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EDITOR'S MATERIAL

Strengthening of Traditions and Search for New Forms: The Basic Rules for Publishing in The Natural Systems of Mind

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Abstract. This article presents the basic rules for publishing manuscripts in the Natural Systems of Mind (NaSoM). The best world practices served as the basis for drawing up the rules. The Institute of Psychology of the Russian Academy of Sciences (IPRAS) acts as a guarantor of the high scientific quality of published manuscripts. The journal adheres to traditional publication formats. However, the NaSoM editorial board closely monitors changes in the forms of scientific communication and promptly responds to the challenges of modern society. The journal consistently follows the principles of openness of scientific information, enshrined in international documents and corresponds to the Russian publishing culture. The journal is positioned as a platform for open scientific dialogue using both traditional forms of scientific communication (various types of articles) as well as publications of classics "Learning from the past", comments and others. Particular attention is paid to the problems of originality of submitted manuscripts. It is not allowed to submit a manuscript to several journals. The NaSoM does not charge any fees from authors or readers.

Keywords: Publication Rules, Publication Ethics, Open Access, Plagiarism, Auto-Plagiarism, Types of Articles.

1. Introduction

In the current issue we continue the publication of the policy of the Natural Systems of Mind and provide the publication rules[†]

1.1. NaSoM General Information

The Natural Systems of Mind is an international multidisciplinary open access journal. It is fundamentally important for the editors to ensure open access to research results. This position is consistent with the UNESCO recommendations [14], the Plan S [22] and the Russian publishing culture [4, 5, 6, 12, 24, 25].

The main owner and publisher of the NaSoM is the Institute of Psychology, Russian Academy of Sciences (IPRAS, Moscow, Russia). The IPRAS is a leader in the field of psychology. The publication of the journal under its auspices makes high demands on the quality of the manuscripts. The IPRAS is the founder of five journals and ten non-periodical series. It publishes more than 15 books annually. The grants from IPRAS allow us not to charge either authors or readers.

The NaSoM publishes original (previously unpublished) completed systems research in the fields of human brain, mind, body, society, and intellectual technologies.

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[†] The rules can be found at: https://natural-systems-of-mind.com/guidlines/

The NaSoM has the following sections in issue: Editor's Material, Reviews, Empirical Articles, Case Studies, Book Reviews, Brief Reports, Comments, Meeting Abstracts, and Learning from the Past.

Since the mission of the journal is to promote effective international multidisciplinary interaction of scholars, we considered it possible, in addition to traditional scientific headings, to create a special section dedicated to the heritage of outstanding Russian scientists, whose works had made a significant contribution to the development of various branches of science. But their research is often unknown to a wide range of scientists, and translations of their publications are difficult to access.

The full-text electronic version of the journal is published at

http://natural-systems-of-mind.com

Neither the Editors nor the Publisher accept responsibility for the views or statements expressed by authors.

1.2. The main headings of the journal:

- **Biological systems of mind** (Brain-Computer Interfaces, Behavioral Genetics, Neurochemistry and Endocrinology, Neuroimaging, Neuroscience).
- **History and Philosophy of Sciences** (Anthropology, Evolution of Mind, Grand Challenges, Information Science, New Concepts and Paradigms).
- **Linguistics** (Bilingualism, Communication, Language Development, Mind and Language, Sentiment Analysis).
- **Mathematics & Statistics** (Artificial Intelligence, Big Data and Network Analysis, Data-Driven Analysis, Nonlinear Dynamics, Robotics and Digital Technology)
- **Medicine** (Microbiota, Neurology, Oncology, Psychiatry, Somatic Systems and Mind).
- **Psychology** (Cognitive Psychology, Comparative Psychology, Developmental Psychology, Educational Psychology, Psychology of Religion and Spirituality).
- **Pharmacology and Biochemistry** (Applied Microbiology, Behavioral Sciences, Biochemistry Molecular Biology, Biophysics, Medical Neurochemistry).
- **Social Sciences** (Big Group Psychology, Collective Emotions, Collective Intelligence, Cross-Cultural Studies, Psychology of Propaganda).

A detailed analysis of the trends in the development of these fields of science was presented in the Editor's Material published in the first issue of the NaSoM [25].

1.3. The Purpose of the Manual

This guide is intended to facilitate and simplify the preparation of the manuscript for the Authors, the scientific examination of the manuscripts for the reviewers, the preparation of the manuscript for publication for the editors, and the orientation in the structure and content of the published materials and their use in scientific practice for the Readers.

Regulation of relations Author–Reviewer–Editor–Publisher–Reader is built on the basis of ethical principles and rules of scientific publications, as well as the standards for organizing and conducting research.

1.4. Peer review

All incoming papers are subject to the refereeing process: they should be appropriate for the Aims and Scope of the journal and should follow the Guide for Authors. Correspondence regarding decisions reached by the editorial committee is not encouraged.

The final decision on the rejection or publication of the manuscript and its assignment to a certain section of the NaSoM is made exclusively by the Editorial Board.

In disputable cases, according to the decision of the Editorial Board, the articles are published with reviews and answers of the Author(s) to the Reviewer(s).

1.5. Submission

The manuscript must be submitted via NaSoM Online Submission System which leads the author(s) stepwise through the process of entering article details and uploading files. All correspondence, including notification of the Editor's decision and requests for revision, is sent only via NaSoM Online Submission

System[‡].

Authors should note that submission implies that the content has not been published or submitted for publication elsewhere except as a brief abstract in the proceedings of a scientific meeting or symposium.

Before submission, the author will need:

- *Cover letter*
- *The title page of the manuscript*
- *Manuscript without author details*
- *Highlights*
- *Supplementary Material*

Cover letter is uploaded as a separate document. A cover letter is a brief business letter designed to introduce your manuscript to an Editor that usually includes some of the following items:

(a) An Author Agreement which is a statement to certify that all authors have seen and approved the final version of the manuscript. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

(b) Any Conflict of Interests (see [13]).

(c) Permissions information.

(d) A Declaration of Interests (see [23]).

(e) A brief background regarding the research.

(f) Any information that will support your submission (e.g. original or confirmatory data, relevance, topicality).

(g) Details of any previous or concurrent submissions.

The title page of the manuscript is to include the title of the paper, the authors details (see 3.1, 3.2), acknowledgments, and CRediT author statement (see 3.5.7).

Manuscript should be a single file including title *without author details*, text, figures, and tables. All required sections should be contained in your manuscript, including abstract, keywords, introduction, methods, results, and conclusions. Figures and tables should have legends. References should be submitted in APA format.

Highlights should be submitted in a separate file via the NaSoM Online Submission System. Highlights is a short collection of bullet points that capture the novel results or methods that were obtained or used during the study. This file includes 3 to 5 bullet statements (maximum 85 characters, including spaces, per bullet statements).

Supplementary Material covers the data that are not of primary importance to the text, or which cannot be included in the article because they are too large or the current format does not permit it. Such data can be uploaded as Supplementary Material during the submission procedure and will be displayed along with the published article.

Our journal does not require prior registration of studies. Based on the metadata obtained as the results of the analysis of pre-registered psychological publications, we concluded that this procedure could significantly limit the free scientific search [10]. However, we encourage the authors to pre-register their studies not to strictly follow the plan, but to compare it with the real work. Such a comparison could help identify the patterns that were not visible in the main study. These patterns can be the subject of another publication. The NaSoM welcomes such type of articles.

2. General standards

2.1. Originality

The editorial board will make efforts to complete the review procedure as quickly as possible in order to promptly inform the scientific community about the latest research. In the modern world, the issues of originality of published manuscripts and excessive self-citation are very urgent. The later problem is also relevant for Russian scientists [9,21]. The COVID-19 pandemic has brought significant changes to the culture of scientific publications. The need for prompt notification of the scientific community and society about scientific developments greatly increased the speed of publishing. The discussion about plagiarism and self-plagiarism intensified. Research publications can even be found on non-specialized social networks such as Facebook, Twitter, and others.

References to social media posts, along with references to articles, became the norm, especially concerning the COVID-19 theme (see,

[‡] https://natural-systems-of-mind.com/registration/

for example, [16]). Despite the changes that have occurred, the NaSoM adheres to the classic positions on the originality of the article, outlined below.

The NaSoM prints only original, previously unpublished manuscripts. The text of the manuscript must not contain signs of plagiarism and autoplagiarism, i.e. material-borrowing from other authors or the author's own works without reference to the source. Autoplagiarism is the transfer by the Author of the same materials simultaneously to different publishers. Meaningful (semantic, but not verbatim) inclusion in the manuscript of materials published earlier in the form of brief reports or in collections of scientific papers with a small circulation (up to 300 copies), is not considered as autoplagiarism.

Any use of previously published materials (concepts, theories, points of view, methods, empirical data, statistical estimates), direct or indirect, must be accompanied by references to the original sources. Referring to previously published material, the author(s) should prefer paraphrasing to exact text enclosed in quotation marks. Previously published own text should be used to substantiate and develop the position of the Author. The use by the Author of a previously published own text should be preceded by such indications as “previously established”, “in previous studies it was …”, the text should contain signs of novelty and end with an exact indication of the source of borrowings. The amount of such borrowing should be kept to a minimum.

2.2. Novelty

The manuscript should contain new conceptual approaches, new facts, synthesis or criticism of existing points of view already published results, new goals and hypotheses, as well as new methodological techniques.

It should be emphasized that the NaSoM welcomes both previously unpublished materials at the intersection of various scientific disciplines devoted to the study of the systems foundations of human mind and behavior, as well as the replication of scientific data to confirm the reliability of the facts and early obtained regularities.

The journal intends to republish and publish translations of the most significant works of scientists in the field of systems human mind and behavior, as well as original experimental studies and methods performed and described in the past, but retaining their significance at the current stage of science development (see “Learning from the past”).

2.3. Completeness

The NaSoM publishes only completed works. Descriptions of pilot studies is not accepted.

2.4. Style

Please write your text in good English (American or British usage is accepted, but not a mixture of these). The articles are to comply with the APA-style requirements, and the spelling must comply with the standards of Merriam-Webster.com [20].

The manuscript is to be edited, be conceptual rigorous, logical coherent of approaches, explanations and conclusions, i.e, to follow the manuals of the NaSoM (see sections 1.1 ÷ 4.8).

To maintain the rigor of presentation, it is recommended to avoid polysemy and ambiguity of statements and not to use of unreasonably long phrases, metaphorical statements, repetitions, allegories, journalistic and popular science style, everyday vocabulary, neologisms and laboratory jargon. It is preferable to avoid synonyms and homonyms of the terms.

All newly introduced concepts and concepts with new meanings, as well as special and technical terms, should be explained when they are first used in the text.

3. Article elements

3.1. Title

The title should be concise (no more than 9 words) and match the objective of the study, omitting terms that are implicit and, where it is possible, be a statement of the main result or conclusion presented in the manuscript. Abbreviations should be avoided. It should be mentioned that including a few keywords in the title is a simple way to maximize your article’s discoverability.

3.2. Authors and Affiliations

Authorship should be based on the following criteria:

- substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data;
- drafting the work or revising it critically for important intellectual content;
- final approval of the version to be published;
- agreement to be accountable for all

aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

All authors' names are listed together in order of their contribution and separated by commas. The Corresponding Author should be marked with an asterisk in the author list.

Affiliations should be keyed to the author's name with lower-case letters and be listed as follows: Department/Laboratory, Institution, City, Country, e-mail, and ORCID iD.

See example:

Ivanov I.I. (a)*, Petrov P.P. (b), Sidorov S.S. (c)

*Corresponding author

(a) Psychology Department, Moscow State University, Moscow, Russia, xxx@ju.se, ORCID iD

(b)Psychology Department, St. Petersburg State University, St Petersburg, Russia, yyy@stsu.ru, ORCID iD

(c) Department of Teacher Education, University of Helsinki, Helsinki, Finland, zzz@helsinki.fi, ORCID iD

3.3. Abstract

Abstract should range between 150 - 250 words. It should be presented as a single paragraph and briefly summarize the goals, methods, and new results presented in the paper. Reference citations are not allowed. Generally accepted abbreviations are allowed (ANOVA, DNK).

Keywords are placed under the abstract. Keywords are listed from the most general, corresponding to the problem, to the more differentiated, corresponding to the description of the participants in the study, and methods. Laboratory jargon and neologisms cannot be used as keywords. Each keyword starts with capital letters and is separated from others by commas. It is recommended to specify from three to seven keywords or phrases. Generally accepted abbreviations are allowed as keywords.

Keywords: Mind, Brain, Cognition

3.5. Sections

Divide your article into clearly defined and numbered sections and subsections (1 then 1.1, further 1.1.1, 1.1.2, ...), 1.2, etc. Any subsection should have a short heading and should appear on its own separate line. Original Research articles usually include the following sections or their equivalents:

1. Introduction level 1
    1.1. heading level 2
        1.1.1. heading level 3
        1.1.2. heading level 3
        1.1.3. heading level 3
    1.2. heading level 2
    1.3. heading level 2
2. Material and methods level 1
    2.1. heading level 2
    2.2. heading level 2
3. Results
    3.1. heading level 2
    3.2. heading level 2
4. Discussion
5. Conclusions
6. Acknowledgments
7. CRediT author statement
8. References

3.5.1. Introduction usually covers the following main points:

(l) Identification of the specific scientific problem in the context of which the study was carried out, with mandatory substantiation of its topicality.

(2) A brief review of the literature, necessary for formulating a theoretical hypothesis, should contain the main approaches to solving the problem with the definition of important terms, based on new methodological procedures and results.

(3) A hypothesis that is formulated in terms of theoretical constructs as a specific solution to an actual psychological problem from the standpoint of a particular research program or paradigm.

(4) The purpose of the study, which also fixes the type of study, such as pre-experiment, quasi-experiment, true experiment.

3.5.2. Materials and methods

This section should contain sufficient details so that when readers could repeat all the procedures used. This section should contain the following mandatory subsections:

3.5.2.1. Participants

A total number of participants, their sex, age (range or median), and other important information for the study (for example, educational status, normal or corrected vision, right-handedness/left-handedness, etc.), the method of sampling, the number of groups. It is necessary to stress that the term “control group” can only be used for a true experiment; for studies of pre-experimental and quasi-experimental types we recommend apply the terms "contrast group" or "comparison group".

3.5.2.2. Procedure

The design of the study should be consistent with purpose and hypotheses. The description of the study should include the sequence of events, the task or stimulus proposed to the participants. It is obligatory to provide instructions (or reference on the standard instruction) and a description of the ways of communication between the researcher and the participants. When applying expert assessments, the number of experts, their professional status and experience, and their relevant individual traits (for example, gender, age). The instructions for experts, and the scale for expert judgments should be indicated. Ethical standards for research on animals and humans must be observed.

3.5.2.3. Methods and equipment

The tests/questionaries must include: name, date, place and author of the validation (or adaptation) with references to sources as well as main psychometric characteristics (e.g., Mean/Median/Mode, Standard deviation, Skewness, Kurtosis, Cronbach's alpha) received on your sample. The detailed description of methods previously not presented in publications should be placed in the Supplementary Materials.

The equipment description covers main characteristics, manufacturer and country. The unique equipment can be described in more details (it is possible to bring diagrams and drawings).

3.5.2.4. Registration of indicators

Data collection method should be indicated (face-to-face, collective or individual contact, phone, mail, Internet). Methods of signal calibration and of synchronizing should be described. The readout frequency when sampling the signal as well as the ways of detecting, eliminating, and correcting artifacts should be specified.

3.5.2.5. Variables

All variables (independent, dependent, secondary, descriptors) or groups of variables should be listed, including the range of variation, gradation of change, frequency of presentation, and methods of their output. The description of the variables should include type of scaling in which they are measured, the accuracy of measurements as well as the correctness of the use of statistics procedures.

3.5.3. Results

Results should be clear and concise. This section should contain only original data without explanation and references to the results of other researchers. When presenting the results of statistical procedures, evidence of the adequacy of their application should be provided.

3.5.4. Discussion

In this section, the attitude to alternatives of the research hypotheses must be formulated and the new fact should be fully declared. This section may include several subsections, the number of which corresponds to the number of tasks (or research hypotheses), while the title of the subsection should correspond to the content of the corresponding task (or research hypotheses).

Discussion usually covers the following main points:

- description of the main result as a statistical solution;
- evidence of non-artifact nature of the results;
- comparison of the results obtained in other studies/by other authors;
- an indication of which of the alternatives is rejected and which is left for further research;
- substantiation of the novelty of the study and its importance for practice.

3.5.5. Conclusion(s)

The final fragment of the manuscript usually reflects assumptions about the possible

consequences of the study and putting forward of new goals or hypotheses for the further research.

3.5.6. Acknowledgments

The editors encourage to gratitude all the persons who helped in the work on the manuscript. Acknowledgments to individuals and organizations that supported the authors in the implementation of the study (including foundations that funded the study) are placed in a footnote to the title of the manuscript.

3.5.7. CRediT author statement

CRediT (Contributor Roles Taxonomy) is introduced with the intention of recognizing individual author contributions, reducing authorship disputes and facilitating collaboration (see [7]). Authors should have confident in the integrity of the contributions of their co-authors and be able to identify which co-authors are responsible for specific parts of the work.

The role(s) of all authors should be listed, using the following categories:

Conceptualization – putting forward the ideas; formulation overarching research goals and aims.

Data curation – producing metadata, scrubbing data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.

Formal analysis – application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.

Investigation – conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.

Methodology – development of design or a set of research methods; creation of statistics models.

Resources – provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.

Software – programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.

Validation – verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.

Visualization – preparation, creation and/or presentation of the published work, specifically visualization/data presentation.

Preparation of original draft – creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).

Review & editing – preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

Sample CRediT author statement:

Ivanov I. I.: conceptualization, methodology, software;

Petrov P. P.: data curation, writing- original draft preparation;

Sidorov S. S.: visualization, investigation;

Vladimirov V. V.: writing-reviewing and editing.

3.5.8. Reference (see example: [19])

All references should be listed alphabetically and numbered. Reference numbers in square brackets are indicated in the text. All references should be opened and included in the list of references. For more information on references, see the 7th edition APA Style website [3]

General reference form:

Journal Article

Author, A. A., & Author, B. B. (Year). Title of the article. *Name of the Periodical, volume*(issue), #–#. https://doi.org/xxxx

Book

Author, A. A., & Author, B. B. (Copyright Year). *Title of the book* (7th ed.). Publisher. DOI or URL

Chapter in an Edited Book

Author, A. A., & Author, B. B. (Copyright Year). Title of the book chapter. In A. A. Editor & B. B. Editor (Eds.), *Title of the book* (2nd ed., pp. #–#). Publisher. DOI or URL

Reference examples, see the 7th edition APA Style [2].

- **Journal Article**

Lachner, A., Backfisch, I., Hoogerheide, V., van Gog, T., & Renkl, A. (2020). Timing matters!

Explaining between study phases enhances students' learning. *Journal of Educational Psychology, 112*(4), 841–853. https://doi.org/10.1037/edu0000396

- **Online Magazine Article**

Gander, K. (2020, April 29). COVID-19 vaccine being developed in Australia raises antibodies to neutralize virus in pre-clinical tests. *Newsweek*. https://www.newsweek.com/australia-covid-19-vaccine-neutralize-virus-1500849

- **Print Magazine Article**

Nicholl, K. (2020, May). A royal spark. *Vanity Fair, 62*(5), 56–65, 100.

- **Online Newspaper Article**

Roberts, S. (2020, April 9). Early string ties us to Neanderthals. *The New York Times*. https://www.nytimes.com/2020/04/09/science/neanderthals-fiber-string-math.html

- **Print Newspaper Article**

Reynolds, G. (2019, April 9). Different strokes for athletic hearts. *The New York Times*, D4.

- **Authored Book**

Kaufman, K. A., Glass, C. R., & Pineau, T. R. (2018). *Mindful sport performance enhancement: Mental training for athletes and coaches*. American Psychological Association. https://doi.org/10.1037/0000048-000

- **Edited Book Chapter**

Zeleke, W. A., Hughes, T. L., & Drozda, N. (2020). Home–school collaboration to promote mind–body health. In C. Maykel & M. A. Bray (Eds.), *Promoting mind–body health in schools: Interventions for mental health professionals* (pp. 11–26). American Psychological Association. https://doi.org/10.1037/0000157-002

- **Online Dictionary Entry**

American Psychological Association. (n.d.). Internet addiction. In *APA dictionary of psychology*. Retrieved April 24, 2020, from https://dictionary.apa.org/internet-addiction

- **Dissertation From a Database**

Horvath-Plyman, M. (2018). *Social media and the college student journey: An examination of how social media use impacts social capital and affects college choice, access, and transition* (Publication No.10937367) [Doctoral dissertation, New York University]. ProQuest Dissertations and Theses Global.

- **Data Set**

O'Donohue, W. (2017). *Content analysis of undergraduate psychology textbooks* (ICPSR 21600; Version V1) [Data set]. Inter-university Consortium for Political and Social Research. https://doi.org/10.3886/ICPSR36966.v1

4. Article types and length

The general principle of the NaSoM is not to limit authors by the length of their article. We welcome articles that clearly and in detail set out all the necessary stages of the study. The format of the electronic journal allows authors to present scientific results in a diverse and complete manner.

The NaSoM has the following Article Type: Editor's Material, Reviews, Empirical Articles, Brief Reports, Case Studies, Book Reviews, Comments, Meeting Abstracts, and Learning from the Past.

The NaSoM recommends authors to carefully select the appropriate article type for their manuscript and to comply with the article type. Please pay close attention to the word count limits. Please indicate the number of words and the number of figures and tables included in your manuscript in the Cover Letter.

4.1. Review

These papers are typically in the 5000–10000-word range and provide a critical analysis of important topics related to the journal. Longer papers can be submitted and will be considered at the discretion of the editors; in your Cover letter, please justify why you are requesting greater than 10000 words.

The essence of the review is a detailed study and systems analysis of a huge mass of literature (approximately 100 original research articles). These Articles should provide a comprehensive summary of research on a chosen topic, and describe perspectives on the research in the given field.

The most common types of reviews are:

- *A theoretical/methodological review* presents the newest theories or substantiation of new research methods.
- *A qualitative review* summarizes the results of relevant studies without using statistics.
- *A quantitative review* uses statistical methods to combine the results of two or more studies.
- *A meta-analysis review* uses statistical methods to integrate estimates of effects

from relevant studies that are independent but similar and summarizes them.

The structure of the review article includes following mandatory sections: a Title, Abstract, Introduction, Methods, Results, Discussion, and References.

4.1.1. The Introduction briefly outlines the topic and explains why the review was undertaken. The main element of the Introduction is the formulation of a research issue/problem.

4.1.2. The Method section is the most crucial part of a review article which should present clearly and logically the search strategy, namely, it following components: keyword combinations and terms employed in the search, databases (PubMed, Scopus, and et. al), inclusion and exclusion criteria, the ways of identification of studies, study selection, data extraction, quality assessment, and data analysis.

4.1.3. The description of the results obtained and their systems analysis are respectively placed in the Results section.

4.1.4. Interpretation of the results obtained, description of the gaps or limitations of the works, and putting forward new hypotheses and goals for future research projects are presented in the Discussion section.

It should be emphasized that a good review begins with a protocol that defines the study design, objectives, and expected outcomes. We recommend you to familiarize with the PRISMA Statement that consists of a 27-item checklist [17] and a flow diagram [18]. These tools help you to develop a review protocol and understand what to include when writing the review.

4.2. Empirical article

Single study research articles should not exceed 5000 words. Research articles reporting multiple (two or more) studies should not exceed 10000 words in total**.** The structure of the Empirical article includes the following mandatory sections: Title, Abstract, Introduction, Methods, Results, Discussion, and References (see 3.1-3.5).

4.3. Book review

Book review (up to 2500 words) should contain a critical analysis in which both the merits and shortcoming of the book must be noted. Mandatory sections of the book review:

- general information (author's name, title of the book, information about the author, main theme of the book, and the book author's purpose).
- brief description of the book contents;
- critical analysis of the book;
- perspectives of the reviewed book.

The editors request the authors to submit a copy of the reviewed monograph along with the review. A book review should be sent to the editor no later than one year after the book publication. Book reviewers are invited predominantly by the editorial board.

4.4. Case study

Case study highlights unique cases: unexpected facts, unusual diagnoses, and treatment outcomes, extraordinary clinical course, and etc. Case study has a maximum word count of 3000 and may contain no more than four figures, tables, or videos.

Case study should have the following format (see [1]):

- abstract;
- introduction (explanation what is unique about the case);
- case description;
- a figure or table with relevant data from the episode;
- diagnostic assessment;
- discussion (strengths and limitations of the approach to the case, discussion of the relevant literature (similar and contrasting to the cases), conclusions from the case);
- perspective.

4.5. Brief Report

Brief Report is an original study in a more succinct way, and with fewer details, than Original Research article. The NaSoM encourages Brief Reports of negative results and the non-reproducibility of previously published results. These articles should not exceed a total of 2500 words (including tables, figures, and references). Additional tables or figures can be included in Supplementary Material. Brief Research Report article has the following format:

- abstract;
- introduction;
- method;
- results;
- discussion;
- supplementary material.

4.4. Comments

Comments provide critical discussion on a previous publication in the NaSoM Natural Systems of Mind. Author should provide the complete citation of the article being commented on. Comments are peer-reviewed, have a maximum word count of 1000 words. They must not contain unpublished or original data. Comments articles should have the following format:

- title: "Comments: Title of the original article";
- introduction;
- subsections relevant for the topic;
- discussion.

4.7. Meeting Abstract

Meeting abstract (up to) informs Readers about scientific congresses, conferences, and symposiums. It must contain no more than 3000 words and must be received by the editors of Natural Systems of Mind no later than one month after holding the event.

4.8. Learning from the Past

The "Learning from the past" presents the articles of Russian scholars that are inaccessible to English-speaking readers. The articles are not only of historical interest. The development of science is like a spiral, and the modern researcher can often learn a lot from the scientists of the past. Articles are selected by the editorial board, at the same time we will be grateful for the recommendations of materials in this section and responses to published materials.

5. Ethical principles of scientific publications

5.1. Basic ethical principles

5.1.1. The NaSoM strives to follow the principles of the Association of Scientific Editors and Publishers (ASEP), as well as the recommendations of the Committee on Publication Ethics (COPE) and other international associations of editors and publishers, including the Russian Council on Ethics of Scientific Publications [11].

5.1.2. Ethical norms of the editorial board:

The editorial team of the NaSoM is guided by the principles of science, objectivity, professionalism, and impartiality.

5.1.3. Responsibility for compliance with ethical standards:

Researchers, authors, editors, reviewers, and publishers have an ethical obligation to publish and disseminate the results of scientific research.

5.1.4. Rules of communication with authors:

Interaction with authors is based on the principles of fairness, courtesy, objectivity, honesty and transparency.

5.1.5. Review institute:

All content of the journal, except for advertising and editorial materials, is subject to mandatory review by independent experts (double-blind peer review).

5.1.6. Access to publications:

The journal guarantees access to publications, ensuring the storage of materials in the leading libraries and repositories of scientific information in the country. All publications of the journal are freely available on the journal's website.

5.1.7. Information openness:

The NaSoM website present provisions of publication ethics and peer review, clearly articulates the journal's policy, rules for submitting manuscripts, instructions for authors and information on the availability of materials, indicates the ISSN, and the address of the publisher.

5.1.8. Information about paid services:

The NaSoM does not provide paid services.

5.1.9. Compliance with the ethical criteria of authorship:

(a) The author is only a person who was significantly involved in the writing of the manuscript, in the development of its concept, in scientific design, collection of material, analysis and interpretation;

(b) Obligatory is the consent of all authors to the publication. All co-authors must meet these criteria.

5.1.10. Coordination of the final text of the article with the author:

The publication of an article under the name of the author implies the emergence of copyright. The publication of a text not agreed with the author, as well as the inclusion of third parties as co-authors, is a violation of copyright.

5.1.11. Terms of decision-making by the editors:

Editorial decisions are made within a limited time frame and are set out in a clear and

constructive form on the publication's website in the instructions for authors.

5.1.12. Interaction with scientific and professional associations:

The editorial board of the NaSoM seek to interact with professional scientific associations and industry communities in order to ensure the high quality of the work of scientists.

5.1.13. Prevention and correction of violations of ethics:

The duty of scientific editors is to prevent situations when authors, reviewers or other entities involved in the production of scientific texts engage in unethical behavior, as well as to ensure the removal of unscrupulous publications from the scientific space, to cooperate with the ethics council and scientific associations.

5.1.14. Conflict of interests:

The editors encourage authors to disclose relationships with industrial and financial organizations that could lead to a conflict of interest. All sources of funding must be indicated by the authors in the Title page of the article.

5.2. Signs of unethical behavior

The NaSom recognizes the following as unethical behavior in the field of scientific publications:

5.2.1. The requirement for authors to independently provide reviews of their own articles, as well as contractual and pseudo-reviewing.

5.2.2. Proposal of agency services: "turnkey publication", correspondence with the editors on behalf of the author, revision of articles by the agent on the recommendations of the reviewer, preparation of paid reviews.

5.2.3. Sale of co-authorship, gift co-authorship, change of composition of authors.

5.2.4. Transfer of texts of articles to other journals without the consent of the authors.

5.2.5. Transfer of materials of authors to third parties.

5.2.6. Artificial increase in scientometric indices, excessive self-citation and friendly citation, irrelevant links.

5.2.7. Plagiarism, falsification and fabrication.

6. Conclusion

The modern scientific world implies great dynamism in various forms of scientific communication. The rules presented are not permanently defined. The NaSoM believes that its mission is not only to follow already established traditions, but also to be ahead of the curve. In some norms (for example, related to the conclusions of ethical committees), we are ignoring some controversial standards. The main goal of NaSoM is to develop SCIENCE. On this difficult path, we hope for the support of our authors, reviewers, members of the editorial board, and, certainly, readers. We will gratefully accept your comments and ideas on the NaSoM development by e-mail: nsom@ipran.ru

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REVIEW

Consciousness and Mental Reality: From Traditional Foundations to a New Understanding of General Psychological Knowledge

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Abstract. A new book by N.I. Chuprikova "Mental activity of the brain, language and consciousness. In Search of Psychic Reality and the Subject of Psychology" is analyzed. The originality of the author's intention, the relevance of the logic of substantiation of the categorical and structural foundations of general psychological knowledge are stated. The continuity and novelty of the systemic foundations of general psychology are shown. A comparison of the problematic issues of the psychology of consciousness, their solutions in modern research and in the works of N.I. Chuprikova.

Keywords: Mental Reality, Brain, Consciousness, Reflection, Regulation, Language, Communication**.**

A new book by Natalia Ivanovna Chuprikova “Psychic activity of the brain, language and consciousness: In Search of Psychic Reality and the Subject of Psychology” (Publisher: Languages of Slavic Culture, 2021) is an organic continuation and development of the ideas which were presented in a number of her previous publications [5; 6; 7; 8 and others]. In their totality, they define a coherent, logically verified doctrine of the mind and consciousness, which, we believe, has no analogues in modern psychology. A system of basic categories and concepts of psychology are structurally built of components and functions, as well as verified from the point of view of evolutionary ideas and provisions of related natural sciences. This system of categories and concepts is the basis of general psychological knowledge from the positions of the methodology, ontology, and epistemology.

It may seem to some that N.I. Chuprikova opposes the idea of paradigm leaps in the development of scientific systems, since she clearly and unswervingly defends the continuity of psychological knowledge, clarifies the conceptual constructs, enriches with the latest facts and generalized theoretical provisions. The term "paradigm" goes back to the T. Kuhn's theory, according to which the development of science occurs in leaps. There is a significant change in scientific attitudes that determine the basic provisions underlying a particular science. T. Kuhn connects the alternation of stages of scientific knowledge with the resolute and steady upholding by individual scientists and scientific groups of new scientific positions that determine the possibility of resolving existing contradictions [17]. At the same time, continuity in the development of scientific knowledge, i.e., periodic transitions of science to a new state while maintaining certain relationships between the old knowledge and the new content, which allows us to rethink the previous level of science

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development, does not seem to us as an opposite or a paradigm leap. Both are well explained from the standpoint of dialectics. The dialectical-materialistic foundations of Russian psychology, on the one hand, correspond to modern trends in world psychology, and on the other hand, provide a culturally specific line of its successive development [3; 13; 23; 27].

Consistently implemented by N.I. Churikova's transition from the monocategorical basis of general psychological knowledge to dual categoricality (reflection and regulation), in our opinion, corresponds to the continuity of the development of psychology, since the concept of regulation was previously present in psychological discourses. The principal feature of the N.I. Chuprikova lies in the fact that the concept of regulation actually acts in the status of a category, i.e., the base category along with the reflection category. It should be noted that in Russian psychology there are systems of psychological knowledge that are not based on the category of reflection. These are, in particular, the systems of psychological knowledge of V.N. Panferov, as well as V.I. Slobodchikova and E.I. Isaev. In the works of these scholars, the subject of psychology is defined from the standpoint of the idea of human psychology as opposed to traditional ideas about mental phenomena. This approach proceeds from the proposition of S.L. Rubinstein, according to which the first essential sign of the psyche is the belonging of the individual, that is, the personality. The second essential feature of mental phenomena is attitude. Thus, the duality of the foundations of psychological knowledge is emphasized.

Another approach to the restructuring of general psychological knowledge outside the category of reflection was presented in the works of V.E. Klochko, which is based on the concept of "psychological systems". L.S. Vygotsky believed that the category of consciousness is fundamental in the entire system of psychological knowledge. L.S. Vygotsky defined consciousness dually, that is, as communication and generalization, emphasizing the systems and semantic organization of consciousness. In the modern science of consciousness, which is positioned as a wide range of knowledge, including philosophy, cognitive science, neuroscience and other sciences, including psychology, the category of consciousness is the basis of this complex of knowledge [4; 9; 14; 16; 19; 22]. Thus, as it can be assumed, a one-category basis is not quite sufficient for the construction of general psychological knowledge.

N.I. Chuprikova chosen category of reflection as the basic category of the general psychological knowledge. This construct is well-known in Russian psychology. The originality of the author's intention, as it seems to me, lies in the binary bundle of reflection and regulation, functionally complementing the processes, states and properties of reflection. The regulation of activity and behavior has also been used by psychologists in the past to form a more complete picture of the entire complex of mental phenomena. However, this addition to the category of reflection in the definitions of the central foundations of the psychology by other authors was, as a rule, of a side-by-side character and did not have the property of reciprocity of the considered binary.

In the N.I. Chuprikova's monographs logically, theoretically, as well as on convincing examples (both from the history of psychophysiological research and modern neuropsychological studies) is shown the relationship and interdependence of reflection and regulation of human activity in the external and internal plans.

All known mental phenomena are subordinate to the logic of necessary connections, including sensory-perceptual mechanisms of cognition, as well as experience (attitude), communication, needs and motives, thinking and imagination, hierarchy of desires and intentions, organization of actions and behavior.

Another important theme presented in the new book by N.I. Chuprikova, is a psychophysical problem, which received its solution in Russian psychology from the standpoint of dialectical materialism.

This problem, which has become a stumbling block in many studies of consciousness, has received the status of "Hard Problem" in the Science of Conscionsness [4; 22; 25; etc.].The relentless attempts to substantiate consciousness through neurocognitive research and the search for neural correlates of consciousness, with all the positive results, some of which find practical application in brain-computer interfaces, as well as in artificial intelligence programs, nevertheless, do not bring together opposing points of view on the nature of consciousness.

