

**ANNOTATION**  
**of the dissertation for the degree of Doctor of Philosophy (PhD)**  
**in the educational program 8D02304 – Philology**  
**on the topic «Cognitive frame approach in the study of medical**  
**terminology (ophthalmology) in the Kazakh and English languages»**  
**performed by Khassangaliyeva Bibigul Kenessovna**

**Dissertation topic description.** The cognitive approach that emerged within the anthropocentric paradigm of linguistics has contributed to the emergence of new inquiries and perspectives in terminological studies. A deeper examination of the relationship between language and knowledge has highlighted the necessity to consider terminology not only as a system of scientific designations but also to specifically address the human factor in the emergence and functioning of these designations. Utilizing the theoretical constructs and research methodologies of cognitive linguistics, cognitive terminology has raised numerous issues, including scientific knowledge, its verbalization, characteristics of professional communication, the cognition of specific professionals, and cognitive mechanisms in term formation. In cognitive terminology, there has been a notable emphasis on previously unexplored aspects such as the professional linguistic persona and its creative processes in term formation, as well as the naming processes for objects and phenomena within specific fields of science and technology. The cognitive approach in terminology has established new perspectives and positions regarding longstanding issues that have been raised in traditional terminology but remain unresolved to this day, such as the relationship between common words and specialized terms, etymology of terms, loanwords, standardization of terms, and other related questions.

Cognitive linguistics employs conceptual tools such as concept, frame, scenario, and gestalt effectively within cognitive terminology to explore the processes of representing, conveying, and preserving scientific knowledge in language. While traditional terminology emphasizes requirements such as univocality, absence of emotional connotation, and brevity, cognitive terminology is more interested in examining the structure of professional knowledge and the peculiarities of conceptualization.

New perspectives and positions directed towards the study of terms primarily open pathways for considering the cognitive aspect of a term through the lens of the professional linguistic persona. Subsequently, cognitive terminology seeks to investigate the relationships between a term's meaning and sign, its content boundary and form boundary, as well as the relationships between concept and meaning, and concept and notion. This approach aims to recognize the complex nature of terminology.

Recent studies in terminology allow for an examination of terms in relation to their creators, considering their perspectives on and valuations of the surrounding

world. This enables an understanding that a term reflects not only the cognitive experiences but also the thought processes of professionals within their respective fields.

**Relevance of the research.** Today, there is a growing trend to examine a number of complex issues in linguistics in relation to human cognitive activity. Utilizing a cognitive perspective on linguistic phenomena allows for an understanding of language as a source of information about the conceptual structures of knowledge. Concepts, notions, conceptualizations, and frames arise from an individual's perception of the surrounding world; they are formed during cognitive processes and are verbalized in language. Language reflects how the human mind perceives and categorizes the surrounding reality. Each linguistic unit is considered a manifestation and result of human cognitive activity.

Cognitive research in contemporary linguistics is also highly significant for terminology, as each term encapsulates a precise and accurate structure of scientific knowledge. The cognitive-frame analysis of a term reflects the cognitive activity of the professional linguistic persona prior to naming a scientific concept. Cognitive terminology, which considers terms in conjunction with the thought processes of professionals, began to gain attention in Kazakh linguistics from the 2000s onwards. Prior to this, Kazakh terminology was examined primarily from functional, semasiological and onomasiological perspectives. These research directions focused on terms as names for objects and phenomena within specific fields of science and technology, their usage, methods of formation, and the requirements placed on terms; however, the role of the professional linguistic persona in term formation and the peculiarities of verbalizing scientific knowledge were not adequately addressed.

A review of foreign scientific research indicated that the topic has been somewhat explored; however, it became evident that issues related to cognitive terminology require special attention within domestic science. Specifically, areas such as the professional linguistic persona in Kazakh terminology, the scientific representation of the world, cognitive mechanisms in term formation, scientific discourse, comparative analysis of terminological systems across different languages, and methodological issues in cognitive-frame analysis of terms are particularly noteworthy.

