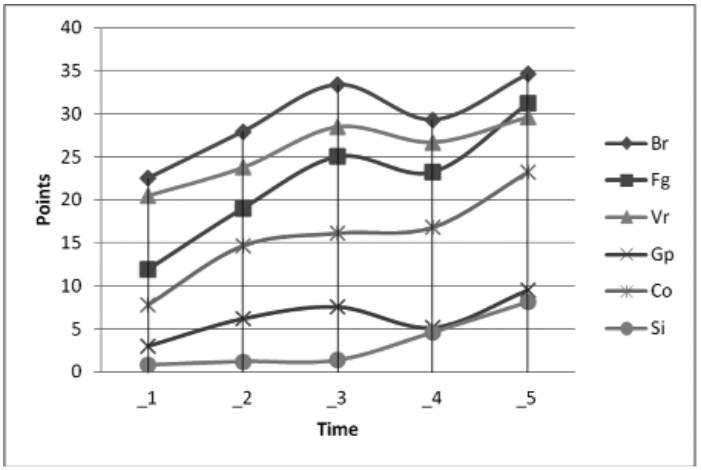
Values	**SCABL** RLAS (6-7 stages)	**SCABL** RLAS (2-5 stages)
Average	235.6	91.6
Dispersion	**6413.8**	**2131.1**
Observations	34	74
df	33	73
F	3.0	
P(F<=f) one-sided	**4.62726E-05**	
F critical one-sided	1.6	

The second objective of this study was to identify the peculiarities of signal (communication) system recovery in the group of patients with severe injuries and in the group of patients with a clear consciousness.

In Group A the dynamics of communication signal recovery had a non-linear dependence.

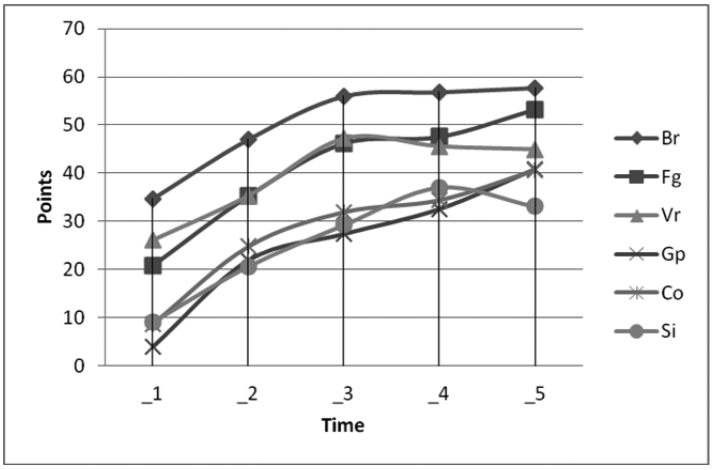
The correlation by Spearman at each time slice in this group was 0.75 ($p<0.05$) in average and covered all the SCABL parameters. The Kendell concordance ratio for all the stages exceeded 0.73, which indicates the correlation of all signal processes recovery.

In Group **B** the Spearman correlation does not have any statistically important evidence. However, there is stable important correlation $r\sim0.8$ ($p<0.05$) for the parameters of “Facial gestures”, “Speech” and “Level of contacts” for all but the last time slice.



"Br" – body responses, "Fg" – facial gestures, "Vr" – vegetative reactions, "Gp" – gestures and pose, "Co" – level of contacts, "Si" – verbal possibilities

Fig. 7. Dynamics of recovery in Group A (in scores)



"Br" – body responses, "Fg" – facial gestures, "Vr" – vegetative reactions, "Gp" – gestures and pose, "Co" – level of contacts, "Si" – verbal possibilities

Fig. 8. Dynamics of recovery in Group B (in scores)

The Kendell concordance ratio in Group **B** was 0.7 only at the first stage; further it decreases to 0.45, on average. This fact may indicate that the signal processes in Group B are restored relatively independently of each other.

DISCUSSION

In Figure 9 a graphic view shows the linear trends of 25% and 75% quartiles of SCABL. Parameter distribution depending on the RLAS scores within stages 2-5 and the coefficient values in the R2 determination.

The number of parameters (signals) in the SCABL scale noticeably exceeds the number of accepted signals in the RLAS scale, which indicates a better sensitivity and more detailed information for this scale. It should be noted that the SCABL scale does not contradict the RLAS scale, and it is designed simply for a better psychological evaluation.