Evolutionary and socio-cultural approaches make it possible to remove the "intensity" of

confrontation in solving this problem [26]. A modern thorough analysis of the psychophysical problem was carried out by V.A. Petrovsky [20]. Another way to solve this problem may be related to the improvement and expansion of the functions of artificial intelligence programs, which was argued in a slightly different style in one of his speeches by M.M. Reshetnikov [2].

The psychophysical problem is of particular relevance in connection with the new possibilities of digital technologies and the design of artificial consciousness programs. The proposition on the ideal nature of mental reality and consciousness is based on the works of P.K. Anokhin, who created a model of a holistic functional system of brain activity to ensure the reflection and regulation of human behavior.

The thesis about the ideal in content and material in terms of the spatial-material organization of mental reality in the works of N.I. Chuprikova is also supported by references to the studies of J. Edelman and A.M. Ivanitsky. N. I. Chuprikova concretized and reviewed studies of the physiological mechanisms of consciousness [15] testifying in favor of the defended A.M. Ivanitsky "Information Synthesis Hypothesis ". This hypothesis preceded the well-known in the science of consciousness " An Integrated Information Theory of Consciousness" [24].

In other categorical meanings (representation, information codes), the idea of integration, in the logic of the complementarity of consciousness from the First person and consciousness from the Third person, is presented in the hypothesis of M. Velmans that "the neural correlates of consciousness are representations of the same content that is represented in consciousness, but in other information codes" [25, p.12].

Another solution of the psychophysical problem, popular today, is presented in the hypothesis of the emergence of consciousness by analogy with the emergence of new properties at the molecular level of the organization of matter in comparison with the atomic one. As an example, a water molecule is usually given, which has new properties in comparison with the properties of hydrogen and oxygen, which are part of it. In this regard, F. Crick's hypothesis about the emergence of consciousness on the basis of resonant electromagnetic phenomena in the brain at a frequency of 40 hertz is also quite popular.

One of the most consistent and thorough attempts to solve this problem, designated in the science of consciousness as the most difficult, is carried out by M. Velmans. The author, based on the facts of psychosomatic medicine and conscious regulation of human behavior, states the mysteriousness of the effects of the influence of the mind (consciousness) on the body (brain) and defines this situation in science as a "theoretical dead end" [25, p. 10]. Velmans does not accept physicalist, eliminative and reductionist, as well as functionalist explanations of consciousness [22], calling them pseudo-solutions to the problem. According to R. Van Gulick, one of the opponents invited by Velmans to discuss the project he announced, the mainstream of philosophical thought of the last quarter of the 20th century on the issue of the relationship between consciousness and brain processes is associated with non-reductive physicalism. Moving away from extreme positions (psyche and consciousness are nothing more than brain processes; consciousness is a state of a functioning brain), non-reductive physicalism corrects dualism in the direction of pluralism as the broadest view of the relationship between mental and physical, including many aspects, such as biological, chemical, evolutionary, geological, historical, and perhaps even Marxist, Freudian, and feminist. R. Van Gulick relates the position of Velmans to a certain type of non-reductive pluralism [11, p.54].

M. Velmans systematizes the phenomenon of causality in the context of a psychophysical problem and distinguishes four types of deterministic connections of an influencing object (subject) on an influencing (changeable) object: physical → physical, mental → mental, physical → mental, mental → physical. Velmans attributes the first two types from the positions of the Third and First person (if possible, observation by an external observer or by the subject himself); he relates the remaining two types to mixed positions, thus allowing the study of these types of determination in the science of consciousness both from the position of the Third Person (objectivism) and the First Person (Subjectivity) [25, p.14-16]. At the same time, Velmans considers the physical world to be "causally closed" which excludes non-physical causes. Referring to the study by B. Libet that the brain prepares the necessary action carried out by the individual about 350 milliseconds before the individual realizes this, Velmans raises two clarifying questions: 1) How can consciousness

be causally efficient if it appears much later than the mental processes in the brain on which it depends? 2) How does the content of consciousness affect the states of the brain and body if the subject is not aware of the biological processes that govern these states? According to Velmans, consciousness is inseparable from preconsciousness, in which the processes of "mental/brain" activity are automatically realized [25, p.19]. In this case, according to Velmans, the brain forms several models, only one of which was identified in the Libet experiment as preceding "volitional awareness." Velmans allows for the preconscious development by the individual of a "set of decisions" that precede the decision made by the individual. Thus, according to Velmans, the individual "simultaneously preconsciously generates processes and is aware of the results" [25, p.20]. Therefore, according to Velmans, the Libet experiment does not refute the conscious regulation by a person of one's actions. Rejecting the biological (brain) determination of consciousness, Velmans comes to the thesis of the mutual complementarity of the physical/mental, body/mental, and brain/consciousness. In search of a methodological justification for his position, Velmans considers various types of connections in the "brain-consciousness" complex: causality, correlation, ontological connection, and comes to the conclusion about the "ontological identity" of the mental and physical. Thus, the developed theory is designated by the author as a psychophysical or two-aspect theory of consciousness.

One of the critical responses collected by Velmans was prepared by S.S. Rakover; the opponent views Velmans' theory as "a combination of ontological monism with epistemological dualism". Dualism, according to Rakover, follows from Velmans' position that consciousness (an ideal phenomenon) and its neural correlates in the brain represent the same information encoded in different ways [21, p.52].

Considering the psychophysical theory of consciousness proposed by Velmans, in the context of the "hard problem" of consciousness, it should be noted that representative means in various encodings (figurative, verbal, other sign) are not fully considered by Velmans and his opponents, which, in our opinion, does not cover all possible arguments, which in this case go beyond the biological determination of consciousness into the area of communicative activity of the external and internal plans, as well as sociocultural determinants [1].

A detailed analysis of the causal relationship between the phenomenon of consciousness and sociocultural factors is fundamental in the historical development of ideas about consciousness in Russian psychology. In the works of N.I. Chuprikova clearly presents the factors of language (a system of socially generated sign-symbolic means of communication, cognition and other social activity of a person) and speech (an individual form of representation by linguistic means of the content of the reflected world in the process of regulating social relations).

N.I. Chuprikova notes that no less important in the problem of consciousness is the factor of reflecting the content of the mind of other people and one's own mind as the basis for regulating social behavior. The discovery of "mirror neurons" expanded the understanding of the brain in the context of the social properties of consciousness and the corresponding neural mechanisms. "Theory of mind" and its applied aspects have become widespread. The metaphor "social brain" received an additional categorical meaning, in particular, in the work of M. Graziano "Consciousness and the social brain" [10]. At the same time, in a very wide range of modern studies of consciousness, one can single out works carried out on the basis of a belief in the social nature of consciousness. The concepts of "manipulative intelligence" (Machiavellianism), "social brain", "mirror neurons", according to these beliefs, and from the standpoint of social psychology, social anthropology and cultural evolution of a person confirm the social nature of the emergence and development of consciousness in phylogenesis [26].

Postulation in the monographs of N.I. Chuprikova's "ideal-material nature of the psyche" is based on the methodological principles of Russian psychology, which makes it possible to "remove" this problem. Such a decision is quite justified in the logic of ideas about the specifics of scientific mentalities and traditional attitudes in different countries [3; thirteen; 23; 26; 27]. Implicit (personal) knowledge and research attitudes of scientists from different schools in this context are consistent with another thesis presented in the monograph by N.I. Chuprikova, this is the position "on the qualitative diversity of mental reality" [5]. It should be noted that the thesis about the multidimensionality of consciousness was presented in a different style in the studies

of V.F. Petrenko [19], and earlier in the work of B.F. Lomov, which outlined the multidimensionality and multilevel nature of mental phenomena, as well as the possibility of their holistic study from the standpoint of a systematic approach [18].

We do not identify the mind and consciousness, however, we believe that the global development of technologies observed today, including genomic ones, as well as the rapid spread of digital technologies and artificial intelligence [2], will create opportunities for the artificial reproduction of an increasing range of sensory-perceptual and cognitive psychic phenomena, not affecting so far (as far as we know) the emotions and consciousness of a person. The well-known connection “affect and intellect”, which goes back to the works of L.S. Vygotsky, is to a certain extent similar to the identification of two main types of consciousness: phenomenal and cognitive (according to D. Chalmers'a - psychological) consciousness [4]; in other versions, it is “subjectivity” and “intentionality” [14;16]. In all versions, the first identification of consciousness is associated with a difficult problem of consciousness, and the second with a relatively easy one. In this context, as we believe, the concept of "mental reality", introduced by N.I. Chuprikova, successfully combines both problems into a single whole, which makes it possible to avoid dead-end lines of the movement of scientific thought of a super-abstract content.

Of particular interest is N.I. Chuprikova's thesis about the diversity of "languages of description of mental reality". The author quite reasonably connects the genesis of consciousness with communication, communication, t. a. exchange of information in the speech and other non-verbal registers of activity of the subjects of interaction. In Russian and international studies on the problem of consciousness, the theme of various languages of consciousness is quite rare, excluding the publications of V.P. Zinchenko [1; 28] and the study of representations, their content and means, as well as what is denoted by the phrases “representational consciousness”, “unconscious representations” [9; 12].

When one considers the notion of representation and related theories of higher-order and first-order representationalism [9; 12], it is appropriate to refer to the well-known Russian constructs "higher mental functions" and "second signaling system". N.I. Chuprikova presents material that formalizes "the highest regulatory and control role of the second signaling system in the human mind and behavior". The potential of this construct for the development of a system of psychological knowledge exceeds the above-mentioned theories of representationalism.

The N.I. Chuprikova’s book "Mental activity of the brain, language and consciousness. In Search of Psychic Reality and the Subject of Psychology" contains twelve chapters. The book ends with three chapters devoted to the psychology of attention, perception of space, needs and emotions, which are considered in the author's amplification of traditional ideas based on a holistic system of categories, structural constructions and worldview positions.

The integrity of the foundations of the system of psychological knowledge proposed by N.I. Chuprikova is ensured by solving a number of important issues, in particular:

1. Mental reality manifests itself as a reflective and regulatory activity of the brain, which is inseparable from a person's social activity in the forms of information exchange, verbal and non-verbal communication. Reflective and regulative activity is also carried out by a person through the acquired abilities to cognize their internal states, the states of other people and manage them.
2. Substantiation of the qualitative diversity of mental reality, including the multiplicity of languages, i.e., a set of symbolic means of designing the external and internal worlds of a person.
3. The promotion of language and speech as factors in the emergence and development of consciousness, due to which the “objective content of the mind of other people and one’s own mind” is involved in the sphere of reflection and regulation, which allows for large-scale “practices of oneself” (M. Foucault) and the surrounding reality.

The powerful methodological and theoretical content of N. I. Chuprikova's book is a kind of guiding compass for mastering the psychology of all areas and levels of psychological education; it can also be used in social, humanitarian, pedagogical disciplines, as well as in the development of artificial intelligence systems.

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Intransitivity and Contextuality in the Decision Making of Social Insect Colonies

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Abstract. Historically, social insects presented researchers with myriad examples of rational behaviour. The ability to make decisions based on a transitive hierarchy of preferences is a cornerstone of rationality. Consequently, models of social insect behaviour often assume social insects act according to fixed decision rules that imply a transitive hierarchy of preferences. However, contextual effects, including the number of options presented and the presence or absence of pheromones, can impair social insects' abilities to behave per their transitive preferences. This paper investigates the conditions where contextual effects cause social insects to display intransitive preferences at the individual and colony levels.
Keywords: Social Insect Colonies; Decision Making, Contextuality, Intransitivity, Non-Rational Decision Making, Cyclic Systems

Intransitivity in Human Decision Making

The idea of a correct manner of thought dates back at least to the time of Aristotle and his exposition of the principles of logic as laid out in the Organon. For Aristotle, logic appeared to be a tool for reasoning from true statements to true statements. In the 19th Century, logic became a subject in its own right, particularly in mathematics, spawning not one logic, but many distinct logics together with ideas of theory and model. The idea of thought as a tool for achieving goals emerged gradually, particularly within the economics literature. This led gradually to the concept of rationality as a tool for making effective decisions in economics, a tool that enables an agent to make choices leading to the achievement of an economic goal, such as maximizing a utility, maximizing a profit, or minimizing a cost or risk.

One subject area that has received a great deal of attention is preference, which is important in an individual making one choice over another, and indifference, when a choice is made randomly with equal probability for the alternatives. An important feature of rationality in the determination of preferences is said to be the presence of transitivity [1]. This means that if an agent prefers choice A over choice B, and choice B over choice C, then they will prefer choice A over choice C, regardless of context, order of presentation or the presence of competing attributes. Preferences in which transitivity fails are said to be intransitive and characterized as being irrational or non-rational, and therefore to be avoided or dismissed. In both economic and psychological measurement theory, the existence of transitivity has the status of an axiom, since it is necessary in order that an ordinal scale exist for the observable being measured [2]. Since subjects are living agents and not machines, they are prone to errors and inconsistencies in their decision making. This leads to two forms of transitivity, a strong form (strong transitivity, ST) as depicted in the example above, and a stochastic form (weak stochastic transitivity, WST) where x is preferred

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over *y* if it is chosen more than 50% of the time [2].

There has been much debate in the literature on decision making, whether in economics or psychology, as to whether preferences, as expressed by human agents, are always transitive, hence presumably rational, or intransitive, and therefore irrational, and thus worthy of correction. In general, transitivity was held to be fundamental and universal in decision making (since after all humans were clearly rational in forming their decisions) and thus any intransitivity that appeared in experiments must be due to an error of some form or another, and therefore could be dismissed as a genuine form of human decision making. Tversky [2] was among the first to show that under specific experimental conditions it was possible to demonstrate the occurrence of consistent and predictable intransitivity in certain situations of decision making, for example choosing which of two alternatives to take a gamble on. Anand [3] argued on philosophical grounds that intransitivity need not necessarily be irrational. Butler and Progrebna [4] point out that "Transitivity must hold either if a value attaches to each option without reference to other alternatives (choice-set independence), or if an equivalent value results after comparing and contrasting the attributes of the available choice options". Bar-Hillel and Margalit [5] presented three different contexts within which intransitivity might meaningfully occur 1) where intransitivity results from application of an ethical or moral choice rule; 2) where intransitivity results from application of an ethical or pragmatic choice rule; 3) where the choice is intrinsically comparative, depending upon multiple competing alternatives. In these contexts, intransitivity presents as a plausible consequence.

Evidence continues to accumulate for the presence of intransitivity in human preferences. In one study [6], consumers were presented with three different scenarios and surveyed on their preferences: 1) a choice of goods without restrictions; 2) a choice of goods with budget restrictions and price changes, and 3) decreased disposable income. Transitivity occurred in only 8% of the sample. Evidence of intransitivity has been observed in neuroimaging studies [7], in the gamble paradigm, with insular activity involved in magnitude judgments while posterior cingulate activity was involved in probability judgments.

Not all authors agree, however. Regenwetter, Dana and Davis-Stober [8] argue that transitivity is a universal phenomenon, and any deviation from transitivity is due to agent or experimental error. They write "We challenge the standard operationalizations of transitive preferences and discuss pervasive methodological problems in the collection, modelling, and analysis of relevant empirical data. For example, violations of weak stochastic transitivity do not imply violations of transitivity of preference. Building on past multidisciplinary work, we use parsimonious mixture models, where the space of permissible preference states is the family of (transitive) strict linear orders. We show that the data from many of the available studies designed to elicit intransitive choice are consistent with transitive preferences." A related criticism of pair-wise comparison experiments has suggested methodological modifications in order to eliminate the appearance of intransitivity [9]. Intransitivity has been explained through at least two forms of error – random preference, in which preferences are transient at each point in time but vary over time, and context-sensitive preference models, in which choice preferences are influenced by current and prior choice contexts [10]. A test of a particular theory of decision making, regret theory, also failed to show evidence of intransitivity [11].

These arguments all assume some form of error in preference determination and appear to deny the possibility of principled intransitivity. Consider the following simple example. I judge ice cream based on two attributes: taste, and the propensity to cause gastroesophageal reflux. One attribute provides pleasure, the other pain. Consider four types of ice cream together with their attribute ratings (taste, reflux potential): double fudge chocolate (100,100), double chocolate (75,75), chocolate (50,50) and pistachio (25,25). I accept pleasure over pain, but only to a point. If the difference in reflux potential is 50 or less, I choose by taste. If the difference in reflux potential is greater than 50, then I choose so as to minimize pain. This leads to the following preferences: double fudge chocolate > double chocolate, double chocolate > chocolate, chocolate > pistachio, pistachio > double fudge chocolate. These choices are quite rational. If given a choice of two similar reflux inducing choices, I might as well pick the more pleasant as the consequences later will be similar. However, if the difference in subsequent

suffering is sufficiently great, the increase in pleasure is not worth the added pain. Note that my decision is principled. If I based my decision on a single attribute, I would find that the corresponding preference orderings would be dual to one another. Intransitivity occurs here because decisions are based upon two competing attributes which possess incompatible preference orderings.

A different set of preferences will be found if I am presented with three choices simultaneously. For example, given double fudge chocolate, double chocolate, and pistachio, I would choose pistachio, because the first two are guaranteed to cause distress. However, given a choice of double fudge chocolate, chocolate, and pistachio, I would choose chocolate because it balances pleasure and pain. The point is that one cannot determine three choice outcomes from two choice outcomes – the context of the situation matters.

Many authors have provided principled (most often mathematical) arguments for the existence of intransitivity. Formally, transitivity is one of the axioms required to define a concept of order, and hence of ordered sets. As noted previously, the axiom of transitivity is required to ensure that preferences form an ordered set, and thus admit description by an ordinal scale. Mathematically, a *(strict) partial order* is a simply a transitive relation R on a set. It does not require a relationship between arbitrary elements or of an element with itself. Elements a,b for which aRb are said to be *comparable*. Elements that have no relationship are called *incomparable*. A *linear* or *total* order requires that any two elements must be comparable. The orders considered in economics and measurement theory are called weak orders [12] and consist of partial orders where incomparability is given by its own relation I (indifference) and I is required to be an *equivalence relation* (transitive, reflexive (aIa), symmetric (aIb implies bIa)). Luce [12] was the first to introduce the concept of a semi-order, which generalizes the concept of a weak order to allow for intransitive indifference relations. Of particular interest are those semi-orders where the ordering is induced by means of a utility function u, that is $x \geq y$ iff $u(x) \geq u(y)$. Many arguments surround the existence and nature of a utility function u giving rise to the preference relation (and to the probabilities in WST).

An early analysis of intransitivity from a formal perspective was conducted by Fishburn [13]. He surveyed a number of models for intransitive preferences in settings such as economic consumer theory, multi-attribute utility theory, game theory, preference between time streams and decision making under risk and uncertainty. He analyzed several candidate utility functions and suggested that transitivity is not essential to ensuring the existence of maximally preferred alternatives in a number of situations. People need not always engage in decision making that invokes transitivity, and reasonably so.

Butler and Progrebna [4] describe the Steinhaus and Trybula paradox in which the probabilities of choices all exceed 50% and yet Weak Stochastic Transitivity (WST) is still violated. They conducted a set of lotteries and observed rates of transitivity and intransitivity, accounting for factors such as noisy variation. They concluded that the Steinhaus-Trybula Paradox, in the setting of multi-attribute risky choice, shows that reliance on transitivity may result in a failure to select the most advantageous lotteries, and thus may not provide the most rational decision strategy. They write: "Results support our conjectures that the cycles reflect latent intransitive preference rather than noisy implementation of transitive preferences." Moreover, they found that "many typically transitive individuals are the same people who violate transitivity in the circumstances we identify. This suggests neither a transitive nor intransitive 'core' utility function can accurately describe preferences over all lotteries a person may encounter. .... in line with a constructed-preference paradigm". This experiment demonstrated that people use different strategies in different contexts; a strategy which appears rational in one context may not be in a different context. Far from being a liability, this makes human decision adaptable to different circumstances. There is no such thing as a one size fits all, or universal strategy.

Panda [14] examined modifications of rational choice theory in the presence of different degrees of intransitivity. These weaker forms of rationality include quasi-transitive rationality and acyclic rationality. He discusses the consistency of these weaker forms and shows how the results change given bounds on the domain of the utility function.

Klimenko [15] has examined intransitivity in a wide range of settings: economic, psychological, social, game theoretic, thermodynamic, and complex dynamic. His works attempts to provide

a unified framework for studying intransitivity across different contexts and introduces a general measure of intransitivity, the evolutionary intransitivity parameter. He points out that "Human preferences that seem irrational from the perspective of the conventional utility theory, become perfectly logical in the intransitive and relativistic framework suggested here". He concludes that intransitivity should appear under any of the following conditions: relative comparison criteria, multiple incommensurable comparison criteria, multiple comparison criteria that are known approximately, comparisons of groups of comparable elements.

An interesting formal analysis within the setting of game theory again shows that intransitivity need not be viewed as irrational, and indeed may sometimes be the preferred attribute of a decision strategy. Makowski et al [16] present a simple two player choice game and show that the optimal strategy of one player can only be intransitive while that of the second player may be transitive or intransitive. In a quantum version of the game, it turns out that that there is a certain course of the game where only intransitive strategies are optimal for both players.

It has been suggested that there are significant dynamical homologies between collective intelligence systems such as social insect colonies, and neurobehavioural regulatory systems [17] so that collective intelligence systems might serve as experimental proxies for exploring the dynamics of neurobehavioural systems. In particular, a study of intransitivity in collective intelligence systems might provide insights into the role, if any, that intransitivity might serve in neurobehavioural and psychological systems. Thus, we turn now to a consideration of intransitivity in collective intelligence systems.

Intransitivity in Collective Intelligence Systems

Collective intelligence systems refer to a broad range of complex systems, both natural and artificial, all of which are characterized by the capacity to manifest adaptive, intelligent behavior [18] in the absence of any central authority, control, or planning. They are able to make ecologically salient choices in response to changing environmental conditions or contexts through the collective action of large numbers of lesser agents. The prototypical example of a collective intelligence system is the social insect colony of which social wasps, bees and ants make up the principal examples [19,20,21]. Collective intelligence architectures have been applied to the design of computational systems, but they will not be considered here. The focus here is on the presence of intransitivity in decision making among wasps, bees and ants, and what is known or conjectured regarding the reasons why such intransitivity occurs. An important question is whether such intransitivity is due merely to random errors in effecting decisions, or whether it represents a systematic or principled aspect of collective decision making.

Intransitive Behaviour in Social Wasps and Bees

Before considering the phenomenon of collective behaviour, let us first examine that of individual workers. Workers of the wasp species *Vespula germanica* were observed individually searching for food [22]. Two experiments were conducted. In the first experiment, three pairs of foraging runs took place. For the first run of each pair a container of 20 gm of meat was placed in a control location. During the second run the container was displaced by 300, 600 and 900 meters respectively. The food dish remained in the same location for both runs for the control group. Wasps in the experimental group spent more time hovering over the previously learned location and the time taken to locate to displaced food increased with increasing distance. In a second experiment, workers were given a choice between a 20 gm source and an 80 gm source, whose positions were reversed prior to a second trial. For the control group the two sources remained in the same positions between trials. On the initial trial, all of the workers went to the 80 gm food container. On the second trial they went to the 20 gm container.

The authors suggested that the wasps' behaviour was attributable to their use of different transitive hierarchies of preferences during their first and second visits to the meat dishes. During their initial visit, the wasps decided where to land based on the quantity of meat present. The wasps used this information to create a hierarchy of locations. In the wasps' hierarchy, the location with 80 grams was superior to that with less. On their second visit, the wasps used the location-based hierarchy instead of reassessing the amount of available meat. In short, irrelevant contextual information (the location of the meat) was baked into the wasps' use of transitive hierarchies and

consequently produced intransitive behaviour [22].

An early study on preferences in honey bees (*Apis mellifera*) [23] demonstrated the existence of intransitivity in preferences. The author created a set of artificial flowers which varied in height and sucrose concentration, from A (short and weak) to D (long and high). They found that individual workers exhibited a pair-preference ordering of the form A > B >C >D <A, which clearly violates transitivity. In fact, they found workers which violated weak stochastic transitivity and others that violated strong stochastic transitivity. The author suggested that some workers utilized a comparative approach to evaluating the flowers, assessing along several dimensions, each dimension separately. Interestingly, the author identified workers that appeared to utilize both absolute and comparative approaches to decision making.

More extensive studies have been carried out with worker bees. Workers of *Apis mellifera* were tested to determine whether they were capable of learning a transitive hierarchy. Over several days they were trained on 5 different visual patterns (A, B, C, D, E) , presented in pairs, with one pattern reinforced (+) by the presence of sucrose, the other pattern unreinforced (-). The pairs were thus (A+, B-), (B+, C-), (C+, D-), (D+, E-). After training, the bees were then presented with novel unreinforced pairs (A, E) and (B, D). The bees consistently chose A over E, the only pair of stimuli which were not ambiguously reinforced. However, they chose B and D almost equally, showing that the bees did not construct the implied transitive hierarchy A>B>C>D>E. The worker bees appeared to rely on memory constraints (memory of last experience). Here that would discourage E, and so favour A over E. They also relied on associative strength which analysis showed for the pair (B, D) favoured B. Recency, however, favoured D, which results in more or less equal choices. The failure of transitivity appears to be due to memory constraints rather than contextual effects [24].

Contextual effects may influence transitive preferences among bubble bees. A study examined the impact of different conditioning situations on proboscis extensions by workers of *Bombus terrestris* [25]. Individual workers were exposed separately to linalool, phenylacetaldehyde, and a 50-50 mixture, and responded nearly equally (24%, 23%, 27% respectively). They were then subjected to discriminant pairs with one odor reinforced, the other unreinforced. When linalool was the rewarded odor, the workers preferentially responded to linalool (27.8%). However, in the symmetric situation in which phenylacetaldehyde was rewarded, the workers showed little response to phenylacetaldehyde (6.7%). The authors suggested that linalool may possess salience for the workers which overrides the effect of the conditioning, thus providing in internal contextual effect.

Many experiments in insects have focused on the *decoy effect*. This refers to a situation in which a subject is presented with two alternatives, neither of which is clearly superior, and a decoy option (an option which is asymmetrically dominated—meaning that it is inferior to (dominated by) one option but not to the other) is then presented. In the absence of the decoy, neither alternative should be preferred. If the decoy effect is present, then in the presence of the decoy the subject will show a preference for the dominating option, in violation of the principle of regularity, which asserts that a preference should not change merely through the introduction of additional (non-preferred) options. The decoy effect was observed in a study of *Apis cerana* (Asian hive bees) [26]. Workers prefer warm (30°C) over cool (10°C) sucrose solutions and concentrated (30% w/w) over dilute (10% w/w). Presented with warm, dilute, and concentrated, cool solutions, the workers prioritized warmth. However, if the temperature difference were decreased then priority shifts to concentration. In the latter situation the addition of a decoy favoring the higher concentration solution (the preferred option) did not affect the choice of the preferred solution but did significantly reduce the choice of the alternate solution, demonstrating a decoy effect on preference.

Apis mellifera (honeybees) workers were similarly vulnerable to decoy effects. Workers prefer short over long flowers and high sucrose concentrations over weak. Comparing a medium-length flower containing a high sucrose solution to a short one containing less sucrose, the bees demonstrated no preference. But the introduction of long high sucrose flower made the medium length flower more attractive. Likewise, the appearance of a short, low sucrose flower made the short, moderate sucrose flower more attractive [27]. The bees demonstrated that they did not form a transitive hierarchy of preferences based on the intrinsic value of the flowers or sucrose solutions that they saw.

Instead, they compared their options and determined their relative values. Decoys altered the context within which choices should be made, biasing preferences in favour of the option with which they shared an attribute.

Latty and Trueblood [28] provide a detailed and deep analysis of experiments into the preference choices of bumble bees and honeybees. They argue that flower choice is a complex process involving economic considerations, constancy, choice-set size, innate preferences, and composition, all influenced by attributes such as sex, age, nutritional state, satiation, and experience. These different factors interact with one another; it is difficult to imagine that simplistic (rational) strategies will capture the complexity expressed by these insects. Nature may trade optimality for efficiency or adaptability, so that rationality may be the ideal of economists and mathematicians, but not of nature.

Intransitive Preferences in Individual Ants

Some of the most detailed and interesting work on decision making among social insects has been carried out with individual workers and colonies of various species of ants, particularly *Temnothorax albipennis*. Workers of *Temnothorax* choose nest sites based upon several characteristics such as level of lighting (dark over bright) and entrance width (narrow over wide). Edward and Pratt [29] presented ants with two nest sites, A (dark with average entrance) and B (bright with narrow entrance). Workers choose either of these sites with equal likelihood. However, when suitable decoys are presented, the symmetry in preference is broken: with decoy A (dark with wide entrance) ants prefer A, while with decoy B (bright with narrow entrance) ants prefer B. This showed that individual workers run afoul of the decoy effect. This result was confirmed in a subsequent experiment [30].

Individual ants are also vulnerable to another class of contextual effects, namely contrast effects. A tenet of Prospect Theory is that humans may assess options relative to some reference point rather than based upon some absolute value. Wendt et al. [31] demonstrated a similar phenomenon among workers of the ant *Lasius niger*. Workers were either fed high or low molarity sucrose for a sustained period. Ants routinely fed high molarity sucrose were less accepting of low molarity sucrose solutions than ants routinely fed low molarity sucrose regardless of their levels of satiation. The ants appeared not to assess the value of food based on its ability to satiate them but rather compared to alternative food sources, even when the alternative food sources in question were not even present. Food received from other workers within the nest appeared to serve as a reference value. The authors showed that this was primarily a cognitive rather than a sensory phenomenon.

Human judgments are frequently influenced by extraneous factors such as the presence of labels. For example, the same wine can be placed in bottles labelled with different prices, and humans will often choose the pricier over the less expensive. A similar phenomenon has been observed in workers of *Lasius niger*. When allowed to choose between high-quality food associated with a low-quality odour or low-quality food with a high-quality odour, workers always selected the high-quality odour despite previous experience with both food sources [32]. Wendt and Czaczkes [33] confirmed these results, showing that *Lasius niger* workers spent more time eating a medium-quality food source if it smelled of high-quality food than if it was unscented. By overvaluing medium-quality food that smelled high-quality, the ants showed that they based their sense of food quality on contextual information provided by smell, which suggests that they could form transitive hierarchies of food preference based on smell alone. However, ants also spent twice as long eating medium-quality food that smelled of low-quality than medium-quality food that smelled medium-quality. In short, smell gave them expectations about food quality, but food quality ultimately played a role in the time ants spent eating. Therefore, the ants' behaviour could not be explained exclusively by reliance on a transitive hierarchy of food smells. Instead, the presentation of low-quality odour directed ants to compare the medium quality food they tasted to the low-quality food they expected. That is to say, the ants' perception of the choice set's composition (a contextual effect) influenced the amount of time they spent feeding and caused them to overvalue medium-quality food relative to its placement on a transitive hierarchy [33].

Contextual effects have also been demonstrated in the movements of ants [34]. *Atta insularis* workers were allowed to escape from a cell using either of two symmetrically placed exits. In the absence of external factors, the workers chose the exits with equal

probability. However, in the presence of an alarm pheromone, workers broke symmetry and preferentially exited from only one of the exits. The choice of exit appeared to be random and independent of the spatial distribution of workers within the enclosure at the time of release of the alarm.

Intransitive Behaviour in Ant Colonies

The studies presented in the previous sections have all dealt with decision making by *individual* workers within a social insect colony. However, the most interesting studies involve decision making by the colonies themselves, what is called *collective intelligence*. As has been noted above, individual workers are capable of complex decision making, taking account of a potentially large number of factors, and integrating those assessments into a single choice. Often those choices (or the preference probabilities) violate one or more of the principles of rational thought. However, we have also seen that for agents living in the natural world, outside of a laboratory, restrictions of decision making to only rational strategies may not provide the resilience, adaptability, and robustness necessary for survival. The concept of a naturally occurring computational system (NOCS) [35,36] was proposed many years ago to make explicit the distinction between decision making which must be carried out by a living agent in a complex environment, with imperfect knowledge and on the fly, and the idealized agents presented in mathematics, economics, philosophy, or cognitive psychology, which live in simplistic, unchanging environments, have perfect information and have infinite time to examine every possible alternative, and select out only the best according to some arbitrary criterion (usually a fantasized utility function or fitness or truth valuation). Instead, it was argued that NOCS utilize decision strategies that are *good enough*, that achieve some immediate ecological function or goal, in the moment, and then move on to the next task or challenge. Resilience, robustness and adaptability, are far more important than some ideal of optimality [35,36].

Individual workers utilize decision making strategies that manifest some of the features of resilience, robustness, and adaptability, and so often have the appearance of being non-rational. The term non-rational is preferred to irrational as the latter suggests some kind of error or flaw or illness, whereas non-rational simply suggests a normative decision strategy which simply does not conform to the standards of (idealized) rationality. It then becomes an interesting question to ask whether decision making at the collective level, at the level of the colony itself, is different from that of the individual workers and whether it might offer to the collective an advantage not accorded to the individual. It is important to understand that by collective intelligence one does not simply mean the sum of decisions of the individual workers treated in isolation to one another. That certainly is more typical of collective actions by humans, especially in crowds and mobs. Collective intelligence refers to decision making at the collective level that *emerges* from interactions between the workers of the colony among themselves and with their environment, that *transcends* the abilities of individual workers, which is more than simply the sum of the parts, that is reproducible given similar circumstances, and serves the achievement of salient ecological goals by the colony as a whole.

The dynamics of collective intelligence systems (and NOCS generally) is characterized by generativity, transience, emergence, contextuality, openness to the environment, stigmergy, creativity, and symmetry breaking [37-39], among many other properties. Moreover, it has recently been suggested that there are deep dynamical homologies between collective intelligence systems and the neurobehavioural regulatory systems of the human brain, and that the study of collective intelligence systems, particularly social insect colonies, may shed light into neurodynamics [39].

The most detailed study to date of collective decision making was conducted by Franks et al. [40]. They studied nest emigration by colonies of *Temnothorax albipennis*. Emigration to a new site occurs when a so-called quorum threshold of returning recruiting workers is achieved, a form of mass action or democratic choice. They identified several attributes of potential nest sites which the ants appeared to utilize in making a decision including the brightness of the site, its height, and the width of the entrance. They exposed the colony systematically to a range of paired alternatives under forced emigration and observed which alternative was preferred, measured by the probability of the colony migrating to that site by the end of the day. They showed that the colony appeared to express transitivity in its preference hierarchy. Moreover, following a detailed analysis of the preference hierarchy, they determined that the

colony appeared to use a weighted additive strategy, a sophisticated strategy that can be difficult even for humans [40].

In their study of the decoy effect, Edwards and Pratt [29] subjected the colony as a whole to the same set of alternatives and decoys that were presented to the individual workers. Unlike its workers, decisions at the colony level evaded falling prey to the decoy effect. The fact that colony level decisions arise from interactions between workers rather than simply summing worker preferences may provide a mechanism by which the colony is able to effect more rational decisions which its workers cannot on their own.

However, the situation is nuanced. The ability of the colony to utilize a rational strategy depends upon contextual factors. For example, a study of foraging by *Myrmica rubra* [41] found that modifying the available choice set by increasing the number of nest entrances from one to two resulted in worse foraging outcomes. In nests with one entrance, *Myrmica rubra* ants leaving the nest navigated to the more abundant of two food sources 43% of the time compared to 34% of the time in the two-entrance condition. The poorer performance appeared to be due to fact that these colonies use pheromone to recruit to foraging trails, and pheromone must be dispersed over a wider region in the two-entrance case compared to the single entrance case.