Although the medical terminology system in Kazakh terminology has been studied within a structural-systemic paradigm, there has been no specific research focus from the perspective of cognitive terminology. The history of the formation of knowledge about eye diseases in Kazakhstan dates back to ancient times; however, a dedicated study of Kazakh ophthalmology terms using the methods and techniques of cognitive linguistics is being undertaken for the first time. In this regard, the dissertation addresses the following issues: the history of term research is analyzed in chronological order, tracing the evolution from traditional terminology to the emergence of cognitive terminology principles; the main principles of cognitive terminology are identified; concepts such as the scientific representation of the world and professional linguistic persona are defined; the cognitive mechanisms of metaphor and metonymy in term

formation are investigated; frame analysis is established as a methodological basis for studying ophthalmology terms; a comprehensive comparative methodology for cognitive-frame analysis of ophthalmology terms in medical discourse is proposed; the frame representation of Kazakh and English ophthalmology terminology systems is determined; common and distinguishing features in the frame representations of these two structurally different languages are identified; and an electronic ophthalmology dictionary is created. All these issues are highly significant questions for both the theory and practice of Kazakh terminology, thereby underscoring the relevance of the dissertation being defended.

**Research Objective.** The aim of the study is to identify the peculiarities of the verbalization of professional knowledge through cognitive-frame analysis of ophthalmology terms in Kazakh and English.

To achieve this objective, the following tasks are set forth:

- To review the research directions from traditional terminology to cognitive terminology;
- To identify the main principles of cognitive terminology;
- To define the concepts of the scientific representation of the world and professional linguistic persona;
- To determine the cognitive mechanisms of metaphor and metonymy in term formation;
- To establish the methodological basis for frame analysis in the study of medical terms and to propose a methodology for cognitive-frame analysis;
- To create and conduct a comparative analysis of the frame representation of Kazakh and English ophthalmology terminology systems;
- To develop an electronic dictionary of ophthalmology terms.

The subject of the dissertation is the ophthalmology terms in Kazakh and English.

**Research Subject.** The frame representation of the Kazakh and English ophthalmology terminology systems in medical discourse.

**Theoretical and Methodological Basis of the Research.** The theoretical and methodological foundation of the research is based on traditional terminology theory, drawing from the works of O. Wüster, J. A. Fodor, G. Felber, R. Jackendoff, A. Rey, J. Seiger, D.S. Lotte, G.O. Vinokur, A.A. Reformatsky, among others. The principles and term formation guidelines of Kazakh terminology during the Alash period are studied based on the works of A. Baitursynov, E. Omarov, J. Aymauytov, H. Dosmukhamedov, S. Kozhanov, A. Konkashpayev, M. Zhumabaev, K. Zhubanov, and others. For comparative terminology studies, the works of D.S. Lotte, M.O. Isambaev, E. Ramazanov, E.A. Moldataev, S.S. Zhanseitova, Zh.S. Beisenova, R.S. Baymukhanbetova, G.K. Ismailova, K.A. Ashinova, A.R. Sulkarnaeva, G.Z. Beisembaeva, A.T. Baekeeva, G.A. Kozhakmetova and others were considered important references.

The functional aspect of terms was analyzed based on the works of B.N. Golovin, I.V. Arnold, V.M. Leychik, V.P. Danilenko, A.S. Herd, L.B. Tkacheva and others. In

terms of semasiological terminology studies, guidance was taken from scholars such as S.V. Grinev-Grinevich, O. Aitbaev, B.K. Kaliev, Sh. Kurmanbaiuly, E.K. Abdirasilov, S.K. Aliszhanov, S.S. Issakova, K.Zh. Aydarbek, B.S. Zhonkeshov, S.K. Kulmanov and others.

The onomasiological direction of term research was studied based on the works of V.P. Danilenko and K.Zh. Aydarbek; social-linguistic terminology was examined through the contributions of E.D. Polivanov, I.V. Arnold, O.B. Alekseev, M.V. Volodina, L.V. Ivina, O.G. Kozlovskaya, D.I. Lebedev, A.V. Superansky and other scholars.

The theoretical issues of cognitive terminology are based on the works of V.M. Leychik, M.N. Volodina, E.I. Golovanova, L.M. Alexeeva, S.L. Mishlanova, L.A. Manerko, V.F. Novodranova, Yu.A. Vorobyova, I.S. Gavrilina, K.A. Gromova, L.V. Ivina, O.G. Kozlovsky, D.I. Lebedev, M.T. Kozhaeva, A.Kh. Azamatova, S.S. Issakova, and N.U. Abdullina.