While analyzing the data obtained during this study, one can note different patterns of recovery of signal systems in patients with long-term impairments of consciousness after brain injury and in patients with a "clear" consciousness.

While analyzing the SCABL components for children with long-term impairments of consciousness for various reasons one can see that the "body responses" and "vegetative reactions" are the most important manifestations in their communicative activity and that they appear prior to all the others.

The voice channel is the most delayed component in the recovery process of communication with the outer world and restores itself in about 8 weeks after the brain injury. Once it has appeared, a total increase in the number and frequency of signals is seen in all other communication channels. The most significant changes occur in the channels "Facial gestures" and "Contacts", while the parameters in the "Gestures and pose" channel are the least dynamically changing in this situation (Pachalska 2012; Kaczmarek and Pachalska 2013; Manko et al. 2013; Tomaszewski et al 2013).

Recovery in Group B on the basis of the SCABL findings appeared to be a different scenario. Here, there is a rapid increase in all communication channels by the 4th week after brain injury. Later, by the 6th week, one can observe some

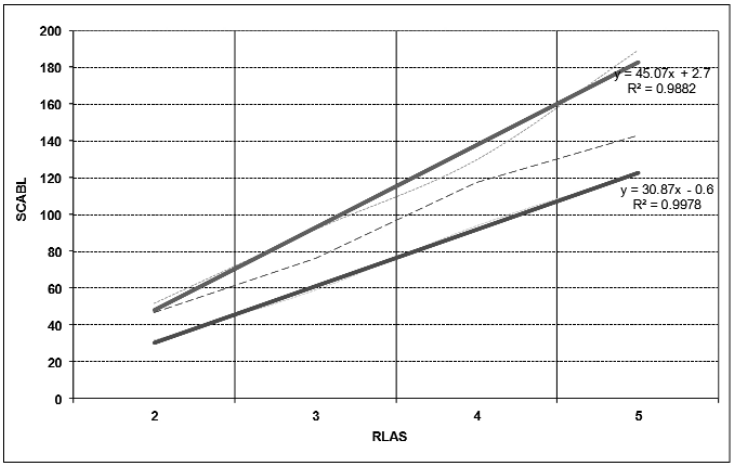


Fig. 9. Distribution of RLAS (2-5) and SCABL

delay and stabilization of the process. It should be noted that the recovery rate in all the channels in this group is opposite to this process in the first group when one can see a more rapid restoration in the channels of “Body responses” and “Vegetative reactions”.

CONCLUSIONS

As it has been shown by the present study, the SCABL scale possesses a statistically reliable correlation with the RLAS scale.

The SCABL scale is significantly more sensitive and gives more detailed information than the RLAS scale about the communication signals of patients with different levels of consciousness suppression. However, the SCABL scale is not effective for assessing the communicative activity in patients with a “clear” consciousness.

The SCABL scale performs a more differentiated and precise quantitative and qualitative evaluation of communication signals in children after brain injury of various etiology and may become a new objective approach for psychological studies in this group of patients.

For example, our analysis of signal recovery for communication with the outer world in children with a deeply altered consciousness has shown that body responses and vegetative reactions are the first to be restored, and only later when voice responses appear can one see an associated polyphony of all the possible communication channels. In Group **B** with patients who had regained a “clear” consciousness, the picture is different: with a simultaneous restoration of all the signal systems with little correlation to time points.

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Annex 1. Summarized table of syndrome-based levels of consciousness suppression and score ratings on the RLAS and SCABL scales (standard values)

Clinical characteristics and recovery symptoms	**RLAS (stages)**	**SCABL Median (Q25; Q75)**
Generalized reaction – level of complete dependence, assistance.	**II**	**46 (31; 51)**
Local response– level of complete dependence, assistance.	**III**	**76 (58; 91)**
Confusion-agitation. Level of dependence– maximum amount of assistance	**IV**	**117(93; 129)**
Confusion-inadequacy. Level of dependence– maximum amount of assistance	**V**	**143 (122; 189)**
Confusion-adequacy. Average level of dependence, amount of assistance	**VI**	**157 (146; 171)**
Automatism-adequacy. Minimum level of dependence, amount of assistance in daily life. Automatic performance of familiar skills.	**VII**	**288 (231; 333)**