In a study of nest selection in *Temnothorax albipennis* [42], researchers forced ants to migrate from a high-quality nest and to choose between a mediocre and a poor nest site. The ants universally moved to the mediocre site. However, if ants were exposed to an alternative nest site prior to being forced to emigrate, and then later forced to choose between the familiar alternative and an unfamiliar alternative, they showed an aversion for the familiar alternative, even when that led to the choice of a poorer site. The intensity of this aversion was influenced not just by the quality of the alternative but also by the quality of the home nest. For example, if the home nest was of mediocre quality the aversion appeared to disappear. The authors used formal modeling to show that these results did not necessarily imply that workers used comparative strategies to effect decisions, as often assumed to be the cause of non-rational decisions. Comparative strategies might manifest at the colony level, but individual workers could use absolute strategies combined with threshold-based decision rules. The authors thus demonstrated how an experience-dependent, flexible strategy can emerge at the global level from a fixed-threshold strategy at the local level.

O'Shea-Wheller et al. [43] observed that individual workers appear to manifest a heterogeneous range of decision thresholds which manifest in the duration that they spend in a potential nest site. Overall, the duration of time spent in an alternative site varied directly with nest quality, but the actual times spent varied from individual to individual. They then carried out a computational simulation and showed that the presence of heterogeneous thresholds allowed the colony to effect optimal, self-organized emigration decisions without the need for direct comparisons at the local level.

Doran et al. confirmed those results [44]. In their study of nest selection in ants they found the tendency of a colony to move was not based on the value of alternate sites in some abstract sense. Instead, colonies assessed nest-sites based on the potential fitness benefit of moving. In an already good nest site, no migration would convey significant fitness benefits. But, for a colony recently made homeless, any nest would do. Therefore, while colonies compared the mediocre nest to the good one, they compared the poor nest to nothing at all. Ultimately, because a nest site's value to an ant colony was context-dependent, two nests assessed under different conditions were not evaluated on the same transitive hierarchy. Furthermore, they were able to show that flexibility was not entirely relegated to the colony, but individual workers were also able to modify their response through changes in recruitment speed.

Healey and Pratt [45] placed *Temnothorax curvispinosus* colonies in either high- or low-quality nest sites for 8 weeks. They then measured the time taken to recruit to a mediocre site. Contrary to expectation, they found that colonies moved more rapidly after living in a good nest than in a poor nest. Life within a poor nest may affect the size and well-being of the workers within the nest, resulting in a slower response but provided evidence for an urgency hypothesis, which suggests that the loss of a nest was more dramatic for colonies housed in good nests, causing workers to lower their acceptance thresholds further than those of ants housed in poor nests.

Franks et al [46] further analyzed the scenario of [42]. As before, when workers in a colony were exposed to an alternative nest site of lower

quality than their own and then forced to emigrate facing the familiar alternative and a novel alternative of similar quality, they avoided the familiar site and opted for the novel. They thus broke what should have been preference symmetry. However, if presented with familiar and novel high-quality sites, they maintained symmetry. The experiment was repeated and just prior to emigration, all pheromone marks were removed, and landscape cues were reoriented. Following this intervention, symmetry was restored in the case of low-quality alternatives. This showed that workers are capable of assessing and retaining information about potential nest sites using pheromones and landmark cues.

Stroeymeyt et al [47] repeated their experiment on nest emigration but examined the impact of seasonality on performance. They showed that the aversion to the familiar alternative site was present during the summer months, but during the winter months preference reversed, now favouring the familiar alternative. This appeared to be due to the presence of a seasonal pheromone which is secreted during the summer months and enhances the aversive response to the familiar site. Location factors did not appear to play a role. The presence of such a pheromone interfered with any ability of individual workers to form independent judgments, which could increase error rates, but at the same time increased cohesion and information transfer among the workers.

The study of decision making among social insects has proven to be a fruitful subject matter for the application of sophisticated mathematical and computational models [37,38], particularly in the past 20 years. However, formal research into the role of context in decision making goes back much further. An early paper by Houston [48] used formal analysis of a mathematical model of foraging to show that the fitness value of any food item was contextual rather than absolute, dependent on its alternatives and its probability of being foraged. He argued that it was unlikely that natural selection could thus assign an absolute fitness value to each food option. Even if rationality was possible, it would perform sub optimally compared to context-dependent decision-making methods that violated a form of stochastic transitivity [50].

These ideas are supported by the work of Varon et al [49] on colonies of *Atta cephalotes*. *Atta cephalotes* colonies modified their food preferences in response to the variable abundance of potential food sources. On coffee farms, where 85% of the foliage was composed of coffee leaves, *Atta* workers derived only a minority of their resources from coffee and collected poro leaves instead. Under lab conditions, where more than 25% of the available biomass was from poro trees, the *Atta* workers neglected it. In other words, ants at the colony level favoured whatever leaf was less abundant, demonstrating that no leaf was assigned a constant fitness value for inclusion in a transitive hierarchy. Instead, foraging behaviour at the colony level was context-dependent [49].

Nicolis et al [50] pointed out that collective intelligence systems often rely upon some form of positive feedback in order to effect their decision making. Using a combination of formal and computational modeling and analysis, they were able to show generically that the probability of choosing the best out of a choice of n options depended crucially upon the strength of the feedback. There is an optimal level of feedback which maximizes this probability, and this optimal value of feedback depends upon the number of options. Thus, changes in the number of options presented to a collective intelligence system could give rise to the appearance of non-rational decisions.

Sasaki et al [51] studied decision making by colonies of *Temnothorax rugatulus*. Through direct experimental observation and computational modeling, they studied the ability of colonies versus individuals to choose between nests having varying degrees of difference among them. Experimentally they showed that colonies outperform individuals when the degree of difference is small so that discrimination is difficult. When the degree of difference is large, and so discrimination is easy, individuals outperform colonies which are more prone to errors in such circumstances. They developed a computational model, which, similar to [48], which emphasizes the role of positive feedback. They showed that positive feedback enabled the colony to integrate information from individuals and enhance the discrimination between fine differences. However, when the differences are large, positive feedback can lock the colony into choices which ultimately turn out to be suboptimal.

Contextuality

The importance of context in probability

theory was noted even by Kolmogorov [52] when he developed his mathematical formulation of the laws and structure of probability theory. It is impossible, in general, to form a joint distribution from arbitrary random variables from which the original distributions can be obtained as marginals of the joint distribution. The conditions under which such a joint distribution may be formed have been known for decades [53], but this has mostly been ignored. Moreover, making the same measurement in different contexts does not imply that the same random variables (probability distributions of measured values) have been obtained. Different contexts may result in different random variables for the same measurement process [54]. Failing to take such contextuality into account can lead to erroneous conclusions. Dzhafarov and colleagues have developed a model of this situation, termed *Contextuality by Default*. A concise summary of the Contextuality by Default model is given in [82]. Following the notation in that paper, each random variable is associated with the quantity, q, being measured and the context, a, within which the measurement is made, and denoted, R_q^a. Consider two measurements, q,q', and two contexts, a,b. For a fixed context, a, the pair R_q^a,R_q^b is termed *bunch*, representing the collection of measurements associated with a specific context. It is reasonable to believe that such a pair is jointly distributed. For a fixed measurement, q, the pair R_q^a,R_q^b is termed a *connection* for q.

The most basic form of contextuality occurs when no joint distribution can be found for a connection. In such a case, they are said to be *inconsistently connected*. This is the situation of Contextuality by Default. Dzhafarov considers this to be the most trivial form of contextuality because it is so ubiquitous. Dzhafarov has developed a more restricted notion of contextuality, in line with contextuality in physics. He considers couplings between bunches. For example, given two bunches, R_q^a,R_q^a and R_q^b,R_q^b, a coupling is a set of jointly distributed random variables (A,B,X,Y), subject to certain constraints, such that (A,B) is distributed as R_q^a,R_q^a and (X,Y) is distributed as R_q^b,R_q^b. The constraints involve A,X and B,Y, which correspond to measurements of q and q', respectively. A measurement, q, is considered to be *context-independent* if, among all couplings (A,B,X,Y), we have $Pr(A\neq X) = 0$. It can be shown that such a coupling may not exist even if the system is consistently connected.

Now, considering all couplings (A,X) for just the connection R_q^a,R_q^b, the minimal value m' can be found for $Pr(A\neq X)$. Then, considering the global coupling (A,B,X,Y), the minimal value m for $Pr(A\neq X)$ can again be found. If $m = m'$, the system is non-contextual, and if $m > m'$, then the system is contextual. This form of contextuality is analogous to that found in physics.

The discovery that contextuality occurs even in fundamental physical systems was a seismic shock to physicists in the last century. It has led to endless speculation about the nature of reality, but in actuality it merely was a recognition that contextuality is a fundamental feature of nature. However, the probability theory of quantum mechanics is non-Kolmogorov, founded upon complex numbers rather than real numbers as in Kolmogorov theory. Khrennikov [56] has developed a theory of non-Kolmogorov probability and applied it outside the realm of quantum physics. Dzhafarov's model, on the other hand, is framed within Kolmogorov probability theory, but makes explicit the connections between random variables and their contexts.

The non-Kolmogorov structure of quantum mechanics leads to phenomena which cannot occur within classical Kolmogorov probability theory. This is best seen using the inequalities of Bell, which point to the existence of correlations between random variables which are greater than those possible within a classical Kolmogorov theory. Dzhafarov and Kujala have developed an analogue of the Bell inequalities for use within the Contextuality by Default model, and have demonstrated the existence of these supra-classical correlations in psychological settings [57,58]. In particular they focus upon a specific set of psychological measurements termed cyclic systems.

Contextuality and Cyclic Systems

The random variables considered by Dzhafarov (and used in formulating the Bell inequalities in quantum mechanics) form what is termed a cyclic system. A cyclic system of rank n consists of n bunches based upon n quantities and n contexts and arranged in the following manner

$(R^1_1, R^1_n), (R^2_1, R^2_2), (R^3_2, R^3_3), (R^4_3, R^4_4), \ldots. (R^n_{n-1}, R^n_n)$

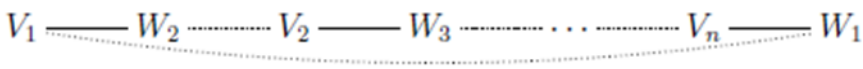
For example, a cyclic 4 system has the form

$$\begin{bmatrix} R^1_1 & 0 & 0 & R^1_4 \\ R^2_1 & R^2_2 & 0 & 0 \\ 0 & R^3_2 & R^3_3 & 0 \\ 0 & 0 & R^4_3 & R^4_4 \end{bmatrix}$$

which can also be written in the form

$$R^2_1 - R^2_2 - R^3_2 - R^3_3 - R^4_3 - R^4_4 - R^1_4 - R^1_1$$

In [55] it is shown that a cyclic system of the form



is non-contextual if the following inequality holds

$$\Delta C = \mathsf{s}_1(\langle V_1W_2\rangle, \ldots, \langle V_{n-1}W_n\rangle, \langle V_nW_1\rangle) - (n-2) - \sum_{i=1}^{n} |\langle V_i\rangle - \langle W_i\rangle| \leq 0,$$

where $\langle \quad \rangle$ denotes expectation value and s_1 is the maximum over all sums of the form

$$\pm\langle V_1W_2\rangle \pm \langle V_2W_3\rangle \ldots \pm \langle V_{n-1}W_n\rangle \pm \langle V_nW_1\rangle$$

such that the number of minus signs is odd

.

Cyclic Systems in the Current Literature

Cyclic systems form convenient but also ubiquitous settings in which to test for the possibility of quantum-like contextuality in classical systems. As noted above, human decision making is an ideal setting for obtaining cyclic systems. Studies of decision making in collective intelligence systems, especially social insect colonies are another potential source of cyclic systems. Pair-wise comparisons of multiple observables in multiple contexts provide excellent opportunities for creating cyclic systems. Unfortunately, most of the studies of decision making in social insect colonies were not designed with issues of contextuality in mind. Some studies examine multiple observables within a single context [34]. Others examine a single observable within multiple contexts [31].

Another problem is that in many experiments, the observables form mutually exclusive pairs, even if multiple contexts are involved. For example, Oberhauser et al [32] examined two observables: the marginal probability of an ant moving towards 1.5M sucrose solution (object X) and the marginal probability of an ant moving towards 0.25M sucrose solution (object Y), and two contexts: one where the ants had conflicting information about the location of the 1.5M sucrose solution (context 1) and one where they did not (context 2). The four random variables produced by this combination are seemingly sufficient to form a cyclic system of rank two. However, the two observables are mutually

exclusive, so that the expectation values in the contextuality inequality are all zero, and such systems are non-contextual by definition.

The problem of the mutual exclusivity of observables is fairly widespread [29, 42, 46, 47].

A Cyclic System of Rank 3

A study of commitment time in Temnothorax albipennis ant colonies provides an illustration of a cyclic 3 system [44]. The study's contexts were the alternative nest sites presented, and its observabless were the perceived values of the original nest sites. More specifically, the study had the following four objects [44].

q_1 = Marginal probability of emigration from a low-quality nest within 6 hours

q_2 = Marginal probability of emigration from a mediocre nest within 6 hours

q_3 = Marginal probability of emigration from a good nest within 6 hours

q_4 = Marginal probability of emigration from an excellent nest within 6 hours

Its four contexts were as follows.

c_1 = presence of a low-quality alternative nest

c_2 = presence of a mediocre alternative nest

c_3 = presence of a good alternative nest

c_4 = presence of an excellent alternative nest

On its face, the number of contexts and objects appear sufficient to form a cyclic system of rank four. However, to form a cyclic system, all objects must appear in two bunches and object q4 only appears in context 4 [52]. Consequently, the cyclic system can only use the objects q_1, q_2, and q_3. Furthermore, c_1 only contains one object, q1. Consequently, the cyclic system can only use the contexts c_2, c_3, and c_4. Therefore, the bunches for each context have the following joint probability distributions [44].

$$c_2 = q_1 \wedge q_2$$

$$c_3 = q_2 \wedge q_3$$

$$c_4 = q_3 \wedge q_1$$

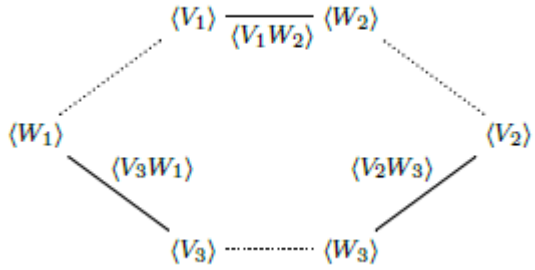
Placing these values into a cyclic system involves the following calculations. Here, the + symbol in the subscripts must act as a stand in for cyclic addition [52].

$V_i = 2(q_n) - 1$

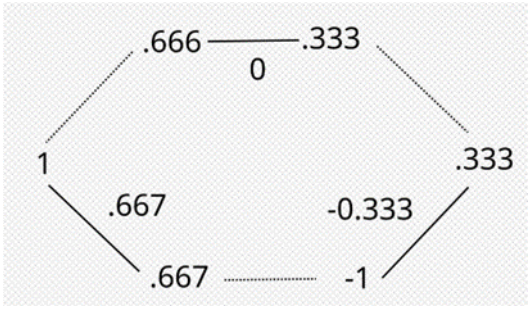
$W_i = 2(q_n) - 1$

$V_i W_{i+1} = 4(q_n \wedge q_{n+1}) - 2(q_n) - 2(q_{n+1}) + 1$

The Cyclic System formed from these values is as follows.



[52]



Here we employ the following formula for calculating contextuality in cyclic systems of rank 3.

$$\Delta C = \mathrm{s}_1(\langle V_1W_2\rangle, \langle V_2W_3\rangle, \langle V_3W_1\rangle) - 1 - \sum_{i-1}^{3} |\langle V_i\rangle - \langle W_i\rangle| \leq 0$$

where

$$\mathrm{s}_1(x, y, z) = \max(x + y - z, x - y + z, -x + y + z, -x - y - z).$$

[52]

In our case, ΔC = -1.99, showing no sign of contextuality.

Conclusions

Rationality is generally held to represent the epitome of decision making – logical, optimal, goal achieving, elegant, perfection, especially from a mathematical perspective. However, the exercise of rationality requires conditions that are far removed from those encountered by agents in the natural world, such as perfect knowledge of present and future possibilities, unlimited time, fixed utilities against which to judge outcomes. The natural world is characterized by transience, contextuality, conditionality, openness, incomplete knowledge, indeterminate (or even absent) utilities, a far cry from the conditions for rationality. The decision making of collective intelligence systems such as social insects may not be rational in the strict sense, but it is certainly well adapted to enable them to achieve ecological functionality and goals. After all, social insects have been present on Earth for over 200 million years. If rationality is so essential to success, then how does one account for the evolutionary success of the social insects? The answer may tell us more about the dynamics of human brains than has previously been thought. In particular, the study of decision making in collective intelligence systems provides an ideal setting for study the role of contextuality in decision making generally.

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Supplementary materials

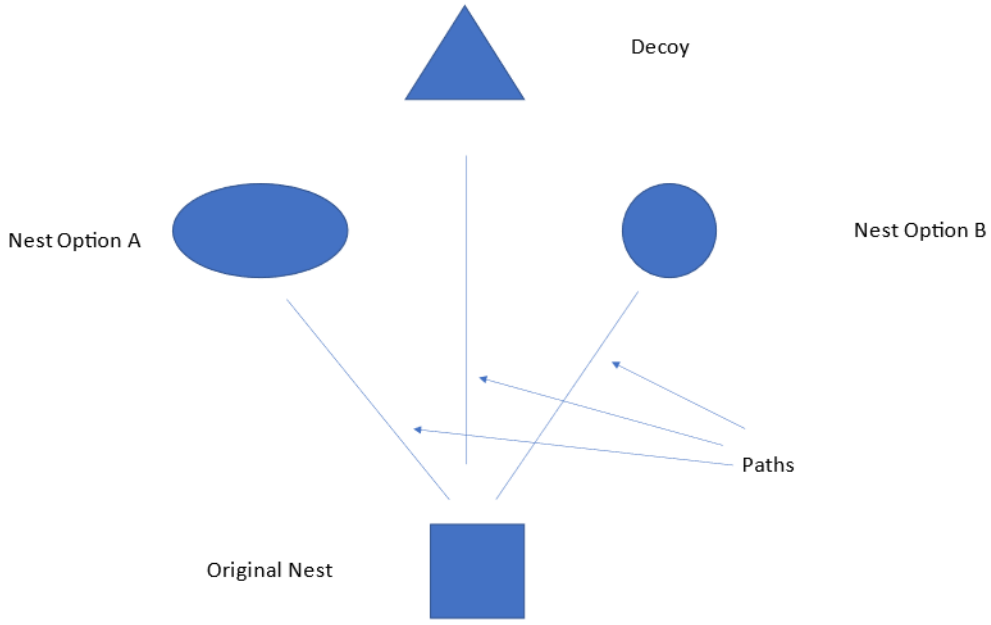

Figure 1. Cartoon of the general experimental arrangement for decision making in social insect colonies

EMPIRICAL ARTICLE

Reading and Self-Presentation Speech Acoustic Analysis for Identification of Personality Traits

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Abstract. The research is devoted to the diagnostics of the person's psychological properties by means of the voice acoustic characteristics analysis. The research is carried out on the example of psychodiagnostics of Big Five traits and Circumplex of Personality Metatraits, as well as the level of Crystallized and Fluid types of intelligence. It was demonstrated that the use of different scenarios, experimental situations and formulated tasks can increase the effectiveness of diagnosing a number of traits. This goal was achieved by creating sets of data taking into account the acoustic characteristics of the examinee when reading texts of two types: text 1 with a neutral emotional tone (Stanislav Lem "Solaris") and text 2 with a negative tone about sufferings of people during the blockade of Leningrad ("Memories of Lihachev") as well as conducting interviews with a simulated situation of employment with a set of questions. The study involved 356 subjects whose voices were recorded while reading texts of two types and answering 12 questions of audio-interviews. We found that the Conscientiousness trait was best diagnosed in males by text reading 1 (ROC-AUC = 0.76), and in females by interview questions (ROC-AUC=0.75). Traits related to emotional stability and mental health (GM, GP) are also best diagnosed in both men and women by text reading 1. An increase in the diagnostic accuracy of Crystallized intelligence in men was shown when using acoustic voice characteristics in text reading 1 (ROC-AUC=0.7).

Keywords: Crystallized intelligence, Fluid intelligence, Personality computing, Personality traits, Social signal processing

Research on the relationship between psychological characteristics and characteristics of the voice has a history of nearly a century [26]. As Sapir notes "There is one thing that strikes us as interesting about speech: on the one hand, we find it difficult to analyze; on the other hand, we are very much guided by it in our actual experience. ...none is entirely lacking in the ability to gather and be guided by speech impressions in the intuitive exploration of personality" [26]. Because of the notion that atomistic analysis makes no sense [1]. and due to the lack of technical means, the first studies of the relationship between speech and psychological characteristics in the early 20th century were conducted based on an impression of the speaker's voice "in general": subjects were asked to listen to audio recordings and evaluate various physical (age, height, build, etc.), social (e.g., profession, political views) and psychological (extraversion, dominance, etc.) characteristics of the speaker.

Early work has shown that some voice characteristics can be related to personality

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traits. In particular, Mallory and Miller [16] found weak but statistically significant correlations of introversion with high pitch, inadequate loudness, lack of resonance, and unconfident manner of speech. Other studies have demonstrated that extraversion and introversion are related to the pace of speech [10, 25].

Current studies, based mainly on the Big Five model of personality, support and broaden previous data. A study by Park *et al.* [22] demonstrated that extroverts, compared to introverts, had shorter pauses before answering questions. In Mairesse *et al.* [15] self-reported extraversion was shown to correlate with speech rate. Biel *et al.* [4] data suggested that extraversion could be predicted by longer speaking time and decreased number of pauses. Stern *et al.* [30] conducted a large secondary data analysis combining eleven independent datasets (2217 participants). They found that self-reported extraversion, dominance, and openness to experience had negative relationship with voice pitch, neuroticism had a positive one, and that there were no correlations between personality traits and mean formant position.

It is important to note that the prediction accuracy of personality traits measured by self-report and expert methods may differ. Thus, although some studies found negative correlations between extraversion and voice pitch [16, 30], others (e.g. [15; 4] found inverse relationships using observer's ratings as personality traits measures. In Mairesse *et al.* [15] the prosodic markers for both observed and self-reported extraversion were intensity variability and mean intensity. On the other hand, emotional stability as measured by self-reported extroversion was characterized by low intensity variability and low mean intensity, whereas these vocal properties did not play a role in external observer assessments. The authors hypothesized that the model for determining personality traits should switch from evaluations by external observers to self-report evaluations, because traits with high obviousness (extraversion) are more accurately evaluated by external observers, whereas traits with low obviousness (emotional stability) are more accurately evaluated by self-report, and Polzehl *et al.* [23, 24]. found that pitch range, speech rate, intensity, loudness, formants, or spectra can predict Big Five elements. However, these and more recent works used expert assessments of speakers' psychological traits. The authors predominantly used regression analysis and SVM (Support Vector Machine). With the development of neural network methods, research using multilayer perceptron (MLP), supplemented by a model for analyzing the verbal side of speech (LSTM) have appeared [2]. In this paper, the maximum classification quality (proportion of correct classifications) achieved was as follows: openness to experience (77%), conscientiousness (63%), extraversion (64%), Agreeableness (61%), and neuroticism (68%). The method proposed by Carbonneau [7], which relies on the use of spectrograms and SVMs, increased the recognition efficiency of Agreeableness to 65% and neuroticism to 70%, while decreasing the prediction quality of the other indicators. Further works extended approaches to the characteristics selection and performed comparison of different neural network models. E.g., Tayarani *et al.* [33]. proposed to use the analysis of the pause fillers ("ehm", "uhm") in speech. When comparing *Cascade Forward Neural Network* (CFNN), *Feed Forward Neural Networks* (FFNN), *Fuzzy Neural Networks* (FNN), *Generalized Regression Neural Networks* (GRNN), k *Nearest Neighbors* (kNN), *Linear Discriminant Analysis* (LDA), *Naive Bayes Classifier* (NB), *Support Vector Machines* (SVM) and using the PCA-QEA approach to feature selection, the LDA classifier was shown to provide significant increase in classification quality for experience openness and extraversion. In terms of analyzing the frequency of the predictors selected by the algorithm, a lower frequency of delta coefficient selection should be note. One possible explanation is the fact that indicators should capture temporal variations, but pause fillers tend to be pronounced as long vowels, in which speech properties remain stable and, therefore, no major changes are observed. The main exceptions to this general pattern were observed for extraversion, where delta regression coefficients were chosen more frequently in the RMS and basic tone frequency (F0) groups. The next result was that the first two small-frequency cepstral coefficients (MFCC) were selected more frequently for conscientiousness and neuroticism.

In terms of experimental design, the Guidi *et al.* [12] study can be highlighted. The subjects were asked to read the text "The Universal Declaration of Human Rights" twice before and after the experiment, for three minutes. The

subjects were asked to comment on a set of images from the Thematic Apperceptive Test between the readings of the text. The subjects also completed the Spielberger Anxiety Test. No model was constructed in this study, but a correlation analysis was conducted. It was shown that the mean values of the acoustic measures of the two text readings were negatively correlated with the evaluation of the "Communicativeness" parameter; significant estimates of correlations with other measured personality traits were also found.

Current trends in personality traits diagnostics include the use of deep learning methods and the combination of both verbal and nonverbal speech components analysis along with video analysis to assessing the dynamics of emotional state [19].

The data

The final sample of Russian-speaking subjects who completed the tasks was 356, including 257 females (mean age 34.8) and 99 males (mean age 30.4) [21]. Data collection of psychodiagnostic data and audio-interview recordings was performed using the developed Internet platform without any special organized conditions for voice recording. Due to the large volume of tasks, the subjects were allowed to take the study in several stages. A total of 5,701 audio recordings were obtained (4,134 for women and 1,567 for men).

A. Psychological diagnostics

The study determined the following psychological characteristics of the subjects: disposition of basic personality traits, verbal intelligence, nonverbal intelligence.

1) Personality traits

The Big Five model [8] is the most popular model of personality in psychology. It postulates that a variety of person's thoughts, feelings, and behaviors could be mapped into five broad dimensions (factors): Openness to experience (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N).

In our study, we used the Big Five Inventory (BFI; John *et al.* [13]) in Russian adaptation [28]. The BFI consists of 44 items aimed at measuring five main domains of the Big Five model: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness.

Despite the predominant role of the Big Five model, it is not free from criticism [5]. The main concern arises from intercorrelations usually found between five personality traits [11]. A hierarchical structure and the existence of higher-order personality factors are suggested instead [9]. A related model, the Circumplex of Personality Metatraits (CPM), postulates the existence of two orthogonal metatraits (Alpha/Stability and Beta/Plasticity), with another metatrait representing General Personality Factor (Gamma/Integration), and Delta/Self-Restraint metatrait which is the combination of high stability and low plasticity (or vice versa). The positive and negative poles of each metatrait are defined separately and can be represented by specific combinations of the Big Five traits (see Fig. 1). For example, Alpha-Plus is characterized by low Neuroticism, high Agreeableness, and high Conscientiousness, whereas Delta-Minus includes high Neuroticism, Extraversion, and Openness combined with low Agreeableness and Conscientiousness [31]. We have used the Russian version of The Circumplex of Personality Metatraits Questionnaire [32] which consists of 72 items intended to measure each of the eight metatraits.

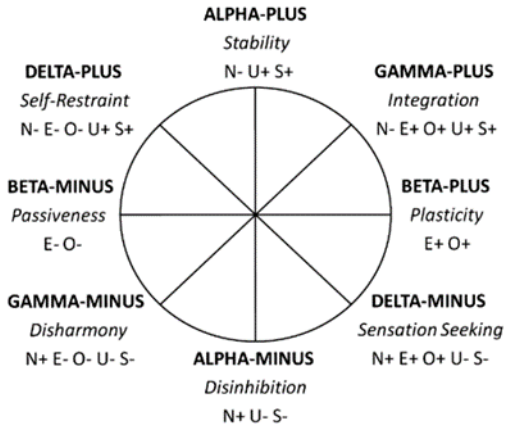

Figure 1. Circumplex of Personality Metatraits. N = Neuroticism; E = Extraversion; O = Openness to Experience; U = Agreeableness; S = Conscientiousness; + means a positive pole of the trait; - means a negative pole of the trait. From (Strus & Cieciuch, 2017). Copyright 2016 by Elsevier Inc.

The answers to the questions obtained by both techniques were presented in the Likert scale, which assumes the tested person should express the degree of agreement and disagreement with the statement on a scale of 1 to 5, where 1 = strong disagreement, and 5 = strong agreement. The resulting distributions of scores are presented in Fig. 2.

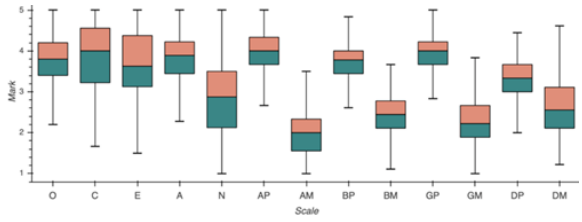

Figure 2. The results of the subjects' scores for different psychodiagnostic variables.

2) Crystallized intelligence (CIQ)

Crystallized intelligence is the ability to reason based on previously acquired knowledge. It is usually measured by verbal tasks involving vocabulary, reading comprehension, analogies, etc. We used three verbal scales in Russian: analogies (20 items for 6 min), generalization (20 items for 7 min) [36] and deduction (16 items for 8 min) [3]. The overall measure of crystallized intelligence was computed as a sum of scores for individual scales.

3) Fluid intelligence (FIQ)

Short form of the Raven's Advanced Progressive Matrices was used as a measure of fluid intelligence [6]. It consists of twelve 3×3 matrices of geometric shapes with one missing item that should be found among eight alternatives. This test is intended to measure the core of fluid intelligence - inductive reasoning and analytical thinking ability. Fig. 3 shows the distribution of tested subjects' results for the two techniques that measure intellectual ability.

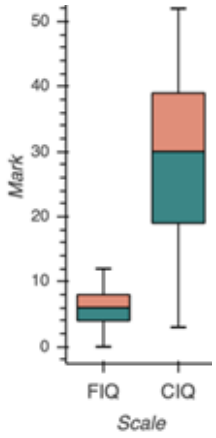

Figure 3. Scatter diagram of the results of the Advanced Progressive Matrices (raven) and Intelligence structure test (verb).

B. Reading and audio-interview

To test the hypothesis of the study, the subjects were given 2 text fragments to read, while their voice recording was made. The first block (Text 1) was a fragment of the science fiction novel "Solaris" by Stanislaw Lem (average reading time 116 seconds) - it was an emotionally neutral text. The second fragment (Text 2) was taken from the memoirs of D.S. Likhachev, describing the besieged Leningrad during World War II (average reading time 118 seconds). This text was heavily emotionally loaded, as it describes scenes of suffering, hunger, and death.

Next, the subjects were asked to imagine themselves in a situation of employment and an audio interview. In this regard, the respondents had to answer 12 questions, which were recorded on the audio by a female voice with a neutral intonation.

Interview questions:

1. Introduce yourself, please.
2. You have two minutes to briefly tell the most important things about yourself.
3. What kind of manager would you not work with?
4. What are your strengths?
5. Name your two shortcomings, describe in detail what you mean by that.
6. By what criteria did you choose where to study after high school?
7. Were you interested in learning?
8. Tell us, please, what exactly have you been doing in the last 2 years for your development, learning on your own initiative?
9. Please tell us about your favorite thing you like to do.
10. What activities you don't like?
11. Tell us about your accomplishment.
12. What do you consider as your failure?

The delta coefficients (numerical derivatives) were additionally computed for each of these descriptors (Fo, ZCR, RMS, MFCC).

The proposed approach

In order to determine variations in the voice of an individual person it is necessary to analyze his speech features in the recording, where personality traits are least manifested.

In Section A we describe the variants of combining the two recordings (text reading and answering a question), as well as the use of averaged data on the examinees' answers.

In Section B we describe the procedure for selecting the basic model to test the hypothesis

of this study.

In Section C we provide the psychological context of the datasets used in this study.

A. Additional dataset

Let $\boldsymbol{I}$ be the matrix of acoustic characteristics values obtained from the subject's answers:

$$\boldsymbol{I} = \begin{pmatrix} a_{11} & \dots & a_{1i} \\ \dots & \dots & \dots \\ a_{n1} & \dots & a_{ni} \end{pmatrix},$$

Where $i = 1, \dots, 389$ is an index of an acoustic feature, $n = 1, \dots, 12$ is the index of the subject's answer to the interview question.

Let $\boldsymbol{R}$ be the matrix of acoustic characteristics values of two text fragments readings by the tested person:

$$\boldsymbol{R} = \begin{pmatrix} r_{11} & \dots & r_{1i} \\ r_{21} & \dots & r_{2i} \end{pmatrix}.$$

$\boldsymbol{T^1}$ is defined as the matrix of differences between the acoustic characteristics of the examinee's answers and acoustic characteristics of reading text #1:

$$\boldsymbol{T}_n^1 = \boldsymbol{I}_n - \boldsymbol{R}_1.$$

$\boldsymbol{T^2}$ is the matrix of differences between the acoustic characteristics of the examinee's answers and acoustic characteristics of reading text #2:

$$\boldsymbol{T}_n^2 = \boldsymbol{I}_n - \boldsymbol{R}_2.$$

Then let $\boldsymbol{M^1}$ be the matrix of averaged acoustic characteristics of the examinee's answers and his acoustic characteristics of reading text #1:

$$\boldsymbol{M}_n^1 = \frac{\boldsymbol{I}_n + \boldsymbol{R_1}}{2}.$$

Then let $\boldsymbol{M^2}$ be the matrix of averaged acoustic characteristics of the examinee's answers and his acoustic characteristics of reading text #2:

$$\boldsymbol{M}_n^2 = \frac{\boldsymbol{I}_n + \boldsymbol{R_2}}{2}.$$

Table 1.

Results of model training by ROC-AUC score on the Full Data Set (Union Data)

Scale	Gaussian Process	Gradient Boosting Classifier	Linear SVM	K Nearest Neighbors	Poly SVM	QDA	Random Forest	RBF SVM
A	0.62	0.62	**0.68**	0.57	0.50	0.59	0.61	0.58
AM	0.56	**0.59**	0.56	0.55	0.50	0.56	0.55	0.50
AP	0.50	**0.67**	0.66	0.60	0.50	0.60	0.64	0.57
BM	0.50	**0.54**	0.53	0.51	0.50	0.52	0.50	0.51
BP	0.50	0.49	0.48	0.51	0.50	0.50	**0.53**	0.50
C	0.61	0.63	**0.67**	0.61	0.64	0.61	0.62	0.66
DM	0.63	0.643	**0.645**	0.57	0.50	0.57	0.61	0.63
DP	0.57	0.58	0.56	0.55	0.50	0.56	**0.59**	0.51
E	0.50	0.55	**0.58**	0.54	0.50	0.54	0.55	0.52
GM	0.49	0.56	0.46	**0.57**	0.50	0.55	0.53	0.50
GP	0.50	0.56	0.56	0.52	0.50	0.54	0.55	**0.57**
N	0.54	**0.58**	0.56	0.56	0.50	0.57	0.52	0.54
O	0.50	**0.53**	0.51	0.47	0.50	0.48	0.52	0.52
FIQ	0.50	**0.550**	0.549	0.50	0.50	0.52	0.54	0.50
CIQ	0.50	**0.55**	0.51	0.51	0.50	0.51	0.51	0.49

The number written in bold is the highest in the row.