The concepts of terminological concepts and professional concepts are informed by the works of M.V. Prishchepenko, E.I. Gureeva, and K.V. Danilov; scientific discourse is examined through the contributions of S.P. Khizhnyak; and the cognitive analysis of industry-specific terms is based on the works of L.M.-R. Allafi, E.A. Sorokina, E.A. Sloyeva, E.D. Makarenko, O.S. Zaborovskaya, D.Yu. Krinitsky, E.S. Zakirova, E.V. Shvetsova, S.I. Madzhaeva among others.

In developing the methodology for cognitive-frame analysis of ophthalmology terms in medical discourse, the works of O.V. Guselnikova, M.G. Zasedatelevna, Yu.S. Smirnova, A.Z. Abdurakhmanova, P.A. Faber, S.L. Mishlanova, N.V. Biserova, and A.A. Filippova were taken into account as foundational references.

**Research Sources.** The primary materials for the study consist of Kazakh and English ophthalmology terms and their definitions as found in dictionary entries and textbooks. A corpus of 20 dictionaries was compiled to create a database of eye disease terms in the Kazakh language, published between 1963 and 2014. These include K. Zhalmukhamedov's "Russian-Kazakh brief explanatory dictionary of terms of eye diseases" (1977, 96 pages), S. Toleuova and J.G. Mustafina's "Russian-Kazakh dictionary of frequently used terms in the field of eye diseases" (1998, 107 pages), M. Isambaev and A.A. Suleimenov's "Medical Reference" (1965, 125 pages), and S.Zh. Kerimbekov's "Russian-Kazakh Explanatory Dictionary of Physiological Terms" (1992, 280 pages). A total of 38 printed sheets were analyzed, resulting in the collection of approximately 500 ophthalmology terms and their definitions.

For English, a corpus of 12 dictionaries was compiled, including three specifically focused on ophthalmological terms: *Millodot: Dictionary of Optometry and Visual Science*, 7th edition. (2009) [<https://medical-dictionary.thefreedictionary.com/ophthalmological>], R.J. Barry and A.K. Denniston's "A Dictionary of Ophthalmology" published by Oxford University Press online in 2017 [DOI:10.1093/acref/9780191830099.001.0001], and Jeffrey D. Henderer Dictionary of

Eye Terminology. Released: September 2024. A total of 43 printed sheet texts were analyzed for English, resulting in the collection of 523 terms and their definitions.

In addition, 87 printed sheet texts from Kazakh ophthalmology textbooks were analyzed, while 94 printed sheet texts from English ophthalmology textbooks were also examined for the study.

**Research Methods.** The dissertation employs general scientific methods such as description, generalization, comparison, analysis, and summarization. Linguistic research methods used include component analysis, semantic analysis, lexical-semantic analysis, comparative methods, comprehensive extraction from dictionaries, and quantitative-statistical analysis.

In selecting the methodology for cognitive-frame analysis of ophthalmology terms in medical discourse, the works of O.V. Guselnikova on the possibilities of frame analysis (Guselnikova, 2009), M.G. Zasedateleva's methodological discourse on the representation of the concept of "Competence" (Zasedateleva, 2011), Yu.S. Smirnova's cognitive-discursive aspect of definitional modeling in the terminological field of sepsis (Smirnova, 2011), A.Z. Abdurakhmanova's linguistic modeling of construction terminology (Abdurakhmanova, 2016), P.A. Faber's cognitive linguistic perspective on terminology and specialized language (Faber, 2012), and the frame analysis of migration terminology by S.L. Mishlanova, N.V. Biserova, and A.A. Filippova (Mishlanova, Biserova, Filippova, 2020) were taken into account.

A comprehensive model for cognitive-frame analysis of ophthalmology terms in medical discourse was developed based on these foundational works.

1. The initial thoughts on terminology date back to the Renaissance. The content of the early theoretical formulations about terms emphasizes the need for monitoring (planning, standardization, and normalization) their development, identifying standardization tools, and prioritizing international terms. The complexity of the term concept has led to the emergence of several scientific directions in its study. Theoretical, applied, general and specific terminology, typological, comparative, functional, semasiological, onomasiological, historical, social, and cognitive approaches have been established.