Let $\boldsymbol{K}$ be the vector of averaged acoustic characteristics for all answers of the tested person:

$$\boldsymbol{K}_i = \frac{\sum_{v=1}^{n} \boldsymbol{I}_{vi}}{n}.$$

The corresponding matrices for all subjects were combined into training and test samples in which the subjects did not overlap.

B. Basic model selection

The choice of the basic model was made among the following machine learning models: Gaussian process classification (GPC), Gradient Boosting Classifier, Linear SVM, K-Neighbors Classifier, Poly SVM, Quadratic Discriminant Analysis, Random Forest, RBF SVM for all psychodiagnostic techniques using a complete data set (*Union data*), including acoustic characteristics of text reading and audio-interview of the subjects. The division into training and test samples was carried out according to respondents, i.e. the training sample did not include recordings of the subject

who fell into the test sample. Thus, it was guaranteed that the model would not overfit on the data from a particular user.

The results of model training without parameter fine-tuning were analyzed by the ROC-AUC score and are presented in Table I.

The model based on the Gradient Boosting Classifier showed the best result for the majority of psychological characteristics, so we have chosen it as a basic one. The effect of different data preprocessing pipelines combined with the GBC method will be clarified further.

C. The psychological meaning of datasets

Different kinds of data processing (i.e., Union data, I, M^1, M^2, T^1, T^2) had a different meaning from the psychological point of view. Answering interview questions and reading Likhachev's memories about the siege of Leningrad presumed deeply emotional involvement. Reading an extract from science fiction was assumed to be emotionally neutral and could be relevant to the basic acoustic characteristics of an individual voice. Interview data represented voice features in personally significant situations. We proposed that such kind of self-presentation should be most relevant to the manifestation of personal traits.

Adding to Interview data any kind of reading data broadened the range of voice properties. The M^2 dataset extended the range of voice properties towards the emotional end, while the M^1 dataset increased the variability of neutral characteristics. The Union dataset incorporated the widest range of acoustic characteristics across different situations.

On the contrary, the T^1 and T^2 datasets (which were Text 1 and Text 2 feature matrices subtracted from the Interview feature matrix) restricted the range of vocal characteristics. We assumed that the acoustic characteristics of the voice in neutral intonation could have an individual profile (for example, neutral tonality is different for people with a strong manifestation of extraversion or introversion). Thus, the dataset T^1 made it possible to identify the acoustic characteristics that are most pronounced in the interview compared to the respondent's personal neutral tone. Similarly, the dataset T^2 allowed us to highlight the emotional manifestations in the speaker's profile compared to the reading of an emotionally loaded text.

The main psychological hypothesis underlying the selection of different data sets was that in order to diagnose personality traits, it was necessary to take into account the voice properties demonstrated by the respondent in different situations, highlighting the most significant deviations from the neutral tone. It was also necessary to consider the recording conditions (the task that the respondent is given), which could also influence the quality of psychological traits diagnostics. For example, if the respondent recorded the voice in a simulated dating situation, then it was more likely that the properties manifested in the voice will differ from those in a hiring situation, because the person would unconsciously try to demonstrate some of his or her features through the voice, introducing some distortion in the voice properties. We considered that recording the neutral text reading would prevent the respondent from introducing this distortion and thus provide a clear baseline for voice features.

Results

A. Personality traits classification results

A comparison of the classification quality measured by ROC-AUC score was conducted on all previously described datasets (T^1 and T^2 - the differences of the acoustic characteristics from reading texts 1 and 2 respectively; M^1 and M^2 - the averaged acoustic characteristics with reading texts 1 and 2 respectively; I - the initial acoustic characteristics without including data from text reading). The models based on the Gradient Boosting Classifier were trained separately for men and women, since it is assumed that men and women differ in the manifestation of psychological features through the acoustic parameters of speech.

Fig. 5 shows the model performance for women. The model trained using the answers to the interview questions (I) showed the best results for the following 5 scales out of 15: Conscientiousness (0.71), Extraversion (0.58), Beta-minus (0.51), Beta-plus (0.59), Delta-minus (0.697). A model trained using averaged acoustic characteristics with text 2 reading scores (Likhachev Memories) (M^2) showed the best results for the following 7 scales: Openness (0.56), Agreeableness (0.67), Neuroticism (0.64), Alpha-minus (0.67), Alpha-plus (0.70), Gamma-minus (0.64), Fluid Intelligence (0.55). The difference in acoustic features with text 1 Stanislav Lem "Solaris" (T^1) showed the best

results for Gamma-plus (0.64) and verbal intelligence (0.55) scales, and for text 2 "Likhachev Memories" (T^2) for Delta-plus scale (0.69). The numerical values of the ROC AUC scores are given in Appendix Table I.

Fig. 6 shows the model performance for men. The model trained using the answers to the interview questions (I) showed the best results for the following 2 scales out of 15: Alpha-minus (0.558), Delta-minus (0.716). The model trained using averaged acoustic characteristics with the reading scores of Stanislav Lem's text 1 "Solaris" (M^1) showed the best results for the Conscientiousness (0.759) and Gamma-plus (0.646) scales, and for text 2 (Likhachev Memories) (M^2) for the following scales: Openness (0.697), Agreeableness (0.588), Beta-plus (0.677), Gamma-minus (0.567). The difference in acoustic features for text 1 Stanislav Lem's "Solaris" (T^1) showed the best results for the scales Extraversion (0.566), Neuroticism (0.619), Alpha-plus (0.666), Crystallized Intelligence (0.701), and for text 2 "Likhachev Memories" (T^2) for Fluid Intelligence scale (0.576). The numerical values of the ROC AUC scores are given in Appendix Table II.

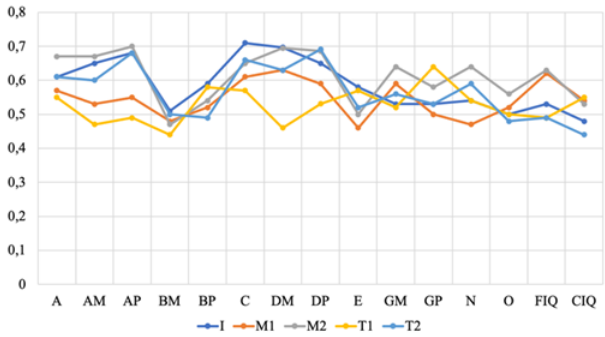

Figure 5. ROC-AUC score for Gradient Boosting Classifier - based model using different initial datasets for women.

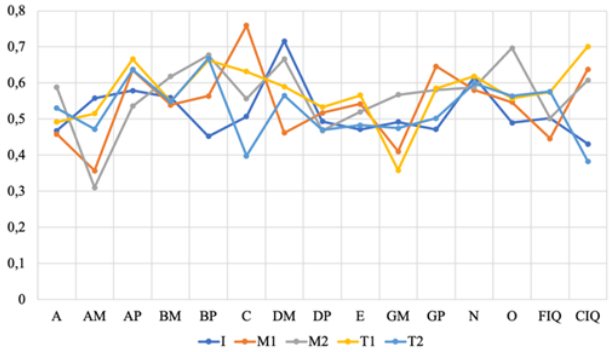

Figure 6. ROC-AUC score for Gradient Boosting Classifier - based model using different initial datasets for men.

The proposed approach for personality psychological traits diagnostics has been shown successful on a different set of personality traits depending on gender. Further comparison was made between the performance of the models for the original data (I) and all of the data modification options under consideration.

In models of psychological traits of *women*, an increase in prediction ROC-AUC of 10% (M^2) was observed for the neuroticism scale and Gamma-plus and Gamma-minus scales of 11% (T^1, M^2) related to mental health, subjective well-being. There was a 9% (M^2) increase in the ROC-AUC of nonverbal ability classification when using averages with reading text 2. Determining the ROC-AUC of the Agreeableness scale increased by 7% (M^2). In 7 of 15 cases, using averages with text reading (M^2) showed the best results for the classification of psychological traits.

In models of *men* personality traits, the greatest increase of 27% (T^1) was observed for the Nonverbal Intelligence scale. The Integrity scale showed an increase of 25% (M^1), and the Beta-plus and Beta-minus scales showed a 22% (M^2) and 10% (G) increase, respectively. The Openness to Experience scale showed an increase of 21% (M^2). Accuracy for the Gamma-plus and Gamma-minus scales increased 18% (M^1) and 8% (M^2), respectively. The Agreeableness and Extraversion scales showed increase of 12% (M^2) and 10% (T^1) respectively. These results do not allow us to identify a single preprocessing approach that would demonstrate the best classification results in most cases, however, an increase in classification accuracy was shown after applying different approaches.

B. Gradient Boosting vs other classification algorythms

As shown earlier in Table I, in some cases the Gradient Boosting Classifier did not show the best results in terms of ROC AUC score. Thus we trained a set of other algorithms using the winning models from Table I on different sets of preprocessed data. We compared the results obtained with the ones of Gradient Boosting Classifier (see Figs. 5 and 6 and Appendix Tables I and II) on different types of the preprocessed data.

Tables II and III show the results of different groups of models:

– #1 Models contain the best results for the Gradient Boosting Classifier on preprocessed data (Figs. 5 and 6; Appendix Tables I and II);

- #2 Models contain the most optimal algorithm from Table I, but applied to all types of the preprocessed data;
- #3 Models contain the training results of merged interview and reading data without preprocessing.

The use of #3 Model allowed us to analyze the effectiveness of the proposed approach to accounting for the audio recording scenario. This is, in case Model 3 won in diagnosing some psychological trait, we could conclude that the task and the recording circumstances did not matter in diagnosing this trait, i.e. our hypothesis was wrong. The results of Models #1 or #2 were interesting in terms of identifying the types of data preprocessing that showed the best result for each of the models.

Let's analyze the first line from Table II: according to Fig. 5 on the Agreeableness scale, the Gradient Boosting Classifier (#1 Models) showed a result of 0.67 (M^2), in Table I we see the winning Linear SVM model for this trait. We further trained the models using all data sets using the Linear SVM algorithm (#2 Model), then compared their performance with the results obtained on the merged data set (#3 Model). The results of this comparison for *women* are shown in Table II.

Table II shows that for the Openness and Crystallized Intelligence traits specific audio processing and recording situation features did not matter, neither did text type of the task (reading or interview). The Beta-plus, Beta-minus, Conscientiousness, Delta-minus, Extraversion traits were not reflected in the acoustic properties of speech, which differed in text reading and in self-presentation task. However, it is important that it was possible to diagnose the features in the interviewing process, but not in the reading process. The scales Agreeableness, Alpha-plus, Alpha-minus, Gamma-minus, Neuroticism, Openness showed the best results when using averaged acoustic characteristics with the text reading 2 "Likhachev Memories" (M^2), which confirms the proposed hypothesis. Delta-plus and Gamma-plus traits demonstrated the best results when using the data sets T^2 and T^1, respectively, which indicates the significance of accounting for the difference in acoustic characteristics between interviewing and reading.

A similar comparison of models trained using different algorithms for *men is* shown in Table III.

According to Table III, it can be noted that for Alpha-minus and Fluid intelligence traits the hypothesis tested was not confirmed: the scenario of interview recording or text reading did not play a significant role for the diagnostic model. The diagnostic models for the Agreeableness and Delta-minus traits showed the best performance during the interview, without taking into account text reading characteristics. We see that in *men* the highest ROC-AUC scores were observed for the data on the average acoustic characteristics of the audio-interview and text reading 1 - Stanislav Lem "Solaris" (M^1) for the Conscientiousness, Extraversion, Gamma-minus, Gamma-plus traits. Average acoustic characteristics of the audio-interview and text reading 2 - "Likhachev's Memories" (M^2) showed the best results for Beta-plus and Openness scales. Alpha-plus, Delta-plus, Crystallized Intelligence traits showed the best results for the dataset T^1 (the difference between the values of acoustic characteristics of audio-interview and reading text 1 Stanislav Lem "Solaris").

C. Male – female differences

When comparing the accuracy results of the models for men and women, it should be noted that the Conscientiousness and Delta-minus traits were best diagnosed by analyzing the acoustic characteristics of audio-interview recordings, as well as by the M^1 dataset for both men and women with similar ROC-AUC values.

In females, the ROC-AUC threshold = 0.7 was achieved for the Alpha-plus trait on the M^2 dataset, in males it was achieved for Openness (M^2) and Crystallized Intelligence (T^1).

It should be noted that the Gamma-plus and Gamma-minus traits were represented among women on the winning models in the datasets (T^1 or M^1), associated with reading the text 1 - Stanislav Lem "Solaris". For men, similarly, the data set M^1 (text 1 - Stanislav Lem "Solaris") proved to be the best for these two traits, and for the traits Extraversion, Delta-plus, Alpha-plus, Crystallized Intelligence, Neuroticism the consideration of characteristics in reading text 1 demonstrated improved results.

Table 2.

Classification results. The table reports the ROC-AUC scores for different kinds of algorithms and input data for women

Scale	#1 Models using preprocessing data			#2 Models with algorithm-winner using preprocessing data			#3 Models using original union data		
	ROC-AUC	Data	Model	ROC-AUC	Data	Model	ROC-AUC	Data	Model
A	**0.67**	M^2	Gradient Boosting	0.66	M^2	Linear SVM	0.64	Interview& Reading	Gradient Boosting
AM	**0.67**	M^2	Gradient Boosting	-	-	-	0.62	Interview& Reading	Gradient Boosting
AP	**0.70**	M^2	Gradient Boosting	-	-	-	0.64	Interview& Reading	Gradient Boosting
BP	**0.59**	I	Gradient Boosting	0.57	T^1	Random Forest	0.51	Interview& Reading	Gradient Boosting
BM	**0.51**	I	Gradient Boosting	-	-	-	0.47	Interview& Reading	Gradient Boosting
C	0.71	I	Gradient Boosting	**0.75**	I	Linear SVM	0.64	Interview& Reading	Gradient Boosting
DM	0.69	I	Gradient Boosting	**0.72**	I	Linear SVM	0.63	Interview& Reading	Gradient Boosting
DP	**0.69**	T^2	Gradient Boosting	0.64	M^2	Random Forest	0.61	Interview& Reading	Gradient Boosting
E	0.58	I	Gradient Boosting	**0.66**	I	Linear SVM	0.57	Interview& Reading	Gradient Boosting
GM	0.63	M^2	Gradient Boosting	**0.64**	M^1	K Nearest Neighbors	0.55	Interview& Reading	Gradient Boosting
GP	**0.64**	T^1	Gradient Boosting	0.57	T^1	RBF SVM	0.58	Interview& Reading	Gradient Boosting
N	**0.64**	M^2	Gradient Boosting	-	-	-	0.51	Interview& Reading	Gradient Boosting
O	0.56	M^2	Gradient Boosting	-	-	-	**0.58**	Interview& Reading	Gradient Boosting
FIQ	**0.63**	M^2	Gradient Boosting	-	-	-	0.57	Interview& Reading	Gradient Boosting
CIQ	0.550	T^1	Gradient Boosting	-	-	-	**0.552**	Interview& Reading	Gradient Boosting

The number written in bold is the highest in the row

Discussion and conclusions

In our study, we have shown the possibility to predict psychological characteristics (personality traits and intelligence) by audio analysis of voice characteristics. Unlike previous studies, we took into account not only personality traits according to the Big Five model, but also considered another personality model (The Circumplex of Personality Metatraits) as well as crystallized and fluid intelligence.

Our data suggest that different processes underline the manifestation of personal traits in voice properties in males and females. Not only the same traits were predicted with different accuracy, but the same datasets provided different accuracy (at least for personality traits). For females, the most relevant data for personality traits diagnosis were those involving different emotional contexts (self-presentation and empathy). For males, it was important to include a variety of situations to broaden the context as much as possible.

We found that in general, the identification of personality traits by acoustic characteristics of speech was more effective than the identification of intelligence. However, the prediction of intelligence was more consistent across men and women. Thus, we should search for more relevant context for intelligence diagnosis. From our data, it is evident that situations concerning self-presentation are less appropriate, but the text reading data contributes to enhanced classification quality. It is probable that more relevant data to predict intelligence could be obtained from think-aloud protocols or by using argumentation procedures.

It is also worth noting that the machine learning models considered were trained without parameter fine-tuning, which is one of the limitations of the current study and the direction of our future work.

It is also worth noting that the machine learning models considered were trained without parameter fine-tuning, which is one of the limitations of the current study and the direction of our future work.

Table 3.

Classification results. The table reports the ROC-AUC scores for different kinds of algorithms and input data for men

Scale	#1 Models using preprocessing data			#2 Models with algorithm-winner using preprocessing data			#3 Models using original union data		
	ROC-AUC	Data	Model	ROC-AUC	Data	Model	ROC-AUC	Data	Model
A	0.59	M^2	Gradient Boosting	**0.61**	I	Linear SVM	0.41	Interview& Reading	Gradient Boosting
AM	0.56	I	Gradient Boosting	-	-	-	**0.66**	Interview& Reading	Gradient Boosting
AP	**0.67**	T^1	Gradient Boosting	-	-	-	0.64	Interview& Reading	Gradient Boosting
BP	**0.68**	M^2	Gradient Boosting	0.59	M^2	Random Forest	0.62	Interview& Reading	Gradient Boosting
BM	**0.62**	M^2	Gradient Boosting	-	-	-	0.53	Interview& Reading	Gradient Boosting
C	**0.76**	M^1	Gradient Boosting	0.66	M^1	Linear SVM	0.64	Interview& Reading	Gradient Boosting
DM	**0.72**	I	Gradient Boosting	0.68	I	Linear SVM	0.69	Interview& Reading	Gradient Boosting
DP	0.53	T^1	Gradient Boosting	**0.56**	T^1	Random Forest	0.55	Interview& Reading	Gradient Boosting
E	0.57	T^1	Gradient Boosting	**0.59**	M^1	Linear SVM	0.52	Interview& Reading	Gradient Boosting
GM	0.57	M^2	Gradient Boosting	**0.67**	M^1	k Nearest	0.43	Interview& Reading	Gradient Boosting
GP	**0.65**	M^1	Gradient Boosting	0.61	M^2	RBF SVM	0.54	Interview& Reading	Gradient Boosting
N	**0.62**	T^1	Gradient Boosting	-	-	-	0.6	Interview& Reading	Gradient Boosting
O	**0.70**	M^2	Gradient Boosting	-	-	-	0.62	Interview& Reading	Gradient Boosting
FIQ	0.576	T^2	Gradient Boosting	-	-	-	**0.582**	Interview& Reading	Gradient Boosting
CIQ	**0.70**	T^1	Gradient Boosting	-	-	-	0.66	Interview& Reading	Gradient Boosting

The results show that the proposed approach to increasing the estimation accuracy of psychological traits of the person (using the audio-characteristics obtained in different types of tasks) sometimes appears to be more effective than the use of self-presentation audio-recordings only. We attribute this to the fact that certain properties are expressed by the person in the process of social interaction only and are related to the context of a situation.

It is of interest that the determination of the high and low level of expression of the psychological trait Conscientiousness showed the best quality among others for both men (M^1 dataset) and women (I dataset). This may be related to the simulated employment situation, where people try to demonstrate Conscientiousness to a greater extent among other personality traits. Also for both men and women, the best results on specific datasets related to reading Stanislav Lem's Solaris (M^1, T^1 datasets), which had a neutral tone, were obtained for the Gamma-plus and Gamma-minus scales, which characterize prosocial orientation, mental health, and self-control. The diagnosis of a number of traits in women was more extensively connected with the peculiarities of reading the emotionally loaded text "Likhachev's Memoirs," which was probably associated with a greater internal response to the tragic situation described in the text. For men, in turn, it was the reading of a neutral fragment of a science fiction novel that allowed to increase the accuracy of the diagnosis of a number of psychological traits.

In order to interpret the results obtained, it is necessary to determine the theoretical model underlying the relationships between voice properties and personality characteristics found in literature. However, almost all works focus exclusively on the studying of features. Mallory and Miller [3] have suggested that voice features (closely related to muscle reactions) and their corresponding personality traits develop in parallel as a result of a set of reactions to certain life events. For example, the situations of submission, falling into which leads to appropriate personality trait development, may

be accompanied by compression of the muscles regulating the vocal cords, leading to the formation of a higher voice, while narrowing of the vocal passages leads to a decrease in resonance properties. Further research has shown that the characteristics of the speech signal depend on the autonomic and somatic nervous system, and the vagus nerve, which supports motor parasympathetic fibers and is responsible for controlling heart rate and sweating, controls the activation of some muscles of the mouth and larynx [14].

Another approach, proposed by Silnitskaya [29], postulates that the connection between psychological characteristics and voice is moderated by the context of a person's activity. She showed that some temperamental and personal characteristics correlate differently with voice features depending on communication context (with or without interlocutor). In our study we found further evidence for Silnitskaya's theory, showing that the relation between voice and psychological characteristics is moderated not only by gender, but also by context in which speaking activity takes place.

Thus, we can conclude that further development of approaches to psychodiagnosis of personality traits through the analysis of subjects' speech should be related to the context and situation of recording of the subject's voice, as this may have a significant impact on the quality of models developed with a more complex structure.

Appendix

Table 1.

Classification Results. The Table Reports the ROC-AUC Scores for Different Kinds of Input Data for Females

Scale	I	M^1	M^2	T^1	T^2	Union
A	0,61	0,57	**0,67**	0,55	0,61	0.64
AM	0,65	0,53	**0,67**	0,47	0,60	0.62
AP	0,68	0,55	**0,70**	0,49	0,68	0.64
BM	**0,51**	0,48	0,47	0,44	0,50	0.51
BP	**0,59**	0,52	0,54	0,58	0,49	0.47
C	**0,71**	0,61	0,65	0,57	0,66	0.64
DM	**0,697**	0,630	0,695	0,46	0,63	0.63
DP	0,65	0,59	0,686	0,531	**0,691**	0.61
E	**0,58**	0,46	0,50	0,57	0,52	0.57
GM	0,53	0,59	**0,64**	0,52	0,56	0.55
GP	0,53	0,50	0,58	**0,64**	0,53	0.58
N	0,54	0,47	**0,64**	0,54	0,59	0.51
O	0,50	0,52	**0,56**	0,50	0,48	**0.58**
FIQ	0,53	0,62	**0,63**	0,49	0,49	0.57
CIQ	0,48	0,54	0,53	**0,55**	0,44	**0.552**

The number written in bold is the highest in the row.

Table 2.

Classification Results. The Table Reports the ROC-AUC Scores for Different Kinds of Input Data for Males

Scale	All	M^1	M^2	T^1	T^2	Union
A	0,468	0,458	**0,588**	0,492	0,530	0.41
AM	**0,558**	0,357	0,310	0,515	0,472	0.66
AP	0,579	0,636	0,536	**0,666**	0,637	0.64
BM	0,560	0,539	**0,618**	0,549	0,548	0.62
BP	0,452	0,564	**0,677**	0,663	0,668	0.53
C	0,507	**0,759**	0,556	0,632	0,398	0.64
DM	**0,716**	0,462	0,666	0,590	0,565	0.69
DP	0,493	0,517	0,468	**0,533**	0,470	0.55
E	0,471	0,542	0,520	**0,566**	0,483	0.52
GM	0,492	0,410	**0,567**	0,358	0,475	0.43
GP	0,471	**0,646**	0,581	0,585	0,502	0.54
N	0,616	0,580	0,588	**0,619**	0,599	0.6
O	0,490	0,547	**0,697**	0,557	0,564	0.62
FIQ	0,502	0,446	0,502	0,575	**0,576**	0.582
CIQ	0,431	0,638	0,608	**0,701**	0,383	0.66

The number written in bold is the highest in the row.

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Inductive Reasoning and Neural Efficiency

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Abstract. A brief review of studies that considers the issues of cognitive performance allows us to identify two sets of data, some studies confirm the Neural Efficiency Hypothesis (NEH), others testify in favor of the Efficiency Paradox Hypothesis. We assumed that the possible reasons for the controversial outcomes could be not only in the task complexity, but also the heterogeneity of the samples. Therefore, we compared the effectiveness of inductive reasoning in samples that are homogeneous according (1) sex, (2) age, as well as the (3) speed and accuracy of solving elementary logical problems. The study involved 251 respondents aged 13 to 27 years (M/F = 118/133, mean age 15.64±2.65 years). Behavioral and EEG data were collected. Significant differences in the performance of elementary logical operations between female and male were not found. However, the values of EEG Power Spectrum in female were significantly higher than in male. The neuro-efficiency hypothesis was confirmed only in the group of "slow" responders. Ceteris paribus, the fast persons expend more energy than the slow ones, the accurate people more than the inaccurate ones, women compared to men.
Keywords: Neural Efficiency Hypothesis, Temperament, Intelligence, Inductive Reasoning, EEG Power Spectrum

1. Introduction

A phenomenon called cognitive neuroefficiency [20], i.e., more efficient use of the cortex (or even whole brain) in people with high intelligence compared to people with low intelligence, was first obtained in the of R. J. Haier's work using positron emission tomography (PET). In the study examining the relationship between intellectual task performance and neural activation levels, R. J. Haier found an inverse relationship between brain glucose metabolism levels and intelligence test scores. Participants with high IQs consumed less energy and worked faster than participants with lower IQs. This fact allowed the authors to suggest that higher intelligence was associated with neural circuits that worked faster and more efficiently. Neural efficiency manifests itself in more clearly localized brain activation areas during cognitive tasks in more capable individuals versus less capable individuals in each brain areas. This effect has been confirmed in many studies using different neurophysiological measurement methods and a wide range of different cognitive tasks. More successful subjects showed less brain activation when solving mental tasks than less successful subjects [6,9,10,12,36-38,47]. Several studies demonstrated the non-linear nature of the correlations between the physiological reactions of the body and the results observed during mental activity. Of great importance is the problem of the ratio of physiological "costs" and the success of the thought process, which can be considered in terms of operational efficiency [5].

1.1. Intelligence and the phenomenon of neuroefficiency

R. J. Haier 's followers Niebauer and Fink in a comprehensive review of intelligence and the

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phenomenon of neuroefficiency reported 29 studies in support of this hypothesis, while 18 studies provided partial support, and 9 studies provided negative results. These scientists suggested that these controversial results could be explained by the fact that some studies included tasks that may not have been demanding enough, while others were too complex and required more cortical resources, leading to a positive correlation between brain function and cognitive ability [12,34,41].

Similar controversial data were revealed in a systematic review of neural efficiency in the athletic brain [31]. Longxi Li and Daniel M. Smith assumed neural that efficiency in athletes is an integration of neuroanatomical structure changes (neural plasticity) and neural proficiency of higher cognitive processing and neural network through long-term training in specific sports. They examined a wide range of sport-specific videos and Multiple Object Tracking (MOT) specific to 18 different sports and utilized Blood Oxygenation-Level Dependent (BOLD) functional Magnetic Resonance Imaging (fMRI), functional Near-InfraRed Spectroscopy (fNIRS), and ElectroEncephaloGram (EEG). They extracted both supporting and conflicting evidence of the Neural Efficiency Hypothesis (NEH). The researchers summarized studies that typically report a negative association between brain activation and optimal task performance. These studies indicated that experts use their brains more efficiently with less energy consumed (a fewer resources are used) than novices or non-athletes for performance of a task. These scientists revealed studies that reported only partial support for the NEH; that is, only for certain categories, under specific conditions/tasks, or for specific brain regions. Moreover, they found studies which presented the opposite point of view: studies on complex visuospatial, visual search, motion observation, and cognitive tasks have shown that athletes' parietal, central, and other areas have higher cortical activation, which is inconsistent with the NEH.

1.2. Efficiency Paradox Hypothesis

D. T. Mann, A. Wright, and C. M. Janelle claim that the neural efficiency hypothesis (NEH) is both scientifically and intuitively simplistic, and underlying mechanisms that correlate with this hypothesis remain speculative. They put forward the efficiency paradox hypothesis: "longer is better" that runs contrary to the NEH [32]. As paradoxical it may seem, extensive evidence shows that even for fast ballistic tasks such as table tennis, soccer, badminton, and archery, the duration of QE (Quiet Eye) tracking is longer for successful shots than for unsuccessful ones, in which the cortex activation in an expert is greater than in a novice [2,3,4,8,13,16].

Longxi Li and Daniel M. Smith explain the paradox of neuroefficiency by the fact that with limited cognitive capabilities of the human brain, a person finds ways to navigate complex spatial information earlier and to maintain their focus under the most challenging situations. More often, at the highest level of sport competition, athletes are faced with a large number of factors that can be difficult to control. These researchers emphasized that the NEH is a dynamic and situational concept that depends on several factors including movement characteristics (e.g., side of the movement), hemisphere, and athletes' personality traits. They believe that the various perspectives associated with NEH need to be considered in a concrete situation [31].

1.3. Neuronal mechanisms of inductive reasoning

F. Qiu, Y. Pi, K. Liu, H. Zhu, X. Li, J. Zhang, et al showed that higher neural efficiency is a bidirectional phenomenon encompassing both decreased activation of task-related areas and decreased deactivation of areas associated with irrelevant information processing [42]. It is also noted that the correlations between intelligence and brain activation differed depending on the intelligence component. For instance, when studying Event-Related Desynchronization (ERD) alpha activity of the EEG, it was found that during the performance of a reasoning task, neuroefficiency was more pronounced in fluid intelligence compared to crystallized (according to Cattell) [34].

The various models are used to explain the neuronal mechanisms of inductive reasoning, most of which follow the principle of complete similarity [22,39,44,51,52]. These researchers believe that categorization, induction, and recognition are closely related conceptual abilities that enable people to draw conclusions from observation and previous experience. As Evan Heit and Brett K. Hayes pointed out, similarities are potentially the common "currency" that links all three cognitive activities [22]. According to the SINC model by V. Slutsky and A. Fisher (A Model of Similarity-Based Induction in Young Children), "categorization

and induction in young children are processes based on similarity" that are calculated on visual and linguistic signals" [52]. The data obtained by these researchers indicated that categorization and induction in young children (4–5 years old) depended on visual coincidences between stimuli, as well as auditory coincidences from the point of view of speech categories. The data of a large-scale experiment, in which 3600 respondents of three age groups (5-8 years old, 11-13 years old, 14-16 years old) took part, aimed at the formation of the ability of the operation of inductive reasoning, showed that the formation of the ability for elementary logical operations led to an improvement in academic achievement and fluid intelligence growth [25]. The Similarity-Based Model is based on perceptual similarity [52]. The Concept-Based Model [18] is based on existing knowledge or concepts. A prerequisite for the performance of the reasoning process in the Similarity Model is the similarity between the objects of thought or the general membership in the category, i.e., there is a definite relationship between objects in a semantic context, is based on taxonomic similarities: an overlap of the features or meanings of words that includes elements of the same generic category (e.g., a mammal with members such as panda, antelope, dog, cat, cow etc.) [48]. Other studies have also shown that taxonomic relationships in the process of reasoning are formed more easily than thematic relationships [49].

The Conceptual Model of inductive reasoning assumes that inductive reasoning is based on a common conceptual property, while perceptual similarities between objects are ignored [17]. One of the conceptual properties is a thematic relationship which is based on complementary related elements in scenarios or events that have a common conceptual feature. It was shown that the processing of thematic relationship requires fewer cognitive resources than that of a taxonomic relationship in reasoning tasks [32,48]. Apparently, that is why, inductive logical reasoning based on conceptual information is often used in everyday life [29].

The existing studies of inductive reasoning have primarily adopted imaging methods to explore the neural difference between taxonomic- and thematic based-inductive reasoning [23,24,26,58]. Fangfang Liu, Jiahui Han, Lingcong Zhang and Fuhong Li tested whether or not distance effects on the processing of taxonomic- and thematic-based semantic relations in inductive reasoning were differently reflected in brain [30]. Event-related potential (ERP) results showed that the effect of context (taxonomic versus thematic) was initially observed in the P2 component; while the distance effect (far versus near) was observed in N400 and later components. It should be noted that distance effects for inductive reasoning based on thematic relationships were found in the frontal and frontal-central regions, while the distance effect on inductive reasoning based on taxonomic relationships was observed in the parietal and central parietal areas.

However, the neural efficiency of inductive reasoning associated with the difference in intelligence and temperament traits remains unaddressed. Thus, the purpose of the present study was to investigate the relations among inductive reasoning, EEG power spectrum, intelligence, and temperament traits. In order to achieve our goal, we need to solve the following tasks:

(1) to compare indicators of temperament, intelligence and EEG power spectrum when solving elementary logical problems in samples of female and male;

(2) to compare indicators of temperament, intelligence, and EEG power spectrum when solving elementary logical problems in 13-14-year-old, 15-17-year-old and 18-27-year-old respondents;

(3) to compare indicators of temperament, intelligence, and EEG power spectrum when solving elementary logical problems in groups of slow and accurate, slow and inaccurate, fast and accurate, fast and inaccurate respondents.

2. Material and methods

2.1. Participants

The present research was administered to 251 subjects, aged from 13 to 27 (M/F = 118/133, mean age 15.64±2.65 years) including early adolescents (13.73±0.45 years), middle adolescents (15.46±0.66 years), and late adolescents (21.11±2.87 years). This study involved respondents from Moscow and Ufa within Russian Federation. All participants were right-handed and without any obvious signs of psychiatric or neurological disorders. They had normal vision. The participants gave informed consent before starting data acquisition experiment. Their participation in the studies were free.

Table 1. Sample

	Male Sample, N=118		Female Sample, N=133		Total Sample, N=251	
	Mean	SD	Mean	SD	Mean	SD
Early adolescents, (13-14), N=92	13.76	0.43	13.70	0.46	13.73	0.45
Middle adolescents, (15-17), N=123	15.45	0.66	15.46	0.65	15.46	0.66
Late adolescents (18-27), N=36	20.82	3.15	21.35	2.58	21.11	2.81

It is well known that at the age of 13-14 years, the formation of secondary sexual characteristics begins, an unstable hormonal profile is observed, and the structures of the brain (cerebral cortex) are in the process of formation. At the age of 15-17 years, the hormonal profile is also unstable, but the cerebral cortex (except for the frontal lobes) and other regulatory structures of the central nervous system (CNS) are formed. At the age of 18-27 years, secondary sexual characteristics have formed, the hormonal profile is stable, the formation of all structures of the central nervous system, including the frontal cortex, has completed [15].

2.2. Measures

Prior to the EEG sessions participants were screened with respect to their intellectual abilities by means of a well-known Standard Progressive Matrixes (SPM) [43] and the "Intelligence Structure Test 2000-R" (I-S-T 2000-R) [1] in Russian adaptation by L.A. Yasyukova [59].

The Standard Progressive Matrixes (SPM) is a well-validated measure of fluid reasoning ability (gF). The Raven's Standard Progressive Matrixes contain 60 nonverbal items. Each item consists of 3 × 3 matrix with a missing piece to be completed by selecting an answer from six or eight alternatives. Time completing the tasks is 20 minutes.

Intelligence Structure Test (IST) is based on Thurstone's and Cattell's intelligence theories and measures verbal, numerical, and figural-spatial abilities. The composite score indicates general reasoning ability which is closely tied to general intelligence. Each verbal, numerical, and figural-spatial tasks consist of 20 items.

- Verbal Intelligence scale includes such tasks as Sentence Completion (SC), Verbal Analogies (VA), Verbal Similarities (VS), Odd One Out (OOD). These scales measure the reasoning ability within a verbal context.
- Numerical Intelligence scale consists of Calculations (CA) and Number Series (NS) tasks. These scales measure calculation skills and numerical reasoning (the ability to make logical connections between numbers).
- Figural-Spatial Intelligence scale covers such tasks as Figure Selection (FS), Cubes (CU), and Verbal Memory (VM). These scales assess the ability to process figural-spatial material (two- and three-dimensional figures) as well as the ability to assess proportions of surfaces and volumes, figural reasoning, the ability to reveal logical relationships among figures.

The Elementary Logical Operations (ELO) test is implemented in both computer and paper-and-pencil versions [46]. The ELO has 24 statements assigned to evaluate the ability to perform elementary logical operations. Respondents are offered to compare the ratio between the values of A, B and C as fast and as accurately as possible and evaluate the truth or falseness of the logical conclusion.

For example, if **A** is equal to **B** and **B** is equal to **C** then "**C** is equal to **A**". This conclusion is true. But the conclusion "**C** is not equal to **A**" under the given conditions is false. There are four possible answers: (1) C is equal to A; (2) C is not equal to A; (3) C is greater than A; (4) C is less than A. Only those problems were offered that had only one correct answer.

The time of the ELO test in paper-and-pencil version was limited to four minutes. Decision time of the ELO test in the computer version was unlimited and the tasks were provided randomly. Decision time and total score are automatically recorded by a special Software InTesting.

Raw scores were converted to S-scores through percentile standardization procedure. The ability to perform Elementary Logical Operations was considered to be high if S-score ≥ 7 and low if S-score ≤ 3.

The Structure Temperament Questionnaire (STQ-S) [45] was used for evaluation of Motor (MA), Intellectual (IA), and Communicative (CA) Activity. Shortened version of the STQ-S

contains 26 items. STQ-S has a high correlation with full version of the STQ questionnaire. The IA-scale is thought to be temperamental scale of intelligence measured by Wechsler test [45].

2.3. EEG procedure

The EEG session started with the mounting of the electrodes and checking the electrode impedances. Participants were in a comfortable EEG recording room. We record two 2-min EEG sequences under resting conditions to determine the neurological profile of the respondents: (a) eyes closed, (b) eyes opened. Then experimental session started the total time of which was about 45 min. The EEG -recorder was synchronized with the InTesting computer diagnostic complex to analyze the change in the EEG power spectrum when solving Elementary Logical Operations. The problems randomly appeared on the screen. The respondent was to evaluate the truth or falsity of the conclusions as quickly and as accurately as possible and press the appropriate key: true or false.

2.4. Apparatus/EEG recording

We used portable electroencephalograph Encephalan-EEGR-19/26 Medicom MTD (European certificate CE 538571 of the British Standards Institute, BSI). The EEG was measured by means of silver electrodes (9 mm diameter) located in an electrode cap in 30 positions (according to the international 10–20 system with interspaced positions). A ground electrode was located on the forehead. Reference electrodes were placed on the left and right earlobes. Electrodes O2-A2, O1-A1, Oz-A2 correspond to occipital lobe; P4-A2, P3-A1, C4-A2, C3-A1, Pz-A1, Cz-A2, CP3-A1, Cpz-A1, CP4-A2 – parietal lobe; F4-A2, F3-A1, Fp2-A2, Fp1-A1, F8-A2, F7-A1, Fz-A1, Fpz-A2, Fcz-A1, FT8-A2 – frontal lobe; T6-A2, T5-A1, T4-A2, T3-A1 – temporal lobe; FC3-A1, FC4-A2 – fronto-parietal lobe; TP7-A1, TP8-A2 – temporo-parietal lobe. The EEG signals were filtered between 0.5 Hz and 50 Hz; an additional 50 Hz notch filter was applied to avoid power line contamination. Electrode impedances were kept below 5 kΩ for the EEG. The sweep rate was 30 mm/s. The EEG recording was scanned for artifacts. The epochs for analysis were selected after the artifacts were removed manually. The duration of one epoch was 10 seconds. We used for the analysis five epochs of the performing ELO test: two epochs at the beginning, one in the middle, and two at the end. The spectral amplitude is an average value over the time interval under consideration. The mathematical basis of spectral analysis is the Fourier transform of the initial EEG data, which was carried out automatically by the Medicom-MTD program. We used the EEG power spectrum that denotes the squared value of the amplitude of the EEG signal. This parameter provides an increase in the stability of the data obtained due to increasing in the strongest differences and the leveling of weak differences [27].

2.5. Statistical Procedures

Statistical treatment of empirical data included descriptive statistics of raw data (Means, SD, Skewness, and Kurtosis). The test scores corresponded to the normal distribution (Skewness and Kurtosis =±1). Reliability statistics (Cronbach's alphas) for the both ELO (Paper-and-pencil version) and ELO (Computer version) was conducted. The statistical analyses involved mixed-design ANOVAs and t-tests. Post-hoc comparisons with Bonferroni corrections were made where it was necessary. The indicators of the ELO test were converted into S-scales. Hierarchical Cluster Analysis (HCA, Ward Method) was used to identify relatively homogeneous groups of respondents based on S-scales of the ELO test.

3. Results

3.1. Behavioral data

Descriptive statistics are presented in Table 2. Test scores corresponded to the normal distribution. Means and standard deviations (SD) are reported for the male and female sub-samples and for the total sample. The reliability measured by the Cronbach Alpha coefficients were within the acceptable range (0.84-0.91). These results testify that the ELO (Computer version) and the ELO (Paper-and-pencil version) scales had sufficient internal consistency. There were no significant differences in the ability to perform elementary logical operations in male and female samples. However, the female sample was characterized by significantly higher rates of intellectual tests such as Odd One Out Task (OOD), Verbal Similarities (VS), Figure Selection (FS), and Verbal Memory (VM).

Table 2.

Mean values and Standard Deviations in Total sample, Male and Female Samples

	Male Sample, N=118		**Female Sample, N=133**		**Total Sample, N=251**		**Alpha: Cronbach coefficient**
	Mean	SD	Mean	SD	Mean	SD	
			ELO				
Computer version, score	21.02	3.22	21.08	3.14	21.05	3.17	0.843
Computer version, sec	5.50	2.06	5.49	1.93	5.5	1.99	-
Paper-and-pencil version, score	20.36	4.96	19.71	4.76	20.01	4.85	0.909
			Intelligence				
SPM (Raven)	3.95	1.39	4.32	1.09	4.15	1.23	-
			Amthauer intelligence test scales				
Sentence Completion (SC)	7.78	2.26	8.04	2.23	7.92	2.24	-
Odd One Out Task (OOD)	8.25	2.92	9.63**	2.62	8.99	2.84	-
Verbal Analogies (VA)	7.00	2.67	7.27	2.99	7.14	2.84	-
Verbal Similarities (VS)	4.69	3.17	6.46**	3.59	5.65	3.50	-
Calculations (CA)	6.94	4.49	7.38	4.28	7.18	4.37	-
Number Series (NS)	6.43	5.18	7.81	4.90	7.17	5.06	-
Figure Selection (FS)	7.38	4.06	8.72*	3.75	8.10	3.94	-
Cubes (CU)	7.96	4.30	8.38	3.43	8.18	3.85	-
Verbal Memory (VM)	13.57	6.12	15.54*	4.68	14.63	5.46	-

The data presented in table 3 indicated an increase in the ability to perform elementary logical operations from Early Adolescence to Late Adolescence. Of particular interest is the fact that the speed of making a decision about the truth or falsity of conclusions is significantly higher in late adolescence compared to middle adolescence.

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As to the temperamental traits, the values of Motor Ergonicity, Intellectual Tempo and Motor Activity in Middle Adolescence were significantly higher than in Late Adolescence. To clarify the courses of the finding obtained, it was advisable to compare the Behavioral data between homogeneous groups that differ in the speed of decision making and accuracy.

Table 3.

Age differences in ELO scores and Formal-Dynamic properties of Individuality

Multi-level properties of individuality	Mean			Bonferroni correction			The results of one-way ANOVA
	Early Adolescence (1)	Middle Adolescence (2)	Late Adolescence (3)	2-1	3-1	3-2	
ELO							
Computer version, scores	19.43	21.69	23.00	***	***	*	F=25.399, p = 0.001
Computer version, sec	5.78	5.98	3.14	-	***	***	F =38.868, p =0.001
Paper-and-pencil version, score	17.72	20.34	22.78	***	***	**	F = 14.475, p =0.001
Temperament traits							
Motor Ergonicity	3.71	3.24	4.52	-	-	**	F = 6.171, p =0.001
Intellectual Tempo	6.51	6.62	5.42	-	-	*	F =3.216, p =0.05
Motor Emotionality	6.51	7.33	7.14	**	-	-	F = 3.775, p =0.03
Motor Activity	38.20	23.53	16.92	***	***	*	F = 36.908, p =0.00

The raw scores of decision-making speed and accuracy were converted to S-scales. Then four relatively homogeneous groups of respondents were identified based on Hierarchical Cluster Analysis (Ward Method) which were conditionally named Slow & Inaccurate, Slow & Accurate, Fast & Inaccurate, Fast & Accurate. Thus, we got two groups with the same speed, but different decision-making accuracy, and two groups with the same accuracy, but different decision-making speed (Table 4)

Table 4. Differences in Intelligence and Temperament traits in groups of Slow & Inaccurate, Slow & Accurate, Fast & Inaccurate, Fast & Accurate respondents

Indicators	Mean				Bonferroni correction						The results of one-way ANOVA
	Inaccurate & Slow N=117 (1)	Inaccurate & Fast N=68 (2)	Accurate & Fast N=38 (3)	Accurate & Slow N=28 (4)	1-2	1-3	1-4	2-3	2-4	3-4	
ELO											
Computer version, scores	20.58	19.00	**24.00**	24.00	** *	** *	** *	** *	** *	-	F = 44.787, p =0.00
Computer version, sec	6.71	3.84	**3.47**	7.25	** *	** *	-	-	** *	** *	F =125.506, p =0.00
Paper-and-pencil version, score	18.98	18.33	**23.36**	22.21	-	** *	**	** *	**	-	F =12.938, p =0.00
Amthauer intelligence test scales											
Calculations (CA)	6.61	5.88	**12.08**	8.23	-	** *	-	** *	-	-	F = 7.594, p =0.00
Number Series (NS)	5.97	7.92	**11.08**	9.09	-	** *	*	-	-	-	F = 5.820, p =0.00
Cubes (CU)	8.17	6.96	**11.92**	7.55	-	**	-	** *	-	**	F =5.189, p =0.00
Temperament Traits											
Motor Ergonicity	3.29	3.69	**4.59**	3.29	-	**	-	-	-	-	F = 4.457, p =0.01
Motor Emotionality	7.00	6.91	7.39	7.14	**	-	-	-	-	-	F = 0.497, p =0.69
Motor Activity	27.02	32.13	20.69	22.82	-	-	-	**	*	-	F = 4.842, p =0.00

According to the data presented in Table 4, the sample of respondents who are equally slow, but differ in the accuracy of decision-making, differ significantly only on the Number Series scale (NS).

In the sample of Fast & Accurate respondents compared with Fast & Inaccurate respondents, we revealed the following significant differences: the higher scores on the Calculations (CA), Cubes (CU), and Motor Ergonicity scales, but the lower scores on the Motor Activity scale.

We found only one significant difference on the Cubes scale (CU) between the samples of equally accurate respondents, but differing in the speed of decision-making. Also, one significant difference was revealed on the Motor Emotionality scale between the samples of respondents, which are equally inaccurate, but differ in the speed of decision-making. It should be noted that Fast & Accurate respondents had higher IQs, while Fast & Inaccurate respondents had lower IQs.

3.2. EEG data

We compared Means of the EEG power spectrum (mV^2) during performance of the Elementary Logical Operations between males and females (see Table 5).

Table 5.

Mean of the EEG power spectrum (mV^2) in Samples of Male and Female

Leads	Means of the EEG power spectrum (mV^2)		t	Sig. (2-tailed)
	Male (N=118)	Female (N=133)		
O1_A1	3.26	3.81	-2.117	0.035
P4_A2	3.22	3.76	-2.230	0.027
P3_A1	3.09	3.59	-2.631	0.009
C3_A1	3.28	3.89	-2.732	0.007
F4_A2	3.76	4.67	-2.549	0.011
F3_A1	**5.00**	**6.82**	-2.100	0.037
T6_A2	2.74	3.47	-2.744	0.007
T5_A1	2.77	3.47	-3.114	0.002
T4_A2	3.06	3.91	-2.427	0.016
T3_A1	3.42	4.07	-2.397	0.017
F7_A1	3.64	4.15	-2.263	0.024
Pz_A1	4.02	5.22	-2.062	0.040
FC3_A1	3.48	4.00	-1.990	0.048
FC4_A2	3.31	3.77	-2.045	0.042
FT8_A2	3.04	3.95	-3.216	0.001
TP7_A1	3.02	3.50	-2.452	0.015
CP3_A1	3.16	3.66	-2.344	0.020
CP4_A2	3.21	4.27	-3.585	0.0001

According to the data presented in Table 5, the power spectrum of the EEG signal under 18 electrodes when solving elementary logical problems were significantly higher in female than in male. At the same time as is seen in Table 2, there were no significant differences in the speed and accuracy of solving elementary logical problems in samples of female and male. The findings testified that female respondents had to expend more "electrophysiological energy" to achieve the same results compared to male respondents. It should also be pointed out that both in males and females, the highest values of the EEG power spectrum were observed under the **F3_A1** electrode, and the lowest under the T6-A2 and T5-A1 electrodes.

Table 6.

Mean of the EEG power spectrum (μV2) in samples of Early, Middle, and Late Adolescence

Leads	Means of the EEG power spectrum (μV2)			F	Sig. (2-tailed)
	Early Adolescence, 13-14 years, (N=92)	Middle Adolescence, 15-17 years, (N=123)	Late Adolescence, 18-27 years, (N=36)		
O2_A2	4.00	3.74	2.77	12.95	0.0001
O1_A1	3.81	3.29	2.35	15.711	0.0001
P4_A2	3.76	3.26	2.72	9.578	0.0001
P3_A1	3.59	3.07	3.01	8.408	0.0001
C4_A2	3.69	3.14	3.34	7.297	0.001
C3_A1	3.89	3.41	2.97	7.144	0.001
F4_A2	4.47	3.77	3.99	4.663	0.01
F3_A1	6.82	4.67	8.92	5.969	0.003
Fp1_A1	5.55	4.47	5.51	6.2	0.002
T6_A2	3.47	3.05	2.33	4.479	0.012
F8_A2	4.20	3.62	5.43	7.979	0.0001
F7_A1	4.15	3.82	3.36	3.448	0.033
Oz_A2	4.83	3.95	3.08	15.783	0.0001
Pz_A1	5.22	4.00	3.37	7.049	0.001
Cz_A2	4.93	4.60	11.32	7.147	0.001
Fz_A1	5.57	4.83	8.03	5.255	0.006
Fpz_A2	4.91	3.85	6.15	6.602	0.002
Fcz_A1	3.86	3.46	3.31	5.372	0.005
FC4_A2	3.77	3.27	3.20	6.648	0.002
FT8_A2	3.91	3.42	2.78	3.692	0.026
CP3_A1	3.66	3.38	2.80	3.869	0.022
Cpz_A1	3.86	3.35	3.05	6.401	0.002
CP4_A2	4.27	3.29	3.57	7.211	0.001
TP8_A2	3.75	3.24	4.52	6.171	0.002

We found more significant differences in EEG power spectrum by age than by sex (24 vs 18). Two types of age-related changes in the parameters of the EEG power spectrum were revealed: descending and U-shaped. Power spectrum values continually decreased from Early Adolescence to Late Adolescence under the following Electrodes: O2, O1, Oz, (occipital lobe); P4, P3, C3, Pz, CP3, Cpz (parietal lobe); T6 (temporal lobe); and F7, Fcz, FC4, FT8 (frontal and frontotemporal lobe).

The U-shaped changes in the EEG power spectrum were found in two subtypes:

(a) The power spectrum in Early Adolescence was higher than in Late Adolescence under electrodes C4, F4, Fp1, CP4.

(b) The power spectrum in Late Adolescence

was higher than in Early Adolescence under electrodes F3, F8, Cz, Fz, Fpz, TP8.

Comparison of the data presented in Tables 3 and Tables 6 indicated that the decrease in Motor Activity indices corresponded to a decrease in the values of EEG power spectrum in the motor cortex of the right hemisphere (leads FC4, FT8).

Table 7.

Mean of the EEG power spectrum (μV2) in samples of Inaccurate & Slow, Inaccurate & Fast, Accurate & Fast, Accurate & Slow respondents

Leads	**Means of the EEG power spectrum (μV2)**				F	Sig. (2-tailed)
	Cluster 1 Inaccurate & Slow N=117	**Cluster 2 Inaccurate & Fast N=68**	**Cluster 3 Accurate & Fast N=38**	**Cluster 4 Accurate & Slow N=28**		
O2_A2	3.82	4.71	3.35	3.42	4.994	0.002
F3_A1	4.86	7.20	8.34	4.32	3.881	0.01
Fp2_A2	5.04	7.16	7.22	3.89	4.186	0.007
Fp1_A1	5.04	6.07	6.80	3.70	3.148	0.026
F8_A2	3.57	4.16	5.41	3.51	6.176	0.0001
Oz_A2	4.57	5.20	3.46	3.80	3.352	0.02
Cz_A2	4.00	7.23	8.60	3.60	3.084	0.028
Fz_A1	4.31	5.80	9.55	3.84	11.419	0.0001
TP8_A2	3.29	3.69	4.59	3.29	4.457	0.005

Let us describe at first peculiarities of accurate respondents with different speed of solving elementary logical tasks. As it shown in Table 3 there are no significant differences in the accuracy of solving elementary logical problems in the samples of Accurate & Fast and Accurate & Slow respondents. At the same time, the values of the EEG power spectrum under the electrodes F3, Fp2, Fp1, Cz, Fz, TP8 (frontal, parietal and parietotemporal lobes of the cerebral cortex) in Accurate & Slow respondents were significantly lower than in Accurate & Fast ones. Thus, data supported the Efficiency Paradox Hypothesis. Whereas the values of the EEG power spectrum under the electrodes O2 and Oz (occipital lobe) were significantly higher. These results are consistent with the Neural Efficiency Hypothesis.

Then let us consider fast responders with different accuracy of solving elementary logical tasks. The values of the EEG power spectrum on the electrodes F3, Fp2, Fp1, Cz, Fz, TP8 (frontal, parietal and parietotemporal lobes of the cerebral cortex) in Inaccurate & Fast respondents were significantly lower than in Accurate & Fast ones. These results correspond to the Efficiency Paradox Hypothesis. Whereas the values of the EEG power spectrum under the electrodes O2 and Oz (occipital lobe) were significantly higher.

Slow responders with different accuracy of solving elementary logical tasks showed the follow results. The values of the EEG power spectrum were significantly lower under all mentioned in Table 7 electrodes in Accurate & Slow respondents as compared as Inaccurate & Slow subjects. Thus, the results obtained as a whole support the Neural Efficiency Hypothesis.

4. Discussion

A brief review of the studies that consider the issues of cognitive performance allows us to identify two sets of data, some of the studies confirm the Neural Efficiency Hypothesis (NEH), others testify in favor of the Efficiency Paradox Hypothesis. According to Callan and Naito [7], four neural mechanisms such as neural efficiency, cortical expansion, specialized

processes, and internal models provide the superiority of experts over novices. The decrease in brain activity and pronounced localization in the more capable compared to the less capable is explained by the continuous adaptation / neuroplasticity of the cerebral cortex, which in each specific area of human competence correlates with skillful control of cognitive and motor activity [4,36]. The increase in the activity of brain regions when performing cognitive tasks in the more capable compared to the less capable, identified in a large number of studies [31], is explained by an increase in the activation of the Default Mode Network (DMN) which leads to an increase in the activity of all neural networks, to the reorganization of old cortical circuits and to the creation of new ones in the course of cognitive development [53,57]. A possible reason for the controversial results could be the variability in task complexity, since neural efficiency was mostly observed for low-to-moderately difficult tasks [38]. Longxi Li and Daniel M. Smith [31] pointed out the heterogeneity of outcomes and emphasized that NEH is a dynamic and situational concept that depends on several factors including task complexity, movement patterns, hemisphere, personality traits, and others. Therefore, in this work, we studied the performance of solving elementary logical problems (simple tasks) in female and male; in the Early, Middle and Late adolescence taking into account the peculiarities of intelligence and temperament traits.

4.1. Neural efficiency of inductive reasoning in female and male

A. C. Neubauer, R. H. Grabner, A. Fink & C. Neuper, studying the influence of task content and sex on the brain–IQ relationship, found that in the female sample when performing figurative-spatial tasks, and in male when performing verbal tasks, brain activity was lower regardless of the level of intelligence [36]. Due to the earlier onset of the formation of brain structures in female, their IQ-level are usually higher than in male [14]. In our study, female also demonstrated higher IQs compared to male. Significant differences in the performance of elementary logical operations between female and male were not found. However, the values of EEG Power Spectrum in female subjects were significantly higher than in male subjects. It means that in order to achieve the same result of inductive reasoning the female subjects spend more resources compared to the male subjects. The highest values of the EEG power spectrum both in female and male were observed on lead F3 (left frontal lobe, field 46 according to Brodman). The field 46 correlates with the motor function of the muscles of the eyeball and the combined movements of the head and eyes, as well as with the comparison of visual information and movements necessary to grasp the field of view. That is, the respondents expend the most energy (in terms of the EEG power spectrum) during the performance of the task. The lowest values of the EEG power spectrum in female and male subjects are also observed under the same electrodes (T5, T6). These electrodes are located above the projection of 20-24 Brodmann fields which are responsible for comparing new data with the information previously received, as well as for consolidating and storing memory. Apparently, the respondents use memory storage structures to a less extend when solving this type of logical problems. The EEG-data show, regardless of sex, the greatest activity is observed under the frontal electrodes, i.e. each task is analyzed using structures responsible for logical operations (analysis, synthesis, generalization, abstraction, comparison and judgment).

4.2. Neural efficiency of inductive thinking in Early, Middle, and Late Adolescence

The data of this study indicate an increase in the accuracy of solving elementary logical problems from Early to Late adolescence. This pattern is confirmed in many studies of cognitive performance. Of particular interest are two types of age-related changes in the EEG power spectrum associated with an increase in the efficiency of solving elementary logical problems: descending and U-shaped changes. The age-related decline in the EEG power spectrum is usually explained by an increase in the stability of hormonal profile and by the maturation of the frontal cortex which is responsible for information processing. The U-shaped age-related change in EEG power spectrum in our opinion is associated with a significant increase in the speed of solving elementary logical problems from Middle to Late adolescence. Apparently, high speed requires additional energy expenditures of the cerebral cortex in terms of Power Spectrum EEG. To confirm this assumption, we compared the EEG power spectrum in groups of respondents who differed in the speed and accuracy of solving elementary logical problems.

4.3. Neural efficiency of inductive reasoning in Samples of Equally Accurate and Equally Fast Respondents.

The NEH holds that the person with high IQs consumes less energy and operates faster than person with lower IQs. In our study, the most "neuroefficient subjects" were those respondents who were noted for higher accuracy, but lower speed of solving elementary logical problems (in terms of the EEG power spectrum). Thus, we received additional evidence that U-shaped age-related change in EEG power spectrum may be associated with an increase in the speed of solving elementary logical problems. It should be emphasized that traditional intelligence tests usually have time limits, i.e., faster responders score more points. Therefore, the inconsistency of our data may be due to both (1) variations in cognitive complexity and (2) time limitations. Obviously, the fast persons expend more energy than the slow ones, and the accurate people expend more energy than the inaccurate ones, and women use more energy than men. These findings confirm every day observations. Apparently, the neuroefficiency hypothesis as well the Efficiency Paradox Hypothesis need to be redefined and the limit of their applicability clarified.

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Supplementary materials

Table 1. Means, Standard Deviations (SD) and Alphas for the Samples

	Male Sample, N=118		Female Sample, N=133		Total Sample, N=251	
	Mean	SD	Mean	SD	Mean	SD
Early Adolescence, (13-14), N=92	13.76	0.43	13.70	0.46	13.73	0.45
Middle Adolescence, (15-17), N=123	15.45	0.66	15.46	0.65	15.46	0.66
Late Adolescence (18-27), N=36	20.82	3.15	21.35	2.58	21.11	2.81

Table 2. Means, Standard Deviations (SD) and Alphas for the Samples

	Male Sample, N=118		Female Sample, N=133		Total Sample, N=251		Alpha: Cronbach coefficient
	Mean	SD	Mean	SD	Mean	SD	
ELO (Computer version), score	21.02	3.22	21.08	3.14	21.05	3.17	0.843
ELO (Computer version), time	5.50	2.06	5.49	1.93	5.5	1.99	-
ELO (Paper-and-pencil version), score	20.36	4.96	19.71	4.76	20.01	4.85	0.909
SPM Raven/ IQ	3.95	1.39	4.32	1.09	4.15	1.23	-
Sentence Completion (SC)	7.78	2.26	8.04	2.23	7.92	2.24	-
Odd One Out Task (OT)	8.25	2.92	9.63	2.62	8.99	2.84	-
Verbal Analogies (VA)	7.00	2.67	7.27	2.99	7.14	2.84	-
Verbal Similarities (VS)	4.69	3.17	6.46	3.59	5.65	3.50	-
Calculations (CA)	6.94	4.49	7.38	4.28	7.18	4.37	-
Number Series (NS)	6.43	5.18	7.81	4.90	7.17	5.06	-
Figure Selection (FS)	7.38	4.06	8.72	3.75	8.10	3.94	-
Cubes (CU)	7.96	4.30	8.38	3.43	8.18	3.85	-
Verbal Memory ()	13.57	6.12	15.54	4.68	14.63	5.46	-

Note. SD: standard deviations; Alpha: Cronbach coefficient

Table 3. Means for Each Age Group, the Results of One-Way ANOVA and Multiple Comparisons by Bonferroni Correction

Multi-level properties of individuality	Mean			Bonferroni correction			The results of one-way ANOVA
	Early Adolescence (1)	Middle Adolescence (2)	Late Adolescence (3)	2-1	3-1	3-2	
Intelligence							
ELO (Computer version)	19.43	21.69	23.00	***	***	*	F=25.399, p = 0.001
ELO (Computer version), time	5.78	5.98	3.14	-	***	***	F =38.868, p =0.001
ELO (Paper-and-pencil version)	17.72	20.34	22.78	***	***	**	F = 14.475, p =0.001
Temperament Traits							
ERM/ Motor Ergonicity	3.71	3.24	4.52	-	-	**	F = 6.171, p =0.001
ERI/Intellectual Ergonicity	6.32	6.34	5.39	-	-	-	F = 2.757, p =0.49
ERS/Social Ergonicity	4.83	4.83	4.94	-	-	-	F = 0.49, p =0.98
Motor Plasticity	6.86	6.92	6.06	-	-	-	F = 2.488, p =0.09
Intellectual Plasticity	5.88	6.60	6.11	-	-	-	F =2.541, p =0.01
Social Plasticity	5.59	5.67	5.25	-	-	-	F = 0.667, p =0.47
Motor Tempo	5.88	6.19	6.06	-	-	-	F = 0.422, p =0.68
Intellectual Tempo	6.51	6.62	5.42	-	-	*	F =3.216, p =0.05
Social Tempo	6.05	6.31	6.08	-	-	-	F = 0.580, p =0.59
Motor Emotionality	6.51	7.33	7.14	**	-	-	F = 3.775, p =0.03
Intellectual Emotionality	5.51	5.19	5.36	-	-	-	F = 0.588, p =0.59
Social Emotionality	6.25	6.43	6.44	-	-	-	F = 0.146, p =0.99
General Activity	6.03	6.32	6.53	-	-	-	F = 0.656, p =0.47
General Emotionality	4.92	4.98	5.28	-	-	-	F = 0.597, p =0.49
Motor Activity	38.20	23.53	16.92	***	***	*	F = 36.908, p =0.00
Intellectual Activity	17.36	17.00	16.28	-	-	-	F = 0.648, p =0.48
Communicative Activity	18.86	20.46	19.72	-	-	-	F = 2.597, p =0.07

Table. 5 Means for each Cluster, the Results of One-Way ANOVA and Multiple Comparisons by Bonferroni Correction

Indicators	Mean				Bonferroni correction						The results of one-way ANOVA
	Inaccurate & Slow (1) N=117	Inaccurate & fast (2) N=68	Accurate & slow (3) N=38	Accurate & fast (4) N=28	1-2	1-3	1-4	2-3	2-4	3-4	
Intelligence											
ELO (Computer version)	20.58	19.00	24.00	24.00	***	***	***	***	***	-	F = 44.787, p =0.00
ELO (Computer version), time	6.71	3.84	3.47	7.25	***	***	-	-	***	***	F =125.506, p =0.00
ELO (Paper-and-pencil version)	18.98	18.33	23.36	22.21	-	***	**	***	**	-	F =12.938,p =0.00
SPM Raven/ IQ	4.05	4.04	4.58	4.45	-	-	-	-	-	-	F =1.183, p =0.32
Sentence Completion (SC)	7.97	7.79	8.50	7.54	-	-	-	-	-	-	F =0.508, p =0.69
Odd One Out Task (OT)	9.09	8.13	9.08	9.50	-	-	-	-	-	-	F =1.022, p =0.38
Verbal Analogies (VA)	7.04	6.50	8.25	7.64	-	-	-	-	-	-	F =1.279, p =0.28
Verbal Similarities (VS)	5.46	5.00	7.42	6.14	-	-	-	-	-	-	F = 1.538, p =0.19
Calculations (CA)	6.61	5.88	12.08	8.23	-	***	-	***	-	-	F = 7.594, p =0.00
Number Series (NS)	5.97	7.92	11.08	9.09	-	***	*	-	-	-	F = 5.820, p =0.00
Figure Selection (FS)	8.20	7.17	9.08	8.18	-	-	-	-	-	-	F =0.717, p =0.48
Cubes (CU)	8.17	6.96	11.92	7.55	-	**	-	***	-	**	F =5.189, p =0.00
Verbal Memory (VM)	14.43	14.42	15.75	15.09	-	-	-	-	-	-	F =0.269, p =0.79
Temperament Traits											
ERM/ Motor Ergonicity	3.29	3.69	4.59	3.29	-	**	-	-	-	-	F = 4.457, p =0.01
ERI/Intellectual Ergonicity	6.09	6.38	5.97	6.36	-	-	-	-	-	-	F =0.346, p =0.79
ERS/Social Ergonicity	4.85	5.04	4.81	4.61	-	-	-	-	-	-	F = 0.305, p =0.98
Motor Plasticity	6.56	7.21	6.47	7.07	-	-	-	-	-	-	F = 1.490, p =0.19
Intellectual Plasticity	6.06	6.83	6.44	6.18	-	-	-	-	-	-	F =1.533, p =0192
Social Plasticity	5.68	5.57	5.25	5.64	-	-	-	-	-	-	F = 0.452, p =0.69
Motor Tempo	5.91	6.34	5.86	6.54	-	-	-	-	-	-	F = 1.21, p =0.38
Intellectual Tempo	6.20	6.91	5.83	6.82	-	-	-	-	-	-	F =1.703, p =0.19
Social Tempo	6.11	6.15	6.03	6.82	-	-	-	-	-	-	F = 1.527, p =0.18
Motor Emotionality	7.00	6.91	7.39	7.14	**	-	-	-	-	-	F = 0.497, p =0.69

Table 4. T-Test for Early Adolescence / Middle Adolescence Samples

	Mean		t	Sig. (2-tailed)
	Early Adolescence (N=92)	Middle Adolescence (N=123)		
Intelligence				
ELO (Computer version)	19.43	21.69	-5.289	0.000
ELO (Paper-and-pencil version)	17.72	20.34	-3.235	0.002
Temperament Traits				
Motor Ergonicity/ ERM	3.71	3.24	1.932	0.05
Intellectual Plasticity	5.88	6.60	-2.245	0.027
Motor Emotionality	6.51	7.33	-2.764	0.007
Motor Activity	38.20	23.53	6.136	0.000
Communicative Activity	18.86	20.46	-2.202	0.030

Total=250

Table 6. Means (Mode) of the EEG Power Spectrum in the Samples of Male and Female

Electrodes	Means (mode) of the EEG power spectrum (mV^2)		t	Sig. (2-tailed)
	Male (N=118)	Female (N=133)		
O2_A2	3.88 (2.40)	4.00 (2.74)	-0.442	0.659
O1_A1	3.26(1.53)	3.81 (2.48)	-2.117	0.035
P4_A2	3.22 (1.89)	3.76 (2.08)	-2.230	0.027
P3_A1	3.09 (2.06)	3.59 (2.02)	-2.631	0.009
C4_A2	3.29 (2.11)	3.69 (2.83)	-1.797	0.073
C3_A1	3.28 (2.16)	3.89 (1.91)	-2.732	0.007
F4_A2	3.76 (1.68)	4.67 (5.29)	-2.549	0.011
F3_A1	5.00 (2.53)	6.82 (5.10)	-2.100	0.037
Fp2_A2	5.49 (3.78)	6.12 (1.61)	-0.898	0.370
Fp1_A1	5.30 (1.37)	5.55 (3.05)	-0.420	0.675
T6_A2	2.74 (0.92)	3.47 (2.67)	-2.744	0.007
T5_A1	2.77 (1.35)	3.47 (2.36)	-3.114	0.002
T4_A2	3.06 (2.03)	3.91 (1.24)	-2.427	0.016
T3_A1	3.42 (1.92)	4.07 (2.12)	-2.397	0.017
F8_A2	3.77 (2.05)	4.20 (2.33)	-1.396	0.164
F7_A1	3.64 (2.99)	4.15 (3.62)	-2.263	0.024
Oz_A2	4.10 (2.34)	4.83 (5.81)	-1.922	0.056
Pz_A1	4.02 (2.57)	5.22 (2.23)	-2.062	0.040
Cz_A2	6.20 (1.05)	4.93 (2.40)	0.991	0.322
Fz_A1	5.32 (3.55)	5.57 (1.20)	-0.374	0.709
Fpz_A2	4.22 (4.28)	4.91 (2.68)	-1.521	0.129
FC3_A1	3.48 (1.91)	4.00 (2.11)	-1.990	0.048
Fcz_A1	3.56 (2.10)	3.86 (2.55)	-1.244	0.214
FC4_A2	3.31 (2.45)	3.77 (2.90)	-2.045	0.042
FT8_A2	3.04 (1.97)	3.95 (2.87)	-3.216	0.001
TP7_A1	3.02 (1.25)	3.50 (4.12)	-2.452	0.015
CP3_A1	3.16 (1.74)	3.66 (1.71)	-2.344	0.020
Cpz_A1	3.47 (1.86)	3.86 (2.92)	-1.287	0.199
CP4_A2	3.21 (3.81)	4.27 (2.12)	-3.585	0.0001
TP8_A2	3.43 (1.64)	3.75 (2.15)	-1.286	0.200

Df between groups =1; Df within groups = 249; Total=250

Table.7 Means (Mode) of the EEG Power Spectrum in Early, Middle, and Late Adolescence