2. The main principles of cognitive terminology have been identified as follows:

- 1) In cognitive terminology, the perspective on the definition of a term has changed. While traditional terminology views a term as a linguistic sign representing the names of objects and phenomena in a specific field of science, cognitive terminology recognizes a term not only as a name for a scientific concept but also as a result of a professional's cognitive process.
- 2) A new approach to defining the relationship between linguistic signs and mental structures. A term is created, processed, and transformed during the cognitive process and materializes in discourse.
- 3) An expansion of views regarding the functions of terms. The cognitive functions of a term include communicative, informational, heuristic, pragmatic, guiding, and didactic functions.

4) The principle of recognizing a term as an ever-evolving structure. In traditional terminology, the definition of a term was described as requirements imposed on it; however, it was not taken into account that this definition changes as science develops and scientific thought evolves. Terms change and expand in accordance with advancements in science and technology.

5) The principle of “Professional Linguistic Personality – A Category of Cognitive Terminology.” This refers to the activities directed towards gradually mastering the field of science chosen by a professional; through such activities, accumulated professional experience helps to master various complexities of professions and develop competencies for solving them.

6) The principle concerning the relationship between terms and concepts. A term-concept is understood as a mental structure that retains information about a specific part of the scientific representation of the world in our consciousness while also being considered a fundamental unit of culture. This is particularly evident in terminological systems where national-cultural characteristics are predominant.

3. The linguistic representation of the world reflects the everyday worldview shaped by culture, while the linguistic representation of the world relies on logic, experience, and theoretical models. These elements are interconnected; science uses language as a tool for illumination, while language adapts to the level of scientific development. A professional linguistic personality is not just someone who has mastered specialized vocabulary; it is also a carrier of professional discourse who understands the linguistic, cognitive, and communicative characteristics of their profession. This concept is closely related to professional communication and reflects the peculiarities of various fields of work. The formation of a professional linguistic personality is determined by the processes of education, professional experience, and interaction within a professional community.

4. The use of metaphor in terminology creation makes complex concepts more understandable and aids in memory retention. The method of metonymy creates terms by linking them to their functions and external characteristics. The cognitive mechanisms of metaphor and metonymy in terminology creation are defined by the similarities and connections between existing objects and phenomena in language, resulting from the specialist's thought process in scientific and professional discourse. These cognitive mechanisms contribute to enriching the system of terms in any science and improving professional communication.

5. A comprehensive model for cognitive-frame analysis of ophthalmology terms in medical discourse has been proposed. The analysis consists of four stages: 1) conceptual-frame analysis; 2) corpus-terminological analysis; 3) definitional analysis; 4) comparative analysis.

6. The definitions in Kazakh and English ophthalmological dictionaries are characterized by conceptual components. These conceptual components contribute to the formation of the frame structure of the term. The conceptual components in both languages do not fully correspond to each other. This discrepancy is determined by the

history of the development and formation of ophthalmological knowledge, the methods of term creation, and the level of research in this field of science. Compared to dictionary definitions, the number of frame-constituting components is more prominent in textbook definitions. The research process revealed that conceptual and pragmatic components are common to both languages in textbook definitions. From the definitions in English ophthalmology textbooks, a social component was identified. The methods of term formation in Kazakh and English ophthalmology are similar; they are primarily created through morphological, syntactic, and semantic methods.

7. The natural metaphorical models in the terminology system of Kazakh and English ophthalmology can be classified into three categories: zoomorphic models, botanical models, and geographical models. Anthropomorphic metaphorical models are divided into two: social models and artifact models. The cognitive patterns of metaphors in the ophthalmology terminology system indicate that they possess universal characteristics as well as national-cultural peculiarities.

**Description of the main results of the research.** The dissertation identifies the cognitive-frame research direction of Kazakh and English ophthalmology terms. The evolution of ophthalmological thought from its inception to its current level of development, as well as the peculiarities of the verbalization of professional knowledge, have been elucidated. The research directions of traditional terminology have been examined in chronological order, and the prerequisites for the emergence of cognitive terminology have been described. The fundamental principles of cognitive terminology have been established. Concepts such as the image of the world, linguistic representation of the world, simple image of the world, and scientific image of the world have been analyzed based on theoretical works, with their definitions clarified. One of the foundational concepts in cognitive terminology, namely the category of professional linguistic personality, has been characterized and its definitions comparatively analyzed. The morphological, syntactic, and semantic methods used in the formation of ophthalmology terms have been identified and comparatively analyzed based on materials from both Kazakh and English languages. Cognitive mechanisms in the methods of term formation through metaphor and metonymy have also been identified.