Electrodes	Means (mode) of the EEG power spectrum (mV^2)			F	Sig. (2-tailed)
	Early Adolescence (N=92)	Middle Adolescence (N=123)	Late Adolescence (N=36)		
O2_A2	4.00 (2.74)	3.74 (2.46)	2.77 (1.27)	12.95	0.0001
O1_A1	3.81 (2.48)	3.29 (1.05)	2.35 (1.53)	15.711	0.0001
P4_A2	3.76 (2.08)	3.26 (2.08)	2.72 (1.88)	9.578	0.0001
P3_A1	3.59 (2.02)	3.07 (1.95)	3.01 (4.19)	8.408	0.0001
C4_A2	3.69 (2.83)	3.14 (1.91)	3.34 (1.72)	7.297	0.001
C3_A1	3.89 (1.91)	3.41 (1.91)	2.97 (2.61)	7.144	0.001
F4_A2	4.47 (5.29)	3.77 (4.16)	3.99 (3.48)	4.663	0.01
F3_A1	6.82 (5.10)	4.67 (1.04)	8.92 (1.44)	5.969	0.003
Fp2_A2	6.12 (1.61)	5.13 (1.09)	6.33 (1.20)	1.929	0.148
Fp1_A1	5.55 (3.05)	4.47 (0.83)	5.51 (1.06)	6.2	0.002
T6_A2	3.47 (2.67)	3.05 (0.61)	2.33 (0.76)	4.479	0.012
T5_A1	3.47 (2.36)	3.04 (2.76)	2.84 (2.06)	1.597	0.205
T4_A2	3.91 (2.36)	3.21 (0.96)	3.49 (1.27)	1.645	0.195
T3_A1	4.07 (2.12)	3.72 (2.66)	3.63 (1.03)	0.204	0.816
F8_A2	4.20 (2.23)	3.62 (1.35)	5.43 (3.86)	7.979	0.0001
F7_A1	4.15 (3.62)	3.82 (4.55)	3.36 (1.85)	3.448	0.033
Oz_A2	4.83 (5.81)	3.95 (2.06)	3.08 (2.34)	15.783	0.0001
Pz_A1	5.22 (2.23)	4.00 (2.44)	3.37 (2.18)	7.049	0.001
Cz_A2	4.93 (2.40)	4.60 (2.77)	11.32 (4.74)	7.147	0.001
Fz_A1	5.57 (1.20)	4.83 (1.58)	8.03 (1.54)	5.255	0.006
Fpz_A2	4.91 (2.68)	3.85 (4.28)	6.15 (2.68)	6.602	0.002
FC3_A1	4.00 (2.11)	3.62 (1.91)	3.42 (1.84)	1.817	0.165
Fcz_A1	3.86 (2.55)	3.46 (1.01)	3.31 (4.25)	5.372	0.005
FC4_A2	3.77 (2.90)	3.27 (2.90)	3.20 (2.45)	6.648	0.002
FT8_A2	3.91 (2.87)	3.42 (1.97)	2.78 (0.95)	3.692	0.026
TP7_A1	3.50 (4.12)	3.08 (1.61)	3.28 (1.25)	2.271	0.105
CP3_A1	3.66 (1.71)	3.38 (2.45)	2.80 (2.45)	3.869	0.022
Cpz_A1	3.86 (2.92)	3.35 (1.07)	3.05 (2.86)	6.401	0.002
CP4_A2	4.27 (2.12)	3.29 (3.81)	3.57 (1.34)	7.211	0.001
TP8_A2	3.75 (2.15)	3.24 (3.42)	4.52 (2.88)	6.171	0.002

Df between groups =2

Df within groups = 248

Total=250

Table 8. Means (Mode) of the EEG Power Spectrum in Respondents of Average and High Scores (23-24)

Electrodes	Means (mode) of the EEG power spectrum (mV2)		t	Sig. (2-tailed)
	ELO (1-22, scores)	ELO (23-24, scores)		
O2_A2	4.42 (2.46)	3.36 (2.93)	4.086	0.0001
O1_A1	3.56 (1.94)	3.41 (1.89)	1.722	0.086
P4_A2	3.35 (2.06)	3.35 (2.59)	0.669	0.504
P3_A1	3.52 (2.83)	3.48 (2.97)	-0.024	0.981
C4_A2	3.56 (1.91)	3.66 (3.31)	0.164	0.870
C3_A1	4.01 (4.16)	4.29 (1.10)	-0.423	0.673
F4_A2	5.26 (5.65)	6.83 (1.04)	-0.966	0.335
F3_A1	5.34 (3.78)	6.43 (1.09)	-1.800	0.073
Fp2_A2	5.86 (6.27)	5.12 (1.37)	-1.554	0.121
Fp1_A1	3.11 (1.36)	3.14 (0.99)	0.946	0.345
T6_A2	3.00 (2.41)	3.13 (2.06)	-0.109	0.913
T5_A1	3.22 (1.20)	3.87 (1.27)	-1.386	0.167
T4_A2	3.73 (2.05)	3.81 (0.94)	-1.827	0.069
T3_A1	3.65 (2.05)	4.44 (3.87)	-0.326	0.745
F8_A2	3.90 (3.62)	3.91 (3.54)	-2.538	0.012
F7_A1	3.90 (3.62)	3.91 (3.54)	-0.041	0.967
Oz_A2	4.86 (3.52)	4.02 (2.46)	2.227	0.027
Pz_A1	4.53 (2.44)	4.80 (2.18)	-0.451	0.652
Cz_A2	4.32 (4.10)	7.03 (3.26)	-2.115	0.035
Fz_A1	4.77 (2.79)	6.32 (1.54)	-2.315	0.021
Fpz_A2	4.34 (0.20)	4.89 (2.68)	-1.189	0.236
FC3_A1	3.65 (2.81)	3.88 (1.84)	-0.870	0.385
Fcz_A1	3.79 (2.94)	3.64 (2.55)	0.631	0.529
FC4_A2	3.46 (2.49)	3.68 (2.45)	-0.939	0.348
FT8_A2	3.70 (1.74)	3.30 (4.66)	1.395	0.164
TP7_A1	3.22 (1.25)	3.35 (1.81)	-0.645	0.520
CP3_A1	3.38 (2.21)	3.48 (2.45)	-0.451	0.653
Cpz_A1	3.80 (2.57)	3.53 (2.91)	0.899	0.370
CP4_A2	3.82 (2.44)	3.72 (1.34)	0.338	0.735
TP8_A2	3.29 (1.64)	3.98 (3.50)	-2.724	0.007

Df between groups =1
Df within groups = 249
Total=250

Table 9. Means of the EEG Power Spectrum (Mode) in Clusters

Electrodes	Means (mode) of the EEG power spectrum (mV2)				F	Sig. (2-tailed)
	Cluster 1 Inaccurate & Slow N=117	**Cluster 2 Inaccurate & fast N=68**	**Cluster 3 Accurate & slow N=38**	**Cluster 4 Accurate & fast N=28**		
O2_A2	3.82 (4.72)	4.71 (2.46)	3.35 (1.12)	3.42 (1.27)	4.994	0.002
O1_A1	3.60 (2.59)	3.72 (1.53)	3.17 (1.53)	3.45 (1.05)	0.614	0.607
P4_A2	3.48 (3.07)	3.80 (2.39)	3.18 (1.89)	3.32 (1.17)	0.995	0.396
P3_A1	3.33 (1.24)	3.59 (2.06)	3.02 (4.19)	3.30 (1.54)	1.152	0.329
C4_A2	3.48 (3.12)	3.66 (2.83)	3.44 (1.23)	3.30 (1.38)	0.315	0.815
C3_A1	3.77 (2.86)	3.52 (2.27)	3.34 (1.00)	3.50 (1.33)	0.682	0.564
F4_A2	4.11 (2.01)	4.29 (3.48)	4.31 (1.10)	3.61 (1.47)	0.693	0.557
F3_A1	4.86 (14.51)	7.20 (5.65)	8.34 (1.44)	4.32 (2.05)	3.881	0.01
Fp2_A2	5.04 (1.37)	7.16 (3.78)	7.22 (1.20)	3.89 (1.09)	4.186	0.007
Fp1_A1	5.04 (2.86)	6.07 (1.06)	6.80 (0.83)	3.70 (1.54)	3.148	0.026
T6_A2	3.09 (1.78)	3.18 (1.36)	2.99 (0.89)	3.32 (1.23)	0.148	0.931
T5_A1	3.15 (2.41)	3.19 (1.75)	2.89 (0.95)	3.32 (1.14)	0.358	0.784
T4_A2	3.35 (2.03)	3.58 (0.96)	3.71 (1.44)	3.74 (1.23)	0.269	0.848
T3_A1	3.65 (2.88)	3.88 (3.76)	3.79 (0.94)	3.92 (1.36)	0.205	0.893
F8_A2	3.57 (2.05)	4.16 (2.23)	5.41 (3.87)	3.51 (1.44)	6.176	0.0001
F7_A1	3.91 (1.00)	3.89 (3.62)	3.63 (1.62)	4.28 (1.56)	0.701	0.552
Oz_A2	4.57 (10.95)	5.20 (1.49)	3.46 (2.46)	3.80 (1.71)	3.352	0.02
Pz_A1	4.60 (1.67)	5.46 (2.44)	4.08 (2.05)	3.72 (1.88)	1.273	0.284
Cz_A2	4.00 (3.33)	7.23 (2.40)	8.60 (1.37)	3.60 (1.77)	3.084	0.028
Fz_A1	4.31 (1.20)	5.80 (2.79)	9.55 (1.79)	3.84 (1.54)	11.419	0.0001
Fpz_A2	4.37 (0.59)	4.70 (4.95)	5.61 (1.49)	3.84 (1.42)	1.565	0.198
FC3_A1	3.70 (2.02)	3.95 (2.11)	3.52 (1.84)	3.81 (1.64)	0.406	0.749
Fcz_A1	3.69 (2.94)	3.89 (2.12)	3.42 (1.22)	3.85 (1.38)	0.533	0.66
FC4_A2	3.44 (2.49)	3.74 (2.90)	3.74 (2.45)	3.35 (1.08)	0.647	0.586
FT8_A2	3.78 (2.78)	3.26 (1.74)	3.06 (4.66)	3.74 (1.16)	1.399	0.244
TP7_A1	3.26 (2.12)	3.09 (1.25)	3.50 (1.32)	3.50 (1.38)	0.797	0.497
CP3_A1	3.44 (1.74)	3.32 (2.45)	3.41 (1.10)	3.36 (1.06)	0.255	0.858
Cpz_A1	3.78 (3.19)	3.74 (2.91)	3.42 (2.97)	3.47 (1.77)	0.295	0.829
CP4_A2	3.76 (1.05)	4.23 (2.38)	3.34 (1.34)	3.35 (1.19)	1.563	0.199
TP8_A2	3.29 (3.32)	3.69 (2.15)	4.59 (1.51)	3.29 (1.17)	4.457	0.005

Df between groups =3
Df within groups = 247
Total=250

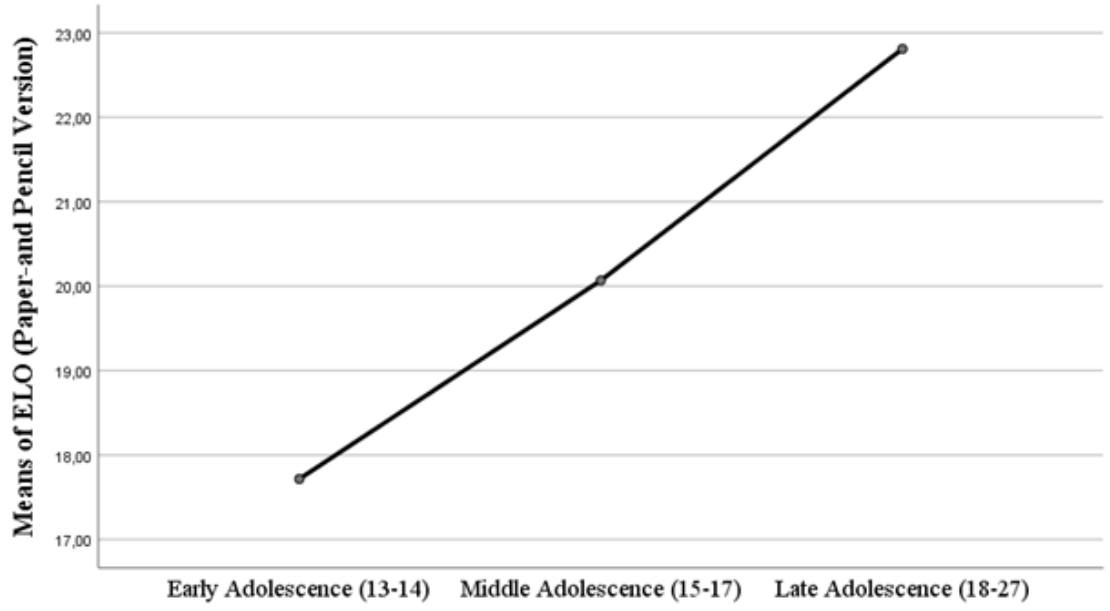

Fig.1. Age Dynamic of ELO (Paper-and Pencil Version), Scores

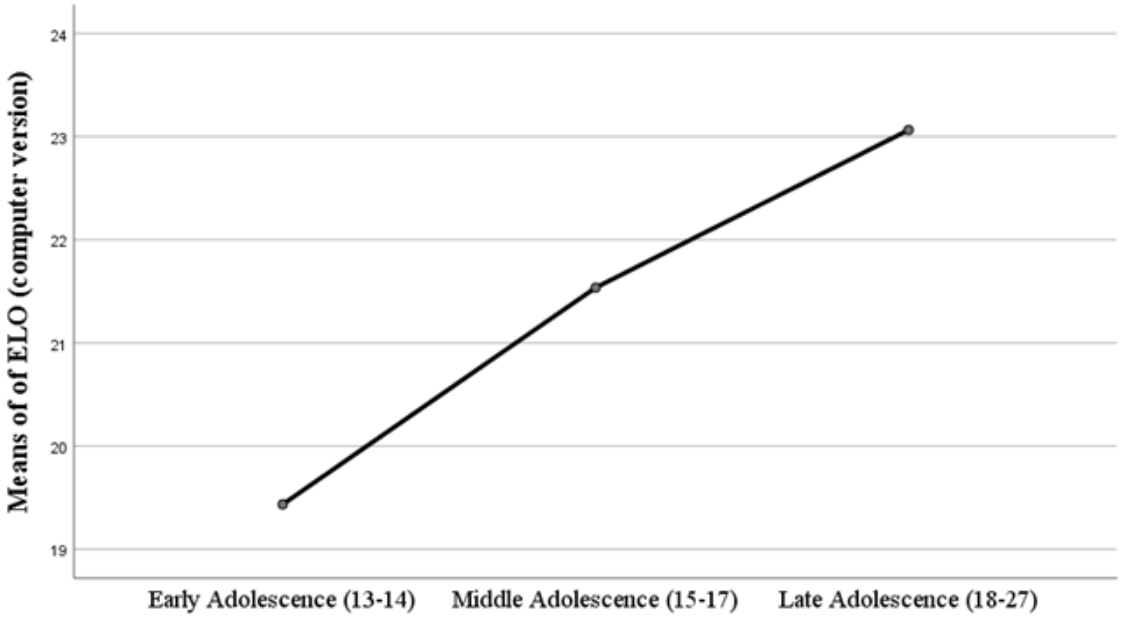

Fig. 2. Age Dynamic of ELO (Computer Version), Scores

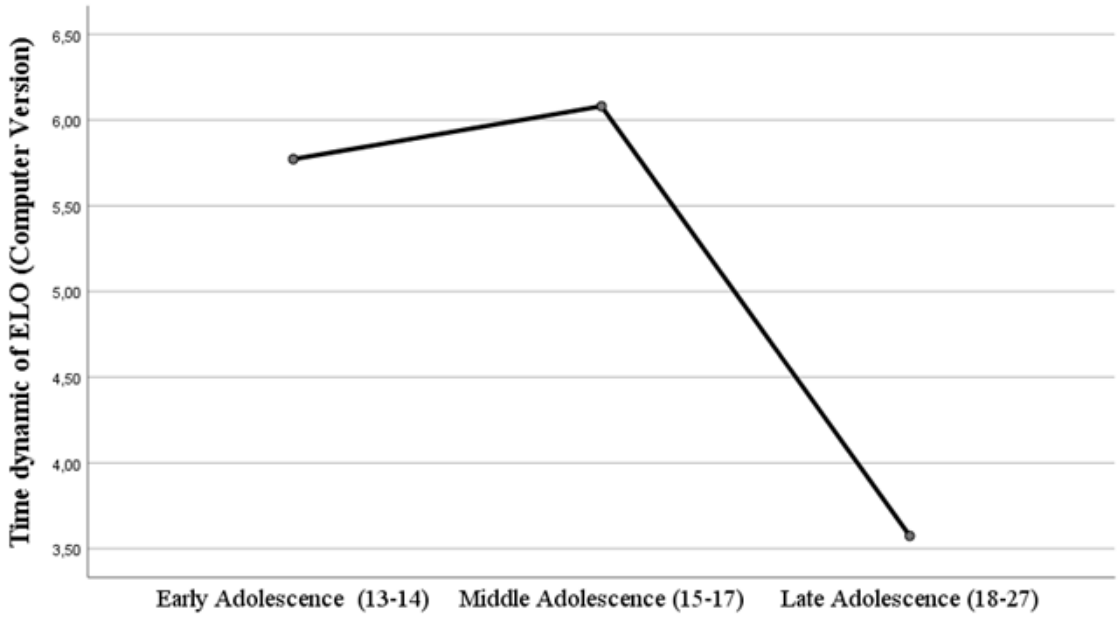

Fig. 3 Task completion time in different age groups of respondents (ELO, computer version)

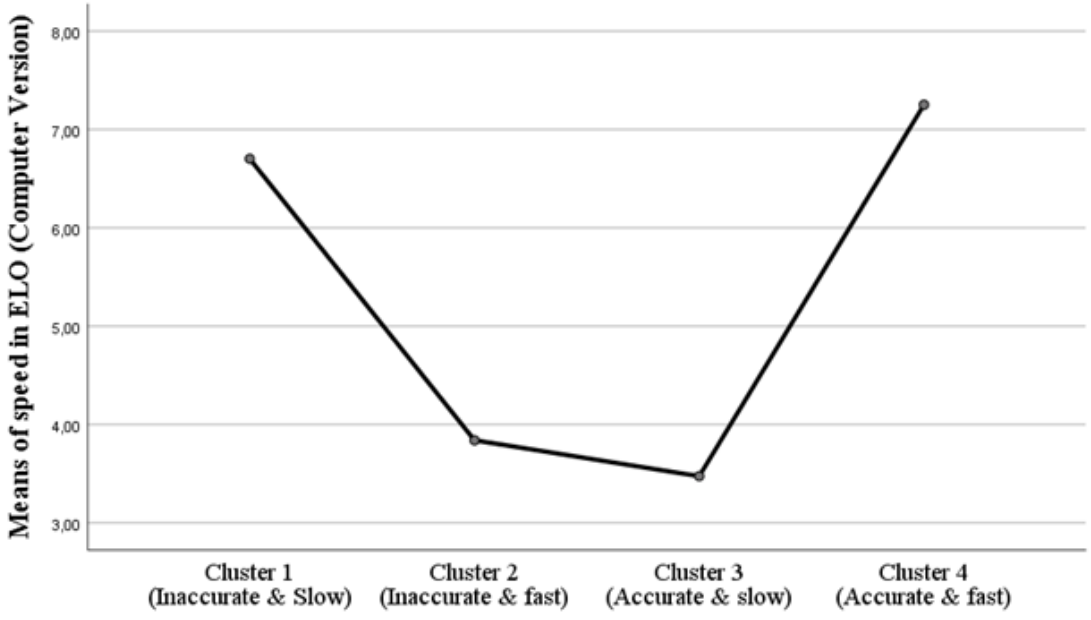

Fig. 4 Task completion time in different clusters (ELO, computer version)

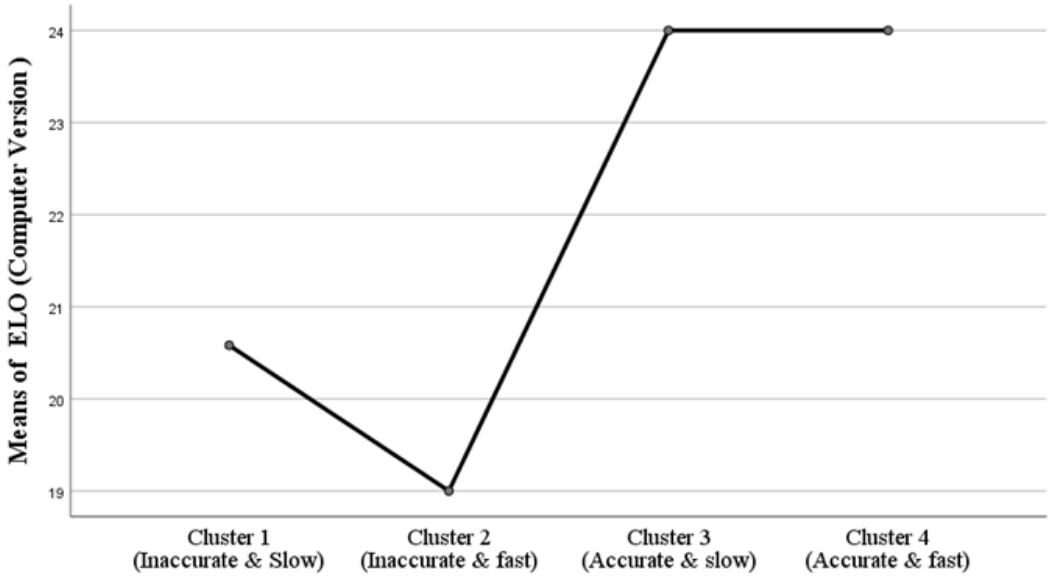

Fig. 5 Means of ELO (Computer Version) Scores in Clusters

Principle of Differentiation of Cognitive Structures as a Basis of Intellectual Development in Early Adolescence

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Abstract. The current article presents a program "I choose success!". The purpose of this program is conceptual thinking development in middle school students. The program "I choose success!" is designed in accordance with the principle of systems differentiation & integration of logical-semantic and verbal-semantic cognitive structures, which are the substratum of conceptual thinking. The four stages of conceptual thinking development are discussed. The exercises aimed at developing various aspects of conceptual thinking are described in detail, as well as the criteria for evaluating the performance of these exercises. "I Choose Success classes" are held twice a week.

A comparative formative experiment was carried out to test the developmental effect of the program "I Choose Success!". Students aged 11-12 were involved in learning experiment. It should be emphasized that the students of the experimental sample had lower IQs and experienced great difficulty in highlighting the main idea of the text compared to the students of the control group. The study used J. Vann 's group intelligence test and the author's conceptual thinking assessment tool.

Qualitative analysis showed that, at the end of the learning experiment, the initially weaker students of the experimental sample were twice as successful compared to the students of the control sample. Thus, the data obtained showed that the purposeful formation of differentiated logical-semantic and verbal-semantic cognitive structures affected the accuracy of highlighting the main idea of the text and led to the intellectual development of students.

Keywords: Cognitive Activity, Intellectual Development, Cognitive Structures, Principle of System Differentiation, Logical-Semantic Cognitive Structures, Verbal -Semantic Cognitive Structures.

1. Introduction

Issue of intellectual development of students is a current problem of modern education. Requirements to cognitive activity considerably increase when child enters to the first-grade.

In cognitive psychology the intellectual development is understood as purposeful formation at the child in the course of training of cognitive representative structures. The concept "representation" means "image", "display of one in another". In the context considered by us it is about formation of the internal psychological structures containing ideas of the outside world, of world "picture". These internal psychological structures are formed in the course of life and training in the mind of the person.

R. Solso notes that our ideas of the world are

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not necessarily identical to its valid essence. Of course, representation of information is connected with those its incentives which are received by our sensory device, but it is also exposed to significant changes. These changes or modifications are connected with our past experience of which the rich and complex network of our knowledge was the result. Thus, the arriving information abstracts (and it is to some extent distorted) and is stored then in the system of memory of the person. From this it follows that our internal representation of reality has some similarity to reality external, but when we abstract and we will transform information, we do it in the light of our previous experience [22].

The concept of cognitive representation is identical to a concept of the anticipating scheme in a certain way organizing and structuring the perceived material. According to U. Neisser [15], the anticipating schemes are cognitive structures which prepare the individual for adoption of information of a certain aspect and thus operate its current informative activity.

According to N.I. Chuprikova [23], cognitive representative structures contain the systematized various knowledge and ideas of ways of performance of different cogitative actions and ability of their practical application. They become means of cognitive activity of the child subsequently.

In practical psychology there is an idea of development of thinking of students "from above". It is connected with assimilation by school students of a system of scientific knowledge of whom ordered cognitive structures are result. All sum of knowledge acquired by students from concrete to abstract generalized is stored in these structures, at the same time cognitive structures begin to act as the instrument of knowledge and self-knowledge. Development of thinking of students "from above" represents assimilation of knowledge from the general to the particular. The hierarchy of cognitive structures is the course of process of intellectual development of the person in general [23].

Intelligent "instruments" of ordering, systematization and structuring knowledge allow the child most to pack the structured and interconnected system of knowledge in the head.

Zh. Piaget's theory is one of the most noticeable milestones in development of cognitive psychology. According to Piaget, in development of intelligence of the person it is possible to allocate four main periods of development conditionally: a stage of sensor-motor intelligence (from the birth up to 2 years); preoperational stage (from 2 to 7 years); stage of concrete operations (from 7 to 11 years) and stage of formal operations (from 11 to 15 years) [17].

The period from 7 to 11 years is followed by reduction of centration and egocentrism of thinking, development of ability of understanding of maintaining quantity, weight, volume, formation of a concept of time and space, growth of a possibility of classification and a seriation and many other things that is important to start school training. At this age at the child the ability to deductive conclusions, but with restrictions of a stage of concrete operations is formed. So, children are already capable to solve a syllogism, but only at visual presentation of its conditions. Or, for example, in a task on establishment of balance on a yoke of scales where it is required to consider two parameters (weight of cargoes and length of a shoulder), the child at a stage of concrete operations is limited by manipulation of only one system at present – either distance or its weight.

Upon transition to high school the demand of full and high-quality implementation of cogitative, analytical-synthetic activity as the complexity and volume of the studied disciplines grow increases. Changes of educational requirements and the nature of a training material can promote to a degree formation of abstract and logical forms of thinking at students. However, this process is spontaneous and unstable.

Researches of psychologists obviously show that transition from younger school age to teenage qualitatively changes thinking of the child: evident and figurative and initial forms of verbal thinking will be transformed to the hypothetic-arguing thinking which is under construction on the basis of high degree of generality and abstractness.

There were engaged in studying of this problem by L.S. Vygotsky [4], A.B. Zaporozhets [9], D. B. Elkonin [26], V.V. Davydov [8]. D.B. Elkonin noted that "at the beginning of teenage age children are sensitive to transition in educational activity to the new, higher level while for the teenager the sense of educational activity as activities for self-education and self-improvement" is revealed [26]. V.V. Davydov emphasized that "characteristics of this new type of the relation to the activity make ... important

psychological growths of this age, define reserves of its development" [7].

Already in middle forms of school the educational activity places more and more great demands on the level of development of abstract forms of thinking. Abstract and logical forms begin to be formed spontaneously due to the need to acquire a training material. Thus, the teenage age is the sensitive period for development of abstract and logical forms of thinking.

In modern cognitive psychology the idea of intelligence includes ability to isolate from a flow of information significant signs and properties of objects including abstract and also ability to operate with essential properties and the relations, separating them from insignificant properties and the relations. Therefore, the intelligence is the created representative and cognitive structures providing processing of all current information. And IQ of subjects is higher, while cognitive structures are internally more differentiated, hierarchically ordered and accurately dismembered [25].

N.I. Chuprikova understands the internal steady psychological systems of representation of knowledge as a result of extraction and the analysis of information as cognitive structures [24]. These are peculiar matrixes of all knowledge of the person of the world. The person takes information from the world around, imprints and puts it in storages of the memory in the form of the cognitive structures which developed at it. Cognitive structures develop in the course of human life as the system of intellectual processes of the analysis inherent in it and synthesis, abstraction and generalization.

The analysis of ontogenetic development of the informative sphere of the person showed that during intellectual development a universal principle of development of all organic systems is decisive. It is the law of development from the general to the particular, from whole to parts, from global, complete to dismembered and differentiated. It is the principle of system differentiation [23].

Extent of development of differentiation of cognitive structures directly corresponds to the level of intellectual development, mental capacities and I.Q. The intelligence represents ability to allocate and operate with essential abstract signs and properties of objects, their relations. At the heart of intelligence there is an ability of the person to form internally differentiated, well dismembered and hierarchically ordered representative cognitive structures. The level of their hierarchical orderliness is higher, the processing of the current information is carried out more precisely. Therefore, the level of intellectual development of the person is defined by the level of formation of representative and cognitive structures.

The essence of the principle of differentiation is that the simple, badly dismembered, indistinct, global structures are gradually differentiated in highly dismembered, complex developed and hierarchically ordered cognitive structures. This process is carried out repeatedly and provides the wide and deep, flexible and many-sided analysis and synthesis of reality. Development of cognitive structures can metaphorically be presented in the tree form with more and more branching crown: the cognitive internal psychological structures are more hierarchically dismembered, the crown is more magnificent, the I.Q. of the person is higher.

The idea of the principle of differentiation is studied in philosophy, psychology and physiology long ago. It is the defining, leading principle of development in a number of theories. Its action is visually shown in the most various spheres of intellectual development. In G. Hegel's theories [5], theories of I.M. Sechenov [21], A.A. Potebnya [19], Zh. Piaget [17] and some other the central place is allocated to the principle of differentiation. In modern cognitive psychology the authors assign a leading role to the principle of differentiation in development of intelligence (E. Gibson [27], K. Nelson [28], V.I. Beltyukov [1], H. Witkin [29] and a number of other authors).

The research object is to study conditions of formation of logical-semantic and verbal and semantic cognitive structures at the studying middle school.

Research hypothesis: to show a role of formation of the differentiated logical-semantic and verbal and semantic cognitive structures as the factor influencing understanding of texts.

According to the purpose and the hypothesis of the research the problem of an experiment was defined: to study influence of the organization of the necessary psychological conditions promoting formation of the differentiated logical-semantic and verbal and

semantic structures, defining understanding of the text by students of middle school.

2. Materials and methods

2.1. Participants

47 students of the 5th classes of 11-12 years, from them 19 boys and 28 girls participated in the study.

Definition of groups of participants of a research was carried out by the results of group diagnostics at the end of the 4th class. The Group intellectual test of J. Vann (GIT) [20] was offered students. Application of GIT allows to determine the level of formation of verbal and logical thinking.

The students of the fifth class having low indicators of the level of development of mental abilities were defined in experimental group (23 people), students of a strong 5th class – in control group (24 people).

In addition at the beginning and at the end of the 5th class the students of EK and KK wrote statement in K.D. Ushinsky's text "Two plows" and defined the main thought of the text.

2.2. Procedure

Within academic year training classes were held with the students of EK classes 2 times a week. The studies were given in the program by N.G. Klashchus, E.M. Kobzeva "I Choose Success! " on prevention of school desadaptation of students of younger teenage [10]. The program consists of 36 classes and in practice realizes the principle of system differentiation which represents the fundamental mechanism of development of mentality, according to N.I. Chuprikova [24].

Main objective of training in the program "I Choose Success!" is purposeful formation of the verbal and logical cognitive structures which are carrying out irregular shapes of intellectual activity and, first of all, abstract, abstract thinking.

The system of the exercises presented in the program contributes to the development as thinking (its separate processes and qualities), and other psychological processes – imagination, attention, the internal plan of action, spatial representations. Exercises on development of the informative sphere are generally borrowed from N.P. Lokalova's program [14].

Other not less important areas of work with teenagers according to the program "I Choose Success!" are development of the communicative sphere and increase in efficiency of methods of educational activity, their improvement.

The main principle in holding psychological classes is the correct performance of tasks by all students, working off of each exercise. It is important to achieve the correct performance of tasks by all students even if more time will be required for it more than it is provided by this program. For this purpose the program included tasks for self-dependent work of school students which are checked by the psychologist and further they are discussed at the next psychological classes.

Formation of the differentiated logical-semantic and verbal and semantic cognitive structures in students according to the program "I choose success!" begins with the work on a word. At the beginning of the classes, tasks for inclusion of any one word in different statements are offered students. These therefore words become elements of various semantic structures. In exercise "Three words" school students need to make as much as possible offers including these words.

Example: Make as much as possible offers of three words. It is possible to change cases and to add other words.

SCHOOL DESK, SKY, APPLE

In the Make Words task the word is a complete structure in which it is necessary to allocate separate components – to make as many as possible words of letters of this word.

Example: *Make as much as possible words of the letters entering the set word. The made words have to be nouns in the Nominative case of singular. It is impossible to add other letters.*

POWER PLANT

Work with anagrams in exercise "Guess the words" permits understanding about integrity of external structure of a word and change of elements can result words in its distortion.

Example: Decipher the offered words and write down them.

TREMASINT, KURINOS, UPECHAH

In exercise "Explain the Greek words" students define value of the Greek roots, suffixes and prefixes and call from them derivative words. A problem of exercise is in awareness of structure of a word, differentiation of structural and semantic characteristics.

Example: Below the Greek roots of words and a prefix are given. Define their value and write

derivative words with the same combinations of letters.

PHONE - …, HYPER - …, AVI - …

In further work with words synonyms and words antonyms the differentiated dismemberment of external and internal forms of a word is made. And, at first students choose synonyms and antonyms from two columns of ready concepts (exercise "Choose synonyms and antonyms"), and further – select them self-dependently (exercise "Pick up synonyms and antonyms").

*Example: To words at the left in a column **A** self-dependently select and write down a number of words having similar value (synonyms).*

*To words at the left in a column of **B** self-dependently select and write down a number of words having opposite value (antonyms).*

A	***B***
Chill	*A- pupil*
Artist	*Arrival*
Honest	*Often*

The following direction is the work with an internal form of a word. It begins with exercise on differentiation of essential and insignificant signs of concepts (exercise "Essential and insignificant signs").

Example: In each subject or an event it is possible to mark out the main and minor, essential and insignificant signs. You need to define and write essential and insignificant signs of objects.

Significant fiature	***Not significant fiature***
HOURS	

Later tasks are held for understanding of phraseological units and proverbs (exercises "Explain phraseological units", "Pick up proverbs"). They are fulfilled to develop processes of the semantic analysis. Tasks for selection of the proverbs perform the same sense, but different subject contents promote understanding and differentiation of deep meaning of statements and its concrete verbal expression.

Example of exercise "Explain phraseological units":

*Write down value of the following phraseological units: **Crestfallen; And none will be the wiser; Like water off a duck's back; To Disappear into thin air**.*

Example of exercise "Pick up proverbs":

Pick up to the proverb located at the left such proverb from the right part which would be close to it on sense expressed a similar main thought. In an empty column write figure of the corresponding proverb at the left

1	*Fallen in water there is nothing to be afraid of a rain.*		*At first burden, then rest*
2	*Business before pleasure*		*It's no use crying over spilt milk.*
3	*Curve firewood also directly burns.*		*Cut inconsistently out and strong sewed.*

At the end of the program the students are offered to pick up the Russian analogs to proverbs and sayings of the people of other countries in exercise "What is it in Russian?".

Example: Pick up the Russian analogs to proverbs and sayings of the people of other countries.

***French proverb:** Who goes slowly, that will precisely reach. **English proverb:** It is more than haste, it is less than the speed.*

Some tasks demand to express in different ways the same thought, the same subject contents in the “Put Different Into Words” task.

Example: Transform offers, using other words so that the initial sense remained.

PUSHKIN IS MY FAVOURITE POET

Further throughout four classes the school students carry out exercises "We compare concepts" during which they define the relations between concepts when the narrow concept completely enters more general, concepts intersect, coincide or are various, opposite,

contradict each other on sense or correspond as a part - whole or whole - a part. In conclusion of this thematic block children practice in distinction of the relations between the concepts "generalization-a specification" and "whole - a part".

Example: On the previous classes we divided concepts into groups, today we will compare them among themselves, to define in what relations they are. Let's use for descriptive reasons schemes in the form of circles.

The psychologist sorts together with students and writes down examples and schemes (fig. 1) on a board, and then students carry out exercise in a workbook, defining the relations and fixing the scheme between concepts.

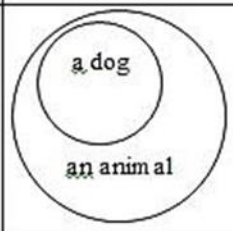
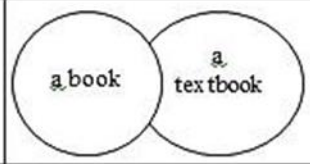
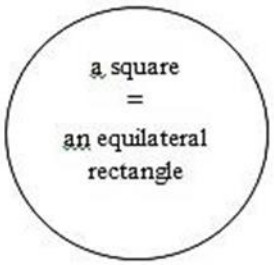
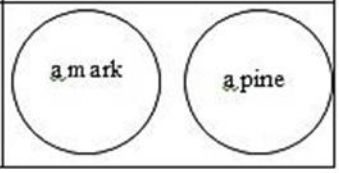
The name of the concepts' relations	Examples	Schema
A narrow concept **entirely** enters into more general and wide concept	A dog – an animal	
The concepts **intersect**	A book – a textbook	
The concepts **coincide**	A square – an equilateral rectangle	
The concepts **differ**	A mark – a pine	

Fig. 1 Example of the exercise "Compare concepts"

Define the relations between the following concepts:

the enemy – the enemy, positive numbers – integers, an ant – an insect, addition – an insect, a riddle – a puzzle, J. Rodari is the author of Cipollino, a seal – a mammal.

After students performed a task and collectively on a chain sorted each couple of words, further they perform self-dependent work which shows difficulties and extent of understanding, digestion of new material at each pupil. Self-dependent work is checked by the psychologist and on the next class analyzes.

Special complexity in a series of tasks for comparison of concepts the generalization specification and a part - whole causes definition of the relations. In this regard we entered the additional class fulfilling differentiation of these communications.

Example: Define the relations between concepts: generalization, a specification, a part - whole or whole - a part: ***the house – a wall, a root – a tree, a rain – precipitation, the child – the boy, an insect – a bee, coal – fuel, a shovel – a shank.***

Integration of the significant communications allocated with the analysis between words,

formation of the formal and logical structure revealing this internal communication results.

On the basis of the worked over material the students pass to definition of a type of judgment (all-affirmative, all-negative, partially-affirmative, partially-negative) (fig. 2).

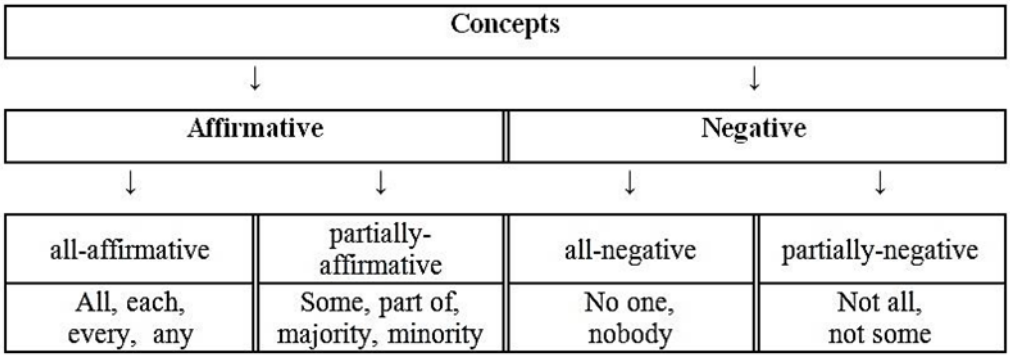


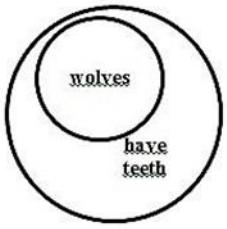
Fig. 2 «Judgment Types» table

Example: Define a type of judgments of the following offers and emphasize the words indicating a type of judgment:

- *All Russians are the Slavs.* _____
- *Some school students learn French.* _____
- *Some lions are not trained.* _____
- *The majority of lakes in deserts are salty.* _____

Throughout five next classes the students carry out formal transformations of judgments in exercises "Change a form, without changing contents". On each class rules of transformation of judgments are considered when the psychologist conducts students on a certain algorithm, suggesting them to define self-dependently a type of judgment, to allocate concepts and the attitude (fig. 3) between them.

The psychologist: The first sentence: "All wolves have teeth". What type of judgment is it? (A.A.) What concepts are here? (Wolves, have teeth) What is the attitude between these concepts? (Small concept entirely enters the large one) Picture the scheme.



The first type of transformation of judgment is all- affirmative in partially-affirmative. What words do point at partially-affirmative judgment? (Some, majority, minority) Formulate partially-affirmative judgment using this concept: Some having teeth are wolves.

Fig. 3 Fig. 3. Example of the reasoning in the exercise «Change Shape Without Changing Content»

Thus on classes there is a work on transformation of judgments: all-affirmative is in partially-affirmative, all-affirmative is in all-affirmative, partially-affirmative is in all-negative, partially-negative is in partially-affirmative, partially-affirmative is in partially-negative, etc. At the end of each task the students surely perform self-dependent work. They think out the examples of transformations.

At final lessons the students carry out conclusions, being based only on their formal and sign features in the tasks "We Learn to Reason". For this purpose they allocate premises, conclusions and the purpose of a reasoning, carrying out various inductive and deductive conclusions available to them.

Example: *All frogs are amphibians.*

All amphibians are vertebrata.

?

What conclusion can be drawn from these premises?

Let's designate each premise by letters: *All frogs (A) are amphibians (C).*

All amphibians (B) are vertebrata (C).

Deduction: *All frogs (A) are vertebrata (C).*

Thus, we receive new knowledge: All frogs are vertebrata.

Leaving only alphabetic symbolical record, we receive:

All A - B

All B – C

All A - C

Further it is offered to students, using record in a symbolical form, to solve logical problems with inequalities.

Example: Ann is as old as Kolya. Kolya is as old as Tanya. Are Ann and Tanya of the same age?

Volodya plays chess better, than Seryozha. Kolya plays chess worse, than Seryozha. Therefore Volodya plays chess better, than Kolya. Is a conclusion correct?

Throughout the next two classes the students define correctness of conclusions, solving a problem in several actions (fig. 4).

Problem	Solution
All water-melons (A) like to play tennis (B). Some beetles (C) have clocks (D). All beetles like to play tennis. Therefore, some water-melons have clocks. Answer: Correct.	**Solution statements:** All A - B Some C-D All C- B Some A-D (?) **Action 1:** All A - B All C- B All A - C **Action 2:** All A - C Some C-D Some A-D

Fig. 4. Example of the exercise "Learn to Reason"

Methods

For the purpose of determination of level of formation of verbal and logical thinking the Group intellectual test was applied [20]. GIT was developed by the Slovak psychologist of J. Vann. It is also adapted in laboratory of psychological diagnostics and correction of Psychological Institute of Russia joint stock company for Russian-speaking sample by group of authors: M.K. Akimova, E.M. Borisova, V.T. Kozlova and G.P. Loginova. The GIT test reveals how the pupil seized the words and terms offered in test questions and also abilities to perform some logical operations. All this characterizes the level of intellectual development of the pupil.

GIT is the reliable, valid, well proved in practice of school test. The test is developed in two forms (A and B) which are checked for interchangeability. Strictly limited time is allowed for implementation of each subtest. For estimation of individual results the concept of empirically marked out age norm is used. GIT is intended for students of the 4-6th classes.

The test consists of six subtests and 160 tasks.

The first subtest "Execution of Instructions" (20 tasks) is directed to identification of speed of understanding of simple instructions and their implementation, defines formal dynamic characteristics of course of verbal thought processes. The effectiveness of implementation of this subtest depends on high-speed opportunities of intellectual activity, i.e. lability of nervous system.

Example Cross out the biggest of the following numbers: 2 4 8 6 also draw two circles between the following two names: Shura _____ Yura. Read attentively following words: fruit mushrooms tree morning. Cross out a penultimate letter in the fourth word and the second letter in a penultimate word.

The second subtest "Arithmetic Tasks" (20 tasks) diagnoses formation of mathematical knowledge and actions which are acquired in the course of training. It reveals ability to be guided in statements of the problem, ability to the mathematical analysis and synthesis, logical conclusion and mathematical generalization that does not allow to consider this subtest only an achievement quotient to mathematical skills. It is confirmed also by numerous results of diagnostics by the lowest level of performance of tasks according to all test. A peculiar "failure" of performance of tasks according to subtests, and almost independent of a parallel and type of school (at specialized mathematical schools the level of implementation of the subtest though above, than at usual schools, however below, than other subtests).

Example: How many students are in the city having 20 schools. Each school has 10 classes. Each class consists of 25 students?

How many balls can be bought for 16 rubles if 3 balls cost 4 rubles?

In two herds there are only 35 cows. A big herd has 7 cows more, than a small one. How many cows are in small herd?

The third subtest – "Addition of sentences" (20 tasks), estimates understanding of meaning of separate sentences, development of language skills, ability to operate with grammatical structures. It depends on a lexicon of students.

The analysis of this subtest shows level of proficiency in the speech as thinking tool. As for the correct reconstruction of the deformed sentence it is necessary not only to understand what it is about, but also it is necessary to write

correct words or phrases and to use the necessary terminations, cases, pretexts. The high level of development demonstrates the competent use of necessary words or phrases.

Example: The child can be _____ a boy, or _____.

_____ the _____ is good tomorrow, I will go to bathe.

Tasks of the fourth subtest "Determination of Similarity and Distinction of Concepts" (40 tasks) define abilities to analyze concepts, to compare them on the basis of allocation of essential features; formation of operation of comparison and awareness in concepts of different contents.

Example: internal - external; mean – honest belongings – property; to allow – to forbid; similar - various

The fifth subtest "Numerical Ranks" (20 tasks) reveals ability to find logical regularities of creation of mathematical information, analytical-synthetic mathematical abilities, practically without involvement in process of the solution of verbal structures.

Example

9	*4*	*8*	*4*	*7*	*4*
2	*5*	*8*	*11*	*14*	*17*

The sixth subtest "Establishment of Analogies" (40 tasks) diagnoses ability to think by analogy. It defines the level of development of operation of generalization and the analysis of the logical relations, the level of development of verbal thinking, shows potential opportunities of the pupil, dynamics of age changes.

Example:

mouth	*: person*	*=heel*	*: the person a leg to go a body*
February	*: March*	*=Tuesday*	*: Sunday month Wednesday week*
carrots	*:vegetables*	*=violet*	*: dandelion flowers valley odorous*
warehouse	*: goods*	*=clothes*	*: club cloakroom attendant a coat theater*
fish	*: water*	*=bird*	*: tail insect worm air*

The intellectual test was carried out by students at the end of the 4th class for the purpose of definition of control and experimental group, and at the end of the 5th class to determine dynamics of development of verbal and logical structures.

For the purpose of determination of level of determination of level of allocation of the main thought we used the story by K.D. Ushinsky "Two plows". It is small on volume and finished according to the contents (see below).

At the beginning of a year the teacher at first read to students the text orally. Then the text was distributed to everyone for performance of analyses: phonetic, morphemic, morphological, syntactic, punctuation and lexical. In lexical analysis according to the explanatory dictionary examined the words "merchant" and "plow". After performance of analyses the students handed over the text.

Further on a board wrote down the plan of the text made collectively, and fifth-graders wrote down the main idea of the text.

Then the teacher read the text the second time, and after that children wrote statement.

In the end of the year, during the repeated work with the text, the teacher read the story, made and wrote the plan of statement, wrote down the main idea of the text and worked on statement.

TWO PLOUGHS (According to K.D. Ushinsky)

Two plows were made of the same piece of iron in the same workshop. One of them fell into hands of the farmer and immediately went to work. Another one long and absolutely useless laid around in a shop of the merchant.

It happened so that in several years both fellow countrymen met again. The plow of the farmer shone as silver. It was even even better than when it just left a workshop. And the plow which lay without any matter in a shop darkened and became covered with rust.

— Tell, please, why you shine so much? — asked the rusted plow the old acquaintance.

That answered:

— From work, my the friend. And you rusted because all this time lay on one side and did nothing.

Results

For the purpose of determination of the relevant level of development of mental abilities the students of experimental and control classes carried out the Group intellectual test of J. Vann.

By results of diagnostics which is carried out at the end of the 4th class school students of experimental and control group were defined. Repeated diagnostics was carried out at the end of the 5th class for the purpose of tracking dynamics of level of intellectual development. Data of entrance and repeated diagnostics are presented in tab. 1.

Table 1

Indicators of dynamics of level of intellectual development of students of EK and KK, in %

	Age norm		**Below norm**		**Low level**		**Very low level**	
	4 C.	5 C.	4 C.	5 C.	4 C.	5 C.	4 C.	5 C.
EK	30.4	56.5	34.8	26.1	21.7	17.4	13.1	0
KK	62.5	58.3	20.8	25	16.7	16.7	0	0

When writing by students of the main idea of the story by K.D. Ushinsky "Two plows" the ability to formulate the main thought of the text was determined.

In the research of Lokalovy N.P. [13] conducted with students of elementary school 8 stages of development of the verbal and semantic analysis were allocated: "there is no answer", "echolaliy", "heading – without interpretation / with interpretation", "syncret", "plot", "the beginning of differentiation of sense", "full differentiation of sense".

In our research at students of the 5th classes it was not selected types of statements of the main idea on the three first stages ("there is no answer", " echolaliy " and "heading") and also "plot". However instead of "plot" we allocated a stage "a transitional stage"

Further examples of answers of students on the revealed stages of development of the verbal and semantic analysis are given.

Syncret is incorrectly understood separate phrase, or the wrong retelling with introduction of own contents: *"If you work, then you will be beautiful, hardworking and if you lie on one side, you will not notice how there will pass time", "If the thing is unused, it becomes unnecessary and rusty. The same and with the person. If he works hard, his body looks good, and if not, then it will rust", "If you do not work, you will get soon to a hole of which you will hardly be able to get out".*

"Plot" as more or less full statement of contents of the work is not revealed in our research. A part of statements of the main thought of students do not approach under this category. They are intermediate, kind of pass from the syncret to the beginning of differentiation of sense. The main thought is included in contents, it is expressed not generally, specifically, but has analysis rudiments. It is possible to carry the following statements to "a transitional stage": *"You will lie – you will rust and if you do something, you will not rust", "If you work, then you will shine and if you are lazy – you will appear" in dirt, "If you are unused or shirk work, it is possible to achieve nothing and to remain to rust".*

"The beginning of differentiation of sense" is a short retelling of the text or a part of the text and the generalizing statement of the main idea: *"One plow worked. Another one didn't work so the second plow rusted and the first plow began to shine. The author wanted to tell that it is always necessary to work", "The lazy person will lie, he will achieve nothing. And if the person works, he will achieve everything", "If the person is engaged in some business, he will become interested and will receive result. And if the result is good, then the person will "shine" with joy. Also it happened to one of plows".*

"Full differentiation" - the main thought is formulated correctly and generally: *"Without effort you will not catch also a small fish from a pond", "Work decorates the person, and the laziness spoils", "If you work, then you will improve yourself and it you shirk you will ruin yourself".*

Quantitative processing of the received results

was carried out on a number of statements (in %) in an experimental class and control at the beginning and at the end of academic year. These researches are presented in table 2.

Table 2

Indicators of statements of the main idea of the text at fifth-graders of EK and KK at the beginning and the end of academic year, in %

	Syncret		**Transitional stage**		**Beginning of differentiation of sense**		**Full differentiation of sense**	
	beginning of the year	end of the year	beginning of the year	end of the year	beginning of the year	end of the year	beginning of the year	end of the year
EK	34.8	13	34.8	21.7	17.4	34.8	13	30.5
KK	12.5	12.5	29.2	33.3	33.3	29.2	25	25

Discussion

Apparently from the table 1 "Indicators of Dynamics of Level of Intellectual Development of Students of EK and KK", in the 4th experimental class 30.4% of the students meeting age standard of intellectual development were defined; in the 4th control class – 62.5%. After training in experimental group the percent of students with age norm increased almost twice, to 56.5, and in a control class – decreased a little, to 58.3%.

Rates below norm in an experimental 4th class were 34.8%, in the control class rates were 20.8%. In the 5th experimental class the percent of school students with the level of intellectual development below norm decreased by 1.3 times, to 26.1%, and in the 5th control class the level increased a little, up to 25%.

The low level of development of intelligence in the 4th experimental class was 21.7%, in control it was 16.7%. After work on the program "I Choose Success!" in an experimental class the number of school students with the low level of development decreased to 17.4%. In a control class indicators were without changes.

Students with very low level of intellectual development of 4 class were only in experimental group and made 13.1%. In the 5th class there were no school students with very low I.Q. neither in control, nor in experimental group.

Indicators of dynamics of intellectual development of school students (tab. 1) demonstrate that the purposeful, systematic, specially organized cognitive development which is carried out on the basis of the law of system differentiation provides increase in level of intellectual development of students almost twice.

According to the table 2 "Indicators of a Statement of the Main Idea of the Text at Fifth-graders of EK and KK at the Beginning and the End of Academic Year" it is visible that at the beginning of a year of the statements relating to a stage syncret, it was defined in an experimental class of 34.8%, in a control class it was 12.5%. At the end of the academic year in EK the number of syncretic statements decreased by 2.5 times and made 13%, and in KK 12.5% remained at the same level.

The statements relating to a stage of a transitional stage in an experimental class at the beginning of a year made 34.8%, and in the end of the year their quantity decreased by 1.5 times, to 21.7%. In a control class the small increase from 29.2% to 33.3% is observed.

Stage indicators "The beginning of differentiation of sense" at school students of an experimental class increased twice, from 17.4% to 34.8%, and in a control class the small decrease from 33.3% to 29.2% is observed.

At the beginning of a year indicators of the statements corresponding to a stage "Full differentiation of sense" at school students the experimental group was twice less (13%), than at students of control group (25%). On completion of the forming experiment the percent of students of EK increased by 2.5 times and made 30.5%. At students of KK – remained at the same level, 25%.

Dynamics of the received results (tab. 2) shows positive changes at students of EK in development of a system of the verbal and semantic analysis. They not only caught up with students of a control class, but also surpassed them.

The data provided by us allow to reveal conditions of formation and dynamics of development of the differentiated logical-semantic verbal and semantic cognitive structures influencing understanding of texts by fifth-graders.

Conclusion(s)

During purposeful and systematic cognitive influence the students have a formation of a system of the thought processes promoting assimilation, ordering and systematization of knowledge.

Feature of our experiment is that classes were organized with the weakest class in a parallel. The correctional developing work was carried out 2 times a week out of a schedule grid with all class. Frequency of classes, integrity of collective of a class, performance by school students of self-dependent tasks and a certain operation algorithm of the psychologist with students when performing tasks on formation of logical-semantic and verbal and semantic cognitive structures are necessary psychological conditions of carrying out the correctional developing influence.

Data of the presented experiment unambiguously demonstrate that the purposeful cognitive influences organized in a certain way contribute to the intellectual development of students, form bases of complete system thinking, provide the best understanding of the text and allocation of the main idea of the text. If not to make specially organized cognitive impacts, then there is a partial decrease in the beginning of differentiation of sense and increase in a transitional stage.

Thus, our research confirmed a hypothesis that the main condition leading to the best understanding of texts is the general intellectual development of students, formation at them the differentiated grids of the logical-semantic relations of concepts in which their knowledge of the world is presented.

According to N.I. Chuprikova [24], purposeful development of processes of the analysis and synthesis leads to increase of selectivity at implementation of cognitive activity and to increase in level of intellectual development in general.

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BOOK REVIEW

Tolochek V.A. (2020/2021). Labor Psychology & Technologies of professional selection. M.: Publishing house "Institute of Psychology RAS"

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Abstract. The review analyzes the content of two textbooks by V.A. Tolochek "Labor Psychology" and "Technologies of professional selection". The structure of the books and the content of the material presented by Russian and foreign authors are compared. The features of the reviewed textbooks by V.A. Tolochek solving the problems of the actual future, on the psychological support of the subject throughout his life.

***Key words*:** labor psychology, professional selection, methodology, subject, tasks, technologies, human resource management.

In 2021, the next reprints of two books by V.A. Tolochek were published. In view of the fact that they reprinted six times – "Labor Psychology" [17; 18; 19; 20; 21; 22] and four times "Technologies of professional selection" [22; 23; 24; 25], their publication is a reason to pay attention to them and consider them as the "focus" of a number of disciplinary problems.

We single out two reasons: 1) Initially, in the 1970s, when psychology as a discipline was still at the stage of its formation, more precisely, when it was being restored after the memorable decree of 1936, it was extremely difficult to collect and combine in one book the rather meager material of domestic scientific research. practical work and the then still inaccessible experience of foreign scientists (not counting the stage of openness of science at the beginning of the 20th century). 2) Later, at the turn of the XX-XXI the subject area of the discipline began to expand dramatically (covering new areas of human activity, new scientific and practical problems, borrowing the concepts of related sciences), which also makes it difficult to review and cover them in one book by one author. So, in the 1970s-1980s, only recognized authoritative scientists undertook the experience of writing a textbook [5; 11]. And if in other disciplinary areas of psychology we find a lot of author's concepts and experiences of writing textbooks (on general psychology, personality psychology, psychophysiology, developmental, social psychology, organizational, etc.), then in relation to the labor psychology, a similar presentation of many concepts by Russian scientists and options there are almost no textbooks, which can and should also become a separate topic of serious discussion.

But even in the 1990s-2000s, one can speak mainly about the books of scientific groups of some leading universities [6; 13; etc.], about a more active specialization of scientists in certain areas of labor psychology and their presentation of individual fragments of the discipline [1; 3; 4; 7; 8; 10; 12; 15; 27; 28; etc.], than about their desire to integrate scientific knowledge and reduce it to some "invariants", to a generally recognized factual basis, on the one hand, integrating the achievements of the discipline for about a century and a half, on the other hand,

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reflecting the scientific positions of Russian and foreign specialists.

It can be assumed that Russian scientists have "problems" both in relation to the tasks of the first part, and in relation to the second. This is indirectly evidenced by the volume of textbooks, rarely reaching 200-300 pages. Accordingly, many important issues (professional selection, labor motivation, certification, etc.) are covered extremely sparingly, others are simply not considered (career management, human resource management, retraining and etc.). This can be partly explained by the fact that a number of important issues of managing the activities and behavior of an employee in Russian textbooks are "assigned" to another discipline – the psychology of organizational development, which, nevertheless, does not remove the need for a holistic coverage of the main aspects of the activities, behavior and life of a person conducted by him. in labor processes and within the walls of an enterprise, organization.

The extremely uneven history of the development of Russian psychology, incl. Labor psychology (psychotechnics), during the XX century is indeed a serious factor hindering a holistic coverage of disciplinary problems. The accelerating historical evolution of social societies and the organization of social production at the turn of two centuries also act as a very serious circumstance that makes it difficult to conduct a proper analysis of scientific and scientific-practical experience.

Comparing the approaches of Russian authors [5; 10; 11; 13] and foreign authors of textbooks [2; 9; 14; etc.], we note that foreign scientists are approximately equally successful and regularly act both as mono-authors and co-authors; the volume of their books is much larger (about 40.0-45.0 pp), which makes it possible to reveal each section in more detail, provide extensive illustrations with examples, tables, and graphs; The scope of the topics discussed is usually wide and includes an analysis of both the typical features of the internal environment of the organization and the external environment, issues of performance evaluation and human resource management. Textbooks by foreign authors, as a rule, include detailed descriptions of methods for studying the activity and personality of an employee, assessing his work, issues of his retraining and professional health, design of tasks and jobs, typical work modes, and many others. [2; 9; 14].

Against the background of the extremely modest experience of writing Russian textbooks, let's consider two of them. As a rule, when writing textbooks, authors are guided by their own work and the results of research by their closest colleagues, representatives of one scientific school. In this regard, the characteristic features of the books under review by V.A. Tolochek and, probably, explaining their "viability", a wider panorama of coverage of the subject, tasks, scientific approaches; critical analysis; designation of the contours of development prospects, etc.

The logic of the presentation of the material and the composition of the textbook "Labor Psychology" [17-22] is as follows. The first chapter presents the main contours of the scientific discipline, taking into account the traditions and positions of reputable scientists. It reflects the current state of labor psychology. The main attention is paid to its object and subject, the content of the concepts of "labor" and "activity".

The second part is devoted to the history of the discipline and is intended to reflect the dynamism of its development. This dynamic is presented in two ways: a) chronologically, as the history of the development of science through facts, events, tasks, names, dates; c) structurally – as processes of its constant differentiation and integration. Attention is paid to the main factors in the development of science. The third chapter examines the components of labor psychology in the broad sense of the word – as a "complex of sciences about labor and man as a subject of labor": labor psychology (in the narrow sense), engineering psychology, ergonomics, organizational psychology, career guidance, vocational training.

In the fourth chapter – the basic concepts of discipline and its main "units" are discussed – a profession, a labor post, a workplace, their relationship and characteristics. The fifth chapter is devoted to the "macrostructure" of the discipline – an extended discussion of its object and subject. The sixth – presents the methodology and methods of research, experiment, expertise. The main attention is paid to the tactics and strategy of the psychologist as a person who ensures the meeting of science and practice, a specialist who organizes their effective interaction. The seventh chapter discusses working conditions, efficiency, success factors of the subject, their determinants.

In the eighth – the issues of adaptation of a person to professional activity, his formation as a professional are discussed – conditions, factors, psychophysiological "price", levels and specific mechanisms, "units" of adaptation; the possibility of labor psychology going beyond the traditional "scale" of its conceptual apparatus. The ninth chapter analyzes the issues of professiography and professionalism of the subject, the criteria for understanding the professional suitability of a person and the contexts of its assessment in a historical perspective. Chapter ten is devoted to the pole of the "subject" a person as an active subject of his life, a description of the processes of his formation as a subject of activity.

In the eleventh – questions of a professional career, age dynamics of the evolution of a person as an individual, subject, personality are considered. The twelfth section discusses the relationship between scientific and applied problems, the features of socio-psychological technologies on the example of professional selection of candidates (taking into account the characteristics of activities in socionomic professions, activities in the systems "human-technology", "man-artistic image", "man-sign", "man-nature").

Chapter thirteen discusses the issues of selection, selection, professional training and retraining, certification of personnel: principles, methods and technologies. Attention is focused on the historical shift in the logic of working with people – from "personnel accounting" to "human resource management". Chapter fourteen reveals the features of the development of labor psychology as a discipline in the present historical conditions, the features of the search and description by scientists of new essential properties of phenomena included in the subject of labor psychology, historical changes in the configuration of the discipline, its actual tasks.

The second textbook (in the first three editions "Psychological support of professional activity. Methods of professional selection", in the fourth "Technologies of professional selection"), according to the title, is focused on covering a few individual topics of the discipline. Notable features of this book: 1) The author sees the key, defining questions in covering the selection problem not as methods and technologies, but as the answers of the psychologist "Why?", "For what?" should carry out psychodiagnostics in a given organization at a given stage of its evolution, in its given relations with the surrounding social reality. That is, highlighting as the main non-typical questions "How?", and above all, understanding the tasks of leadership in a larger social and chronological context than administrators, managers, and practitioners do. 2) Implementation of the evolutionary approach (the problem of selection is considered in its historical development and its understanding by the customer and contractor, in the development of each specific organization).

Let's name the main topics of the textbook "Technologies of professional selection" [26]: Introduction (in which the subject and objectives of the course are highlighted, the scientific position of the author is disclosed). Chapter 1. Psychological support of professional activity: current and future tasks (including six sections and practical tasks): 1.1. Professional self-determination of the subject. 1.2. Professional selection of personnel and professional training of personnel. 1.3. Adaptation of personnel in the organization and career management. 1.4. Human resource management: motivation, evaluation, certification. 1.5. Professional health and professional longevity. 1.6. The environment of the organization, interactions and organizational behavior of employees. Practical tasks.

Chapter 2. Status of methods and techniques in the system of means for solving scientific and practical problems (includes seven sections and practical tasks): 2.1. Research methods in the structure of the means of scientific knowledge and practical activities. 2.2. Methods of psychological research. 2.3. Methods and measuring scales. 2.4. Projective methods. 2.5. Rank methods. 2.6. Interval scales and standard test questionnaires. 2.7. Multifactorial psychological tests. Practical tasks.

Chapter 3. The structure of the personality and the possibility of predicting the professional success of the subject (includes five sections and practical tasks): 3.1. Personal psychological characteristics. 3.2. Personality and subject in domestic psychology. 3.3. Hierarchical structure of personality. 3.4. The subject's activity in the continuum "inclinations-competencies". 3.4. Data of psychodiagnostics and self-realization of a person in the profession. 3.5. Profession, specialization, workplace: historical trends of change. Practical tasks.

Chapter 4. "Personality" ("man", "individual"): scientific concepts, manifestations of personality and its reflection in psychological methods (four sections and practical tasks): 4.1.

Test questionnaire G. Eysenck: structure and types of temperament. 4.2. R. B. Cattell's test questionnaire: the concept of personality and the content characteristics of factors. 4.3. Level of subjective control: domestic modification of the methodology. 4.4. Strategies of behavior in conflict: actions and personality traits. Practical tasks.

Chapter 5. Professional suitability: a phenomenon, its evolution and evaluation possibilities (six sections and practical tasks): 5.1. Professional suitability as a phenomenon. 5.2. Methods for assessing the professional potential of labor subjects: opportunities and limitations. 5.3. Professionally important qualities and professional activity of the subject. 5.4. Professionally important qualities: positive, negative, factors and determinants. 5.5. Profession, specialization, workplace: historical trends of change. 5.6. PIQ-approach and competency-based approach: opportunities, limitations, additionality. Practical tasks.

Chapter 6. Psychological methods and diagnostics (five sections and practical tasks): 6.1. Psychodiagnostics: a variety of methods and prospects for its expansion of their development, the possibility of their construction. 6.2. Psychodiagnostics: possibilities and limitations. 6.3. Psychometric requirements for measurement instruments. 6.4. Model practice of professional selection: instrumental efficiency and social effects. 6.5. The potential of domain-specific methods. Practical tasks.

Chapter 7. The practice of using psychological techniques in professional selection (five sections and practical tasks): 7.1. Classical methods: practice of use. 7.2. Heuristic potential of special techniques. 7.3. Heuristic potential of piloting techniques. 7.4. Combinations of research methods in solving problems of human resource management. 7.5. Computer diagnostics: opportunities and limitations. Practical tasks.

Chapter 8. Joint activity: factors, conditions, requirements of activity, organizational culture and self-organization of subjects (five sections and practical tasks): 8.1. Subjective success factors. 8.2. Asymmetry of partners' PVK preferences. 8.3. Effects of the distribution of control functions. 8.4. Styles of business communication, the evolution of subjects and organizations. 8.5. The phenomenon of “psychological niche”. Practical tasks.

In the final part of the textbook, typical blocks are presented: Conclusion. Applications (containing tables, reference material, etc.). List of used literature.

It follows from the structure of the content of the textbook [26] that it covers a wider range of important and related issues than Russian authors usually do. The novelty of the presentation of theoretical and empirical material can be said as follows. The author of the book structurally and meaningfully integrates the main issues of related training courses (“Psychological support of professional activity”, “Psychology of organizational development”, “Labor psychology”): the central theme of professional selection is considered in the context of a person’s professional development throughout his working life, factors of maintaining professional health and longevity, the role and possibilities of psychological support of the subject and management of its development, factors of interaction between people in individual and joint activities, in different organizational cultures, at different stages of the evolution of the organization, etc.

The book presents a critical analysis of the traditional understanding of the tasks of professional selection. These tasks have been set and relatively successfully solved since the beginning of the 20th century. Over the course of more than a century, a lot has changed (the organization and technologies of labor, the understanding and attitude of employers and scientists to the “working person”, the methods and methodology for solving selection problems, the people themselves – their preparedness and education, motives and meanings of work, etc.). Empirical material is also presented, reflecting the dynamics of changes in the state of the external and internal environment of the organization, which affects both the "norms" of selection and the content of work with personnel. A number of empirical data, summarized in tables, illustrate both the inevitable changes over time in the personal and professionally important qualities of the employees of each organization, and the extent of these changes; the direction of such changes also acts as a predictor of the future of the company – its future transitions to typical stations of “life cycles”.

At the end of the presentation, as a rule, the current practice is critically examined and a new understanding of the tasks of human resource management is proposed. Along with the coverage of typical technologies, issues of

relations between the organization and its social environment (the socio-economic state of the region, national tasks, etc.) are discussed. The conditions conducive to increasing the success of solving the problems of professional selection are discussed; examples of the organization of activities that allow more successful management of the company's human resources are given. The effects and resources of interaction between the subjects of joint activity are considered (by the way, a topic that has not yet been considered in the coverage of this training course, even theoretically, is still insufficiently and slowly developed).

The author distinguishes diagnostic tasks: strategic, tactical, operational, situational, for the solution of which it is proposed to use three types of techniques ("classical", "special", "pilot"). In view of the fact that the activity of a practicing psychologist is not limited to office work, but includes many different tasks; in view of the fact that they must not only solve "ripe issues" posed by administrators, but also conduct constant monitoring of the organizational stage and its personnel, the psychologist cannot be limited to using exclusively "classical" methods, by the way, in their use in real practice, those many limitations, but must be able to quickly develop and skillfully combine in their work "special" methods that integrate the characteristics of the activities and personalities of representatives of a given company at a given stage of its life cycle, as well as "pilot", not complex, but allowing you to quickly and regularly carry out diagnostics of relations in working groups, etc. Accordingly, the issues of using psychological methods in the environment of real organizations are discussed. People of mature age, who have a certain social status, a rich experience of entering a job and being fired, behave differently than schoolchildren and students, based on the experience of working with whom methods and recommendations for their use are often developed.

The textbook argues for the need to create data banks, the formation of "personnel logistics" (i.e., it is noted that a psychologist must not only solve problems, focusing on the "cut" data, but also analyze the history of the company, predict its evolution prospects). Options for the development of the theory and practice of psychodiagnostics are proposed (transition to the tasks of selection not for a profession, but for a specific workplace; an interpretation of "selection" as a "selection" and subsequent distribution of people to appropriate jobs; selection to complement the qualities of already working employees companies with the qualities of newcomers, ensuring the integration of personal and professionally important qualities of all interacting subjects of joint activity; transition from the paradigm of assessing the actual qualities of the subject to the paradigm of updating the resources of the subjects of joint activity, etc.).

How fundamentally important are the tasks of human conservation; active management of the interactions of subjects in micro- and small social groups (these issues, at best, act as separate in different disciplines, while in the real environment of real organizations they are closely "intertwined"); the issues of transition from retrospective psychodiagnostics (based on past experience) to projective, prospective diagnostics (from classical to modern psychodiagnostics) are discussed.

The two peer-reviewed books "Labor Psychology" and "Professional Selection Technologies" seem to complement each other, reveal similar topics at different scales of historical time, discipline, organization (working group, company, industrial enterprise). If, for example, the issues of professional selection are separate, private, along with others, considered on the scale of labor psychology, then when they are considered key, central, main, one can see how this "part" is associated with the "whole", as in particular and in particular, the general is manifested, how the success of solving one personnel task contributes to the success of human resource management as a whole.