The research conducted a comprehensive analysis of scientific and theoretical works related to terminology, terminography, cognitive terminography, and cognitive linguistics. The identification of the scientific-theoretical foundation of the dissertation influenced the selection of methods and approaches for the research.

In this work, frame theory was adopted as the methodological basis for studying ophthalmology terms. As a result, based on cognitive-frame approaches to the study of the ophthalmological terminology system, a comparative comprehensive methodology for cognitive-frame analysis applicable to any terminological system was proposed. According to this methodology, a model for cognitive-frame analysis of terms was developed, consisting of several analytical stages.

For the cognitive-frame analysis of Kazakh and English ophthalmology terminology systems, lexicographic sources and textbook materials were utilized. The frame representations of Kazakh and English ophthalmology terms were comparatively analyzed, identifying their common and distinguishing features. Metaphorical patterns within the Kazakh and English ophthalmology terminology systems were identified and analyzed comparatively. An electronic version of the dictionary of ophthalmology terms in both Kazakh and English was prepared.

This dissertation presents, for the first time, a comparative analysis of Kazakh and English ophthalmology terms, elucidating their frame structures illustrated in diagrams. The definitions of terms from dictionaries and textbook materials underwent cognitive-frame analysis, with quantitative and percentage indicators determined, leading to corresponding conclusions.

Justification of the novelty and significance of the obtained results. For the first time, the Kazakh and English ophthalmology terminology systems have been analyzed from a cognitive-frame perspective in this dissertation. The research directions, beginning with the history of terminology, have been studied in chronological order, leading to the identification of the prerequisites for the emergence of contemporary cognitive terminology. The foundational principles of cognitive terminology have been clarified. The concepts of the scientific image of the world and professional linguistic personality have been formulated within the framework of cognitive terminology theory. The cognitive mechanisms of metaphor and metonymy in term formation have been analyzed. Frame analysis has been considered as a methodological basis for studying ophthalmology terms. A comparative comprehensive methodology for cognitive-frame analysis of terms has been proposed.

The novelty and significance of this methodology lie in its comprehensive and universal nature, allowing for cognitive-frame analysis to be applied to any field's terminological system. According to the proposed methodology, a frame representation of the Kazakh ophthalmology terminology system was developed in accordance with the research stages. The frame representation of the English ophthalmology terminology system was also established. For the first time, a comparative analysis of frame representations of ophthalmology terms from two structurally different languages was conducted, identifying their common and distinguishing features. Metaphorical patterns within both Kazakh and English ophthalmology terminology systems were identified and substantiated through specific linguistic units. An electronic dictionary of ophthalmological terms was created.

**Theoretical significance of the research.** The theoretical works examined in the first section of the dissertation, along with critical analyses of the opinions of terminology scholars, and the conclusions drawn from comparing traditional terminology and cognitive terminology principles, contribute to a deeper understanding of cognitive terminology's relationship with professional discourse, scientific discourse, professional linguistic personality, and the linguistic and scientific representations of the world. The insights and conclusions related to the methodological



foundations of frame analysis will enhance the overall framework of Kazakh terminology and cognitive terminology theories. The methodology for cognitive-frame analysis designed for examining any terminological system will be significant in addressing methodological questions within cognitive terminology.

### **Practical significance of the research.**

The analysis of ophthalmology terms conducted in this research will be beneficial for compiling a Kazakh-English dictionary, as well as for creating explanatory dictionaries and reference materials based on the collected definitions of these terms. The model for cognitive-frame analysis of terms will assist in practical classes within the fields of terminology and lexicology. The results obtained from the cognitive-frame analysis of Kazakh and English ophthalmology terms will be of interest for writing course papers, theses, and dissertations at the master's and doctoral levels. The electronic dictionary of ophthalmological terms, developed as part of the research, may serve as a foundation for future lexicographic projects. The online resource on ophthalmological terminology will provide a platform for discussion and exchange of opinions among ophthalmology specialists, future physicians, terminologists, and researchers. Additionally, it will contribute to the development of Kazakh ophthalmological terminology and the preparation of educational materials.

### **Validation of the research.**

The main results and conclusions of the dissertation have been discussed at domestic and international research institutions and higher education establishments:

At the XI International Conference “Zhubanov 's Heritage” dedicated to the 125th anniversary of K. Zhubanov (Aktobe, November 1, 2024);

At the scientific seminar “Philology: Current Research” (Ufa, April 24, 2024), during a scientific seminar titled “Scientific-Cognitive Friday” for doctoral students at the Department of Kazakh Philology at Q. Zhubanov Aktobe Regional University (2023);

At another scientific seminar “Philology: Current Research” (Aktobe, April 23, 2025), where presentations were made reflecting these findings.

### **Publication and approval of the research:**

6 articles have been published based on the main sections of the dissertation.

### **Works published in journals indexed in the Scopus scientific database:**

1. Metaphorical Models of Ophthalmology Terms in Kazakh and English // World Journal of English Language. Vol. 15, No. 4; 2025. P. 203-212. Процентиль: 47%, Q2. DOI: <https://doi.org/10.5430/wjel.v15n4p203>
2. Frame representation of medical terminological system in kazakh and English // Forum for Linguistic Studies, Vol. 7, Iss. 5, may, 2025. Page 255-268. Процентиль: 55%, Q2. <https://journals.bilpubgroup.com/index.php/fls/index> DOI: <https://doi.org/10.30564/fls.v7i5.9233>

### **Works published in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Republic of Kazakhstan:**

2. The Fundamental Principles of Cognitive Terminology // Bulletin of the Eurasian Humanities Institute, No. 4/2023, pp. 162-176.  
<https://ojs.egi.kz/index.php/BULLETIN/issue/view/42/69>
3. Cognitive Mechanisms of Metaphor in Term Formation // Bulletin of Kazakh Ablai Khan University of International Relations and World Languages, Philology Series, Vol. 74, No. 3 (2024), pp. 322-343.  
<https://bulletin-philology.ablaikhan.kz/index.php/j1/article/view/1287/450>

**Works published in the proceedings of international conferences:**

5. The Cognitive Nature of Terminology Research // Proceedings of the XI International Conference “Zhubanov's Heritage” dedicated to the 125th anniversary of K. Zhubanov – Aktobe: K. Zhubanov Aktobe Regional University, 2024, pp. 300-304.
6. Features of Scientific Discourse // Proceedings of the All-Russian Scientific and Practical Conference "Turkic Philology in the Context of Modern Achievements" dedicated to the 65th anniversary of Doctor of Philological Sciences, Professor Zugura Idyrysova Salyakhova. April 5, 2025. Sterlitamak, Russia. – pp. 169-174.

**Structure and volume of the research.** The dissertation consists of an introduction, two sections, a conclusion, a list of references, and definitions. The research results are presented in 9 figures and 35 tables. The list of references includes 198 sources. The total volume of the academic work is 147 pages.

The dissertation research aligns with the development directions of relevant fields in linguistics such as **cognitive linguistics, cognitive terminology, and discourse analysis**, as well as with the State Programs of the Republic of Kazakhstan:

- Resolution No. 914 of the Government of the Republic of Kazakhstan dated October 16, 2023, “On Approving the Concept for the Development of Language Policy in the Republic of Kazakhstan for 2023-2029.”

- Decree No. 659 of the President of the Republic of Kazakhstan dated September 13, 2021, regarding measures to implement the Address to the People of Kazakhstan by the Head of State on September 1, 2021: “Unity of the People and Systemic Reforms are the Foundation for a Strong Nation's Prosperity” (with amendments dated April 17, 2023).

- Resolution of the Government of the Republic of Kazakhstan on approving the national project “National Spiritual Revival” dated October 12, 2021, No. 724.

- On Kazakhstan's historical and cultural heritage and spiritual values: Commonalities in history and culture, literature and language, customs and values // Resolution No. 988 dated December 27, 2019, on approving the State Program for Education and Science Development in Kazakhstan for 2020-2025.

**Contribution of