In comparison with other Russian and foreign analogues, in both peer-reviewed textbooks, several "copyrights" are distinguished: socio-psychological and social phenomena generated by this historical time. 2) Consideration of individual tasks of human resource management as interrelated, as defining each other. 3) Presentation of different topics of the course (career guidance, selection, certification, etc.) as components of a single process of the subject's professional development. 4) Methodological reflection (covering all the basic topics not only in terms of their factography and methodological solutions, which distinguishes many textbooks, but also in terms of analyzing the scientific approach to understanding and explicating each scientific and scientific-practical problem); reflection, organically included in the subject and organization of research (each chapter of the "Psychology of Labor" ends with a section -

"Paradigms"). 5) An evolutionary approach to highlighting the content of the training course (presenting not only the content of the issue under study, not only the main approaches to solving it, but also the historical changes in the discipline itself, manifested both in the expansion of its subject, the increase in the tasks being solved, and in their periodic reinterpretation) . By the way, the evolutionary view of the subject and tasks of the discipline was already stated in the first version of the textbook [16]. 6) Periodic revisions and additions (sections, list of references, tables). 7) Wide inclusion of works of domestic researchers, carried out at the turn of the XX-XXI century (i.e., chronologically the latest, integrated into the history of the study of the issue). 8) An extensive list of literary sources, serving as a separate important component of the textbook, allowing the thoughtful reader to better navigate the sea of scientific and scientific-methodical literature.

At the end of article, we note that abstracts to both books that are addressed to university students, graduate students and teachers, employees of personnel departments and personnel development departments of state and commercial organizations. Judging by the number of references in the RIC, these books are really read and found something important not only by students, but also by graduate students, teachers, practicing psychologists, authors of scientific and scientific-practical publications.

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MEETING ABSTRACT

B.F. Lomov & A.V. Brushlinsky Congress “History of the Institute, history of psychology, and history of science” Moscow, December 22, 2021

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Abstract. The conference "B.F. Lomov and A.V. Brushlinsky — history of the Institute, history of psychology, history of science” dedicated to the 50th anniversary of the Institute of Psychology of the Russian Academy of Sciences was held as a session of the permanent seminar "Dialogue of Scientific Schools" in IP RAS on November 22, 2021. The idea of the conference was to discuss the foundations of the scientific schools of the Institute, to trace the contribution of B.F. Lomov and A.V. Brushlinsky, the first directors of IP RAS, to the development of science, their influence on modern psychology.

The conference "**B.F. Lomov and A.V. Brushlinsky — history of the Institute, history of psychology, history of science**” dedicated to the 50th anniversary of the Institute of Psychology of the Russian Academy of Sciences was held as a session of the permanent seminar "Dialogue of Scientific Schools" in the Institute of Psychology, Russian Academy of Sciences on November 22, 2021.

In his welcoming speech the Director of the Institute of Psychology, Academician of the Russian Academy of Sciences ***D.V. Ushakov*** said that the scientific schools of B.F. Lomov and A.V. Brushlinsky had defined the scientific style of the Institute and had set a high methodological level of research, relying on their predecessors of B.G. Ananyev and S.L. Rubinstein. From the very beginning the theoretical and empirical research had been focused on the actual needs of science and practice, including the psychology of thinking, engineering psychology, etc. The contacts between the Soviet scientists with foreign colleagues had been developing intensively. Pointing to the importance of understanding the history of the Institute of Psychology development, D.V. Ushakov emphasized the need to be open to the new areas of research, for example, related to big data analysis, and to the challenges of such intensively developing field as artificial intelligence. One of the unique features of Russian science - the preservation of traditions and the development of research integrated within the framework of historically established scientific schools - was noted.

The Scientific Director of the Institute of Psychology RAS, Academician of the Russian Academy of Sciences ***A.L. Zhuravlev*** raised the question about the development of the scientific schools and the existence of a single school of the whole Institute - the IPRAS meta-school. A.L. Zhuravlev noted that the foundations laid down in the Project for the establishment of the Institute had had an integrative character; they included the tasks of a comprehensive, interdisciplinary human study. Systemic methodology has been the core feature of the scientific school of the Institute of Psychology, the Academy of Sciences of the USSR (later - the Institute of Psychology of the Russian Academy of Sciences). A.L. Zhuravlev mentioned three fundamental roots of the

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Institute's research — interdisciplinary research of the Leningrad school of B.G. Ananyev, the subject-activity approach of S.L. Rubinstein and the theory of functional systems by P.K. Anokhin. He pointed out the need to identify separate periods in the development of the scientific school of the Institute.

D.V. Ushakov and A.L. Zhuravlev had named the famous scientists who had worked and were still working at the Institute of Psychology of the Russian Academy of Sciences — Ya.A. Ponomarev, K.A. Abluhanova-Slavskaya, O.K. Tikhomirov, V.N. Pushkin, D.N. Zavalishina, L.I. Antsyferova, K.K. Platonov, K.V. Bardin, Yu.M. Zabrodin, V.Yu. Krylov, V.B. Shvyrkov and others.

In the first part of the seminar "**Scientific creativity and scientific heritage of B.F. Lomov**" the reports were made by Corresponding Member of Russian Academy of Education, Dean of the Faculty of Psychology, Yaroslavl State University, named after P.G. Demidov, ***A.V. Karpov***, Dr. Sci. in Psychology ***V.N. Nosulenko*** and Dr. Sci. in Psychology ***E.S. Samoilenko***, Institute of Psychology RAS. This part of the seminar was completed by the report of Academician of the Russian Academy of Sciences ***A.L. Zhuravlev***, Dr. Sci. in Psychology Professor ***V.P. Poznyakov***.

Karpov A.V. B.F. Lomov: a modern retrospective of his scientific creativity

In the report "Boris Fedorovich Lomov - a modern retrospective of his scientific creation", Professor ***A.V. Karpov*** followed the development of B.F. Lomov's ideas, including those being implemented in Yaroslavl University, and highlighted three main directions. At first, he noted the methodological works of B.F. Lomov, and above all, the systemic approach, which B.F. Lomov urged to consider not as a final result, but as a way to start the study of the psyche. It gave a powerful impetus to the further development of a systemic approach. The systemic approach continues to develop now, in many versions, including the developing metasystem approach by A.V. Karpov, where B.F. Lomov's ideas about the systemic nature of the psyche are coupled with post-nonclassical versions of systemic methodology. Further, Karpov pointed to the paradigmatic shift made by B.F. Lomov in the understanding of one of the basic concepts of Russian psychology - activity. Lomov's development of a systemic approach allowed us to move to a polystructural interpretation of activity and to its investigation in the structural-morphological paradigm. According to A.V. Karpov, further logic of the research of activity in its isomorphism with regulatory processes leads to the transformation from the structural-morphological paradigm into the system-dynamic one. Finally, a systematic approach leads to the study of the procedural content of the psyche and to the study of its hierarchical structure. At the same time A.V. Karpov pointed out that we are now at the initial levels of development of ideas about the procedural content of the psyche. Summing up his speech, A.V. Karpov emphasized the synthetic nature of not only the systemic approach developed by Lomov, but also of the personality of B.F. Lomov, who synthesized in his work theory and practice, various schools, various approaches, uniting and inspiring the team he led. In conclusion A.V. Karpov congratulated the Institute on the anniversary on behalf of all psychologists of Yaroslavl, wished to remain the vanguard of psychology, to achieve new discoveries and fundamental results.

Nosulenko V.N., Samoylenko E.S. B.F. Lomov's general psychological concept of communication and the relevance of the cognitive-communicative paradigm

The report highlights the main theses of B.F. Lomov's cognitive-communicative paradigm and some directions of the development of these ideas. Developing these theses, B.F. Lomov initiated a research direction where cognitive processes were studied in various communicative situations. It is emphasized that communication is one of the most important determinants of cognitive processes, which, in turn, determine the nature of communication between subjects. Any natural situation of human interaction can be considered as a communicative situation, and communication acts as a source of data on the characteristics of cognitive processes in communicants. In empirical studies, the model of the most common natural communicative situation has become the situation of reference communication between communicants transmitting information about some object of reality to each other.

It is noted that in the school of B.F. Lomov, special attention was paid to the mutual influence of communication, cognitive processes, and activity. The result of the integration of these categories was another dimension that significantly expands the

application of the paradigm of cognition and communication - joint activity. Much attention in the report is paid to empirical studies of joint activities initiated by B.F. Lomov and continued to this day by followers of his ideas.

An important consequence of the application of the cognitive-communicative paradigm was the identification of the problem of combining and establishing a connection between the data obtained using different methods and approaches. Examples of the implementation of B.F. Lomov's systematic approach are given, in particular, the triangulation strategy, the task of which is to determine the patterns between empirical data, research methods and concepts belonging to different scientific fields. This is exactly what is shown in the cognitive-communicative paradigm of B.F. Lomov, where the task of examining the role of communication in the organization of perceptual processes required, for example, a new interpretation of psychophysical data.

The relevance of the questions posed by B.F. Lomov in modern conditions, when the joint activity of people is mediated by information and communication technologies, is discussed. It is shown that the digital environment radically changes the relations between the participants of joint activities.

At the end of the report, B.F. Lomov's special attitude to the problem of interaction between man and technology was noted, based on an anthropocentric approach and assigning a dominant place to man in the "Man-Technology" system. Modern trends are associated with the penetration of the latest technologies into all spheres of human life and are often characterized by the transfer of an increasing role to technology, up to the transfer of technology the right to choose the purpose of activity and decision-making to achieve it. One can only assume that the features of modern interaction between man and technology could be of interest to B.F. Lomov.

Zhuravlev A.L., Poznyakov V.P. About the views of B.F. Lomov on the problems of social psychology

Academician of the Russian Academy of Sciences Professor ***A.L. Zhuravlev*** and Doctor of Psychological Sciences, Professor ***V.P. Poznyakov*** presented the analysis of the scientific views of B.F. Lomov in the field of social psychology. The authors of the report identified and described three areas of social psychology developed by B.F. Lomov. First of all, Professor V.P. Poznyakov presented the direction of theoretical and empirical research of communication problems. B.F. Lomov described the function of establishing relationships between people, as an independent function of communication, along with the functions of organizing joint activity and people knowing each other. Thus, the concept of relationships was included in the system of socio-psychological concepts as one of the central categories of social psychology. The second direction is the development of B.F. Lomov psychological problems of collaborative activity. B.F. Lomov considered interpersonal relations in a group as an important structural element of joint activity, mediating its organization and productivity. At the same time, joint activity in the theoretical concepts of B.F. Lomov is a very broad concept: any phenomenon of the life of society can be considered as a joint activity of people, and any individual activity is an integral part of joint activity. The third direction highlights the contribution of B.F. Lomov in the formation and development of management psychology. Lomov's comprehensive approach to the psychology of management, as a new scientific direction, made it possible to integrate the psychological problems of managerial activity or the psychology of a manager's work, and the socio-psychological problems of team leadership, interaction and relationships between the manager and other participants in managerial interaction. Summing up the analysis of B.F. Lomov's ideas in the field of social psychology, the authors of the report note that Lomov implemented the principle of the unity of theory, experiment and practice in his works. Taking into account the contribution of B.F. Lomov in the revival, formation and development of social psychology, he should be considered as one of the founders and leaders of the Moscow academic school of social psychology.

Dr. Sci. in Psychology, Professor, Head of the Department of General Psychology ***V.V. Selivanov*** (Smolensk State University), Dr. Sci. in Psychology, Professor ***V.V. Znakov***, Dr. Sci. in Psychology, Professor ***E.A. Sergienko*** (Institute of Psychology, Russian Academy of Sciences) presented their reports during the second part of the seminar **"The history of the IP RAS continues: A.V. Brushlinsky on the subject, development, forecasting".**

Selivanov V.V. Subject-activity and procedural psychology of A.V. Brushlinsky

V.V. Selivanov points out that the founders of the subject-activity approach are S.L. Rubinstein and K.A. Albukhanova-Slavskaya, A.V. Brushlinsky. A.V. Brushlinsky's contribution is that he expanded the understanding of the subject in psychology and determined its main characteristics. From V.V. Selivanov's point of view, the oppening of new characteristics of the subject and their articulation with such approach to thinking as a process allows us to identify special facets of personal conditioning of thinking, the ratio of cognitive and affective, the regulation of mental search.

V.V. Selivanov's reported that A.V. Brushlinsky was the creator of the continuum-genetic approach in which thinking was considered as an activities and a process. The processuality of thinking was characterized by continuity of thinking; changing relations of external and internal conditions; changing functional structure of thinking; creativity (new forecasts of what you are looking for, new correlations of conditions and requirements of tasks).

Further, V.V. Selivanov discusses the issue, that thinking contains both cognitive and emotional components. Cognitive components of thinking include thought processes (analysis, synthesis, generalization, abstraction, analysis through synthesis as the main mechanism of the thinking process); mental actions, operations (for example, mathematical operations: addition / subtraction, multiplication / division); forms of thinking (concepts, judgments, conclusions). In V.V. Selivanov's and his colleagues investigations the three-membered structure of the cognitive part of thinking is correlated with emotional components. Emotional components of thinking include operational meanings, personal meanings of the conditions and requirements of the task; resistant meanings.

It was pointed out that the development of the continuum-genetic (procedural) approach takes place in the following areas of research: ontology of the unconscious; "instantaneous" insight; "subsensory substructure"; ontology of critical thinking (study by M.V. Gudkova); ontology of structural and functional properties of intelligence; ontology of virtual reality.

In conclusion, V.V. Selivanov noted that the new ontology of the subject's thinking, created by A.V. Brushlinsky, affects all modern areas of research in psychology. The importance of these studies is combined with the priority areas of science highlighted by Russian President Vladimir Putin - the study of the meta-universe and artificial intelligence, which, according to V.V. Selivanov, are impossible without the study of virtual reality.

Znakov V.V. A.V. Brushlinsky, a prediction and the psychology of the possible

Report of ***V.V. Znakov*** "A.V. Brushlinsky, a prediction and the " highlighted the influence of the ideas of A.V. Brushlinsky on modern psychology, in particular the influence of the idea of thinking as a prediction on the formation of a new field of psychological science - the psychology of the possible. It was noted that in the studies of Andrei Vladimirovich, the problem of the ratio of natural and social in a person was gradually transformed into the task of determining the ratio of the past and the future, the influence of previously acquired knowledge on a prediction of possible options for human behavior. Why only today did we start talking about a new field of psychology - the psychology of the possible? Viktor Vladimirovich notes that the novelty lies in the new focus of scientists - the emphasis on the possible as unexpected, incredible, and improbable. In psychology of the possible, at one pole of the understanding by psychologists is the adaptive possible, based on past experience, on the opposite - the possible as a pre-adaptive phenomenon (understanding of events that are not causally related to the ontogenesis of the subject). The connecting link between these poles is the idea of the sought-for in human thinking, the prediction of the initially unknown when solving the problem. The theoretical and methodological foundations of the psychology of the possible were analyzed in detail - the philosophy of the possible by M.N. Epstein, the historical and evolutionary concept of pre-adaptation to uncertainty by A.G.

Asmolov with colleagues, scientific ideas about the uncertainty of the human world. The concept of possible thinking, which analyzes different options and alternatives of the possible, is disclosed and substantiated in detail. At the end of the report, V.V. Znakov summarized three large groups of phenomena in the psychology of the possible: the phenomena traditionally studied in psychology that relate to the possible (affordances, anticipation, and others), the phenomena of the sought-for, and the understanding of the possible as a pre-adaptive phenomenon that characterizes unstable situations, the occurrence of which cannot be predicted.

Sergienko E.A. Mental development from the perspective of a system-subjective approach

E.A. Sergienko presented a report on the topic "Mental development from the perspective of a system-subjective approach". The report is devoted to the system-subject approach, which combines two areas of scientific knowledge - the system approach of B.F. Lomov and the subjective approach of A.V. Brushlinsky. Starting her report, Elena Alekseevna quotes the motto with reference to the composer Gustav Mahler: "Tradition is not the worship of ashes, but the preservation of fire." This motto emphasizes and reflects the essence of scientific communication, where it becomes important not only to preserve a scientific idea, but also to develop and enrich it.

The meaning of one of the critical remarks directed to the cultural-historical theory of L.S. Vygotsky about the role of the sign in the development of the psyche is revealed. The consciousness of an individual, as A.V. Brushlinsky believed, is indeed always formed under the influence of public consciousness, but it happens selectively. This idea is reflected in the works of A.V. Brushlinsky, who wrote about important issues of determining mental development, the relationship between biological and social, individual and social development of a person.

Special attention is paid to the development of Andrey Vladimirovich's ideas in modern concepts. Thus, the principle of continuity and succession of mental development, which A.V. Brushlinsky wrote about, is currently reflected in such fields of science as neuroscience, evolutionary psychology, evolutionary biology, etc. Gilbert Gottlieb's concept of "Probabilistic epigenesis" and his model, which points to the validity of the formula "external through internal" with a constant change of both, are given. The model reveals the principle of ontogenetic and evolutionary development, the multideterminacy of mental development, and emphasizes the reciprocity of the level of development. The final thesis of the report is devoted to the system-subjective approach in psychology. The comparison of system and subject-activity approaches is given, their weaknesses are highlighted. It tells about the correct criterion of the subject, about the role of the continuum-genetic principle in understanding human development. It is noted that the subject and personality should be considered as two hypostases of human individuality, which represent an inseparable unity and develop from the earliest stages of ontogenesis on the principle of continuity and succession, integration-differentiation. At the end of the report, a diagram of the selected levels of subjectivity is presented, which reflects the fact that the hierarchical principle of B.F. Lomov in modern science is supplemented by the principle of heterarchy.

The RTC, named "**50 years later: without changing traditions**" was organized at the end of the seminar. The short reports were made by T.N. Savchenko, E.B. Lomova, I.M. Brushlinsky, V.I. Morosanova, E.V. Volkova, I.G. Skotnikova, Yu.N. Oleinik, V.A. Tolochek, N.V. Tarabrina, M. Nyagolova, Yu.V. Bykhovets, T.V. Drobysheva, A.L. Zhuravlev, D.V. Ushakov.

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Competing interests. The authors declare no conflict of interest.

LEARNING FROM THE PAST

Vladimir Yuryevich Krylov is a well-known mathematician, psychologist, candidate of physical and mathematical sciences and doctor of psychological sciences, methodologist and organizer of science, founder of Russian mathematical psychology. Vladimir Yurievich Krylov was born on February 15, 1933 in a family of Russian intellectuals.

In 1951 he entered the Department of Mathematics of the Faculty of Mechanics and Mathematics of Moscow State University. Upon graduation, he began his scientific career at the school of M.L. Tsetlin, the founder of the theory of collective behavior of automata. In the field of automata theory. V.Yu. Krylov proposed a model of an automaton with asymptotically optimal behavior in a stationary random environment, which went down in history as the "Krylov automaton" and developed several variants of automaton games.

From 1967 to 1971 Vladimir Yurievich served as Deputy Director for Research at the Institute of Higher Nervous Activity of the USSR Academy of Sciences. In 1971 he became the head of the laboratory of engineering psychology at IPAN USSR. In 1983, the first laboratory of mathematical psychology in the country was organized at the IPAN USSR, and Vladimir Yuryevich became its head.

While working at the Institute of Psychology, the scientific interests of Vladimir Yurievich were, first of all, connected with the theoretical problems of mathematical psychology.

The first cycle of scientific works by V.Yu. Krylov is devoted to purely mathematical problems: in them, for the first time, a continuum integral was constructed over alternating distributions in function spaces. At that time, Vladimir Yuryevich worked in the Department of Applied Mathematics of the Mathematical Institute of the USSR Academy of Sciences as a junior researcher.

The second series of works is devoted to the construction of automatic models of behavior, in particular, automatic models of thinking. Vladimir Yurievich was the organizer and one of the leaders of the Soviet-American symposium on this topic.

The third cycle of works is connected with the development of a new modification of the method of non-metric multidimensional scaling, which for the first time made it possible to apply this method in case of violation of the triangle axiom. V.Yu. Krylov was the first to propose a method of non-metric multidimensional scaling, for which it is sufficient only that the differences between the elements of the system be symmetrical.

The fourth cycle of works by V.Yu. Krylov is devoted to the development of a synergistic paradigm in psychology. They describe the adequacy of a number of fundamental models of synergetics to psychological systems, formulate the problem of developing specific models of self-organization of mental processes and phenomena that have no analogues in other, simpler systems. In particular, nonlinear psychological systems have been studied, the mechanisms of self-organization of which are qualitatively different from the mechanisms of self-organization of simpler nonlinear systems. Here the greatest intuition of

Vladimir Yurievich manifested itself. In the 1980s, he foresaw the surge in non-linear modeling work that we are seeing today.

In recent years, V.Yu. Krylov's research has been devoted to the problem of the non-disjunctivity of psychological systems and the development of adequate methods for their analysis. Within the framework of the theory of reflexive behavior of V.A. Lefevre, V.Yu. Krylov proposed models different from the Lefevre's model, which reveal in the binary choice problem the range of values of the probabilities of choosing the positive pole, which are different from the golden section.

In conclusion, we would like to note that Vladimir Yurievich left behind a large number of students in whom he aroused an interest in mathematical psychology, in mathematical modeling. In the Laboratory of Cognitive Processes and Mathematical Psychology of the IP RAS, the work started by V.Yu. Krylov continues.

Psychosynergy as a Possible New Paradigm of Psychological Science

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Psychology and synergetics. General properties of nonlinear systems

Developing a systematic approach in psychology, B.F. Lomov repeatedly noted such properties of mental phenomena system as multidimensionality, non-linearity, hierarchical structure [6, 7, 8].

The multidimensionality of psychic phenomena can now be quite fully studied by the methods of modern multidimensional analysis, including, in particular, the methods of multidimensional statistics, cluster analysis and analysis of latent structures, multidimensional scaling and other methods.

The non-linearity of psychic phenomena (and the hierarchical structure of the system of psychic phenomena closely related to it) is a much deeper property of the psychic, which is clearly insufficiently studied at present. And meanwhile, if multidimensional systems differ from one-dimensional or, say, two-dimensional ones in a quantitative indicator (dimension), then nonlinear systems qualitatively differ from linear ones.

Peculiarities of nonlinear systems, their structure and functioning are studied by a relatively young science - synergetics. The term synergetics (literally - the theory of joint action) was introduced by G. Haken. He explains this term as follows: "I called the new discipline synergetics. It explores the combined action of many subsystems, resulting in a structure and corresponding functioning at the macroscopic level"[4]. The emergence of an integral system of properties that none of its subsystems possesses, we will call the self-organization of the system. Thus, synergetics is the science of self-organization. The very phenomenon of self-organization is a characteristic feature of the development of nonlinear systems.

The qualitative difference between linear and non-linear systems has already been noted above. Let us describe some characteristic properties of nonlinear systems that qualitatively distinguish them from linear ones. But first, let us recall the characteristic properties of linear systems.

First, for linear systems, the reaction force of the system is proportional to the force of the external influence on it. Thus, if any influence leads to some reaction of the system, then the influence several times stronger will lead to an increase in the reaction by the same factor.

Secondly, the reaction to the simultaneous

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application of several influences to the system is equal to the sum of the system's reactions to each of these influences. These two properties are characteristic of linear systems. In essence, the presence of these two properties is the definition of the linearity of the system. Often both of these properties are combined. Then such a general property of linear systems is described as follows: for linear systems, a linear combination (superposition) of actions corresponds to a linear combination of reactions. A linear combination of any quantities is the sum of the products of these quantities by any numbers (coefficients of a linear combination).

The evolution of linear dynamical systems is characterized by the fact that the state in which the linear system is currently located completely determines its future. Nonlinear systems differ radically from linear ones in their properties. By now synergetics has accumulated a large number of models of non-linear physical, chemical, biological systems. The study of these models makes it possible to enumerate a number of characteristic properties of nonlinear systems. We note right away that the world of nonlinear systems is so much richer than the world of linear systems that any enumeration of the properties of nonlinear systems will never be complete, exhaustive. However, some characteristic properties of nonlinear systems that distinguish them from linear ones can already be described.

One of the main properties of nonlinear systems is the irreversibility and multivariance of possible ways of development of nonlinear systems. A typical situation for nonlinear systems is as follows. The system has a certain number of ways of development inherent in it, possible for it. The system can develop only along one of these ways. No arbitrarily strong influences on the system can force it to develop along any other ways that are not characteristic of it. On the other hand, in the course of the development of the system, there are such moments (situations of instability) in which an arbitrarily weak effect on the system can radically

change the path of its development, changing one path of development possible for the system to another, also possible for it. Near such a moment of system development (the so-called bifurcation point), completely different ways of further development can correspond to similar states of the system. In this sense, the future development of a nonlinear system near such points is determined not by the prehistory, but by the way of development the system will take in the near future. That is, in other words, the further evolution (development) of the system is determined by where the path leads it, on which it gets, i.e. the evolution of a system is determined by its future, not by its past.

Various possible variants of the future for a nonlinear system are called attractors in synergetics (attractive sets of development trajectories of a given system). The presence of attractors makes the development of the system predictable. If we know that the system is on a development way that is attracted to a given attractor, then we can predict its future. Naturally, this type of system development is fundamentally irreversible. On the other hand, this type of development of nonlinear systems allows the following possibility of development control, which has no analogue in the case of linear systems control: namely, from what has been said above about the evolution of nonlinear systems, it follows that the control of a nonlinear system should be understood as its transfer from one possible to her development way to another. To do this, it is necessary to influence the system at the moment when it is in a state of instability (near the bifurcation point), and to organize the action which is topologically very accurate, namely, one that will transfer the system to the desired way possible for it. At the same time, such an impact can be extremely weak, but, being very accurate, it will lead to radical changes in the entire evolution of the system, since after this impact, the development of the system will go along a different way, leading to a qualitatively different future state of the system, determined by another attractor.

Basic models of self-organization and psychology

As already noted, the properties of nonlinear systems were studied mainly on the example of nonlinear physical, chemical, biological systems. Speaking of psychological non-linear systems, we can assume that some of them may have more or less exact analogues among simpler physical, chemical or biological systems. On the other hand, the existence of such features of psychological non-linear systems is possible, which are not and fundamentally cannot be in systems of a simpler nature.

From this remark follows a methodical method of studying non-linear psychological systems.

First, some basic model of synergetics is chosen, which describes the evolution of a

physical, chemical or biological system. Based on the study of the model, qualitative features of the evolution of this system are revealed. Next is the psychological system, the evolution of which has similar features. Then we can assume that the original basic model also describes this psychological system, it is enough to interpret the variables included in the model in terms of this psychological system.

Let us illustrate the possibilities of this approach with examples.

Let us consider the main models of population dynamics that describe, in particular, ecological evolution (Nikolis and Prigogine, 1979). [9].

Consider first the simplest case of one kind in the system.

Consider first the simplest case of one kind in the system.

Let be $x = x(t)$ - the number of individuals of this species at time t. The number $x = x(t)$ increases due to reproduction and decreases due to the death of individuals, so that the rate of change in the number of individuals $x = x(t)$ will be equal to: $\dot{x} = kAx - dx$

Here k and k are positive coefficients characterizing the intensity of reproduction and death, respectively. The value A characterizes the presence of food, which is a condition for the process of reproduction. In an ecological niche, the amount of food A is limited and it can be assumed that $A + x = N$ is a constant value. This will be the case when food returns to the system in an amount equal to the number of dead individuals. In this case, we get the so-called Fergulst equation: $\dot{x} = kx(N - x) - dx$

This equation describes a logistic curve showing that in this case a finite (limited) number of individuals of the species under consideration is established in the ecological niche over time. If we assume that the amount of food is unlimited, then we get an exponential increase in the number of individuals to infinity. If there is not enough food, then the population tends to zero over time, the population dies out.

Consider now the more complex problem of the existence of two species in the same ecological niche with limited sources of livelihood. Let the number of the first species at the moment of time t be equal to $x_1 = x_1(t)$, and the number of the second – $x_2 = x_2(t)$. Let us write for x_1 and x_2 the system of Fergulst equations:

$$\dot{x}_1 = k_1 x_1[N_1 - (x_1 + x_2)] - d_1 x_1$$

$$\dot{x}_2 = k_2 x_2[N_2 - (x_2 + x_1)] - d_2 x_2 .$$

Note that in these equations in parentheses, the sum $(x_1 + x_2)$ is subtracted from N, which indicates the fact that both species have the same food source and both occupy the same ecological niche. It can be shown that under the condition

$$N_2 = \frac{d_2}{k_2} \rightarrow N_1 = \frac{d_1}{k_1},$$

the second type x_2 completely displaces the type x_1, while x_1(e) tends to zero, and $x_2(t)$ - to a finite value:

$$N_2 = \frac{d_2}{k_2}$$

even if at the initial moment x it was close to zero (the mutant had just appeared). Note that if $N_1 = N_2$, then the above condition of displacement by the second type of the first takes the form:

$$\frac{d_1}{k_1} > \frac{d_2}{k_2}$$

This condition meaningfully means that the ratio of the rate of death "d" to the rate of birth "k" in the second species is less, which gives it an advantage over the first species.

As has been said, in a number of cases there are psychological systems whose evolution has the same character as systems of a simpler nature. In this case, the mathematical models of the dynamics of such systems will coincide. In this case, the model of the ecosystem, which describes the displacement of one species by another, coincides with the model of learning a complex skill, during which there is a successive change of strategies to more and more effective ones [5].

The problem of learning is one of the central ones in psychological science. The study and modeling of the learning process was started in 1885 by G. Ebbinghaus, who first described the learning curve. It was the solution of the problem of the theoretical derivation of the learning curve that was the first success of mathematical psychology (Atkinson, Bauer, Crothers, 1960). Later, when studying the process of teaching complex skills to operators, a more complex dependence of the effectiveness of training on time was noted, associated with a change in learning strategies to more and more effective ones [10].

An example of a learning curve for a complex skill of compensatory tracking is given in the

book by V.F. Wenda (1980). It shows that for each sequentially mastered strategy (tracking method), it is possible to trace such phases as the beginning of mastering a new strategy, a rapid increase in the tracking efficiency indicator, reaching a plateau, and finally moving to the next strategy.

Thus, in this case there is such a complete analogy of the evolution of the two systems under consideration (ecological and psychological) that they are described by the same mathematical model - the system of Fergulst equations.

As a second example, consider the well-known model of an ecological system consisting of a predator and prey. If we assume that the prey (for example, crucian carp) has a practically unlimited food source (plankton), and the predator (for example, pike) feeds only on its prey, which can die as a result of a predator attack, then such a system is described by the well-known system Lottka–Volterra equations:

$x = kx – sxy,$

$y = sxy – dy.$

Here $x = x(t)$ is the number of prey at time t, and $y = y(t)$ - the number of predators. It is known from theory that the system of Lottka–Volterra equations can have as solutions periodic undamped oscillations in the number $x(t)$ and $y(t)$.

It is important to note that the nonlinear effects in the predator-prey system are ensured by the presence in each equation of a term proportional to the product xy. This term meaningfully describes the result of the "interaction" of the predator and prey. This fact suggests that the dynamics of interacting social (or any other) groups can be described by similar equations in social psychology.

Consider, for example, a model of population migration under the influence of psychological factors.

Let in any region there is a tendency to migration from this region. Let us denote by $y(t)$ the number of persons who have decided to leave the given region by the moment of time t. Suppose that these persons are campaigning among the rest of the population, persuading them to leave the region. Let be $x(t)$ - the number of people who are agitated by y. Assuming that both x and y make up a small part of the population of the region, it is easy to obtain balance equations for x and y, which will coincide with the system of Lottka-Volterra equations.

In these equations the terms sxy, the terms correspond to the act of interaction of an individual from y with an individual from x, leading to the fact that the proportion s of individuals from x, as a result of such interaction goes into the category y, i.e. decides to migrate. The term dy in the second equation corresponds to the migration of the proportion d of individuals from y. Finally, the term kx reflects the involvement of new residents of the region in the process of interaction with individuals from y.

Thus, the dynamics of migration under the influence of psychological factors is described by the system of Lottka-Volterra equations, which is one of the main mathematical models of synergetics, which means that the behavior of the solutions of this system should describe migration effects (in particular, the presence of the so-called will of migration).

The examples given show that nonlinear effects in psychological systems that have analogies in other disciplines are exactly described by the corresponding models taken from physics, chemistry, biology, etc.

Of course, the most important task is to identify such specific non-linear psychological systems that do not have (and cannot have) analogues among systems of a simpler nature. The study of such systems, perhaps, should be the most important part of non-linear psychology. For now, we only note that an example of such systems are systems that have developed language tools.

Such systems first build a plan of behavior in their own language, and then they execute it. Such systems may have developed reflection mechanisms [2].

Towards a new paradigm of psychological science

Since most psychological systems are non-linear self-organizing, it is advisable to consider a special methodology for studying psychological systems as specifically non-linear.

Let us note the main features of non-linear psychology, a new approach to the study of psychic phenomena, which sets as its main task the study of the specific non-linear properties of psychic phenomena.

From the very beginning, any psychological systems must be considered as developing. This, in particular, means that when studying the state

of the system at any moment, it is necessary to fix not only that part of the prehistory of the system's development, which at the moment affects its future, but also how the system is represented in the present state of the system. its future (value orientations, ideals, aspirations, interests, goals, etc.). This must be kept in mind, since it was noted above that one of the features of nonlinear systems is the fact that the future can determine the behavior of the system in the present. Unlike non-linear systems, in linear systems the future state is completely determined by the prehistory of the system and its present state. Such a linear paradigm is fully consistent with the well-known formula of behaviorism, that the stimulus completely determines the response of the system (of course, taking into account the present state of the system).

Further, studying the development of a psychological system, it is necessary to fix the moments of time at which it reveals instability. At such moments, a radical change in the way of development of the system can and does occur. At these moments, even the most insignificant external influences on the system can determine its further evolution. So, for example, the main postulate of astrological science, that the position of the luminaries at the time of a person's birth to a large extent determines many of his individual qualities, finds indirect confirmation in the non-linear paradigm.

Of course, the moment of a person's birth is the moment of the highest degree of instability of all systems. Therefore, at this moment, even weak influences (in particular, of astrological origin) can strongly influence the development of a person in the future.

Of course, everything that has been said about changing the paths of development at points of instability assumes the multivariance of the paths of development of the system. In this regard, the most important task of the non-linear approach in the study of the development of psychological systems is to identify the various ways of development possible for the system in given external conditions. The method of such study should be radically different from the "stimulus-response" method, namely, the system must be placed in certain external conditions that are natural for it and its spontaneous behavior under these conditions should be observed and recorded. To study the possibility of controlling the states of the system, it is necessary to learn how to create states of instability (for example, a typical state of instability of a psychological system is stress), and then try to transfer the system from one possible path of development to another with small but precise influences. An example of such influences seems to be acupuncture.

One should not think that everything that is said here about the principles of studying nonlinear systems is absolutely new for psychological science. So, for example, in the theory of living space by K. Levin, a number of provisions were formulated that echo the methodology of studying nonlinear systems, developed by modern synergetics. So, K. Levin wrote that “the psychological past, present and future are parts of the psychological field in the present. The time perspective is the inclusion of the future and the past, the real and the ideal plan of life in the plan of the present moment” (after: [11]).

Studying the specific behavior of people, which he called field, K. Levin wrote that “in adults, a situation can occur when “field behavior” arises, when objects that are insignificant, do not play any role, acquire an incentive character. But for this there must be a situation of affective tension” (after [11]). Obviously, the situation of affective tension is one of the possible types of psychological instability.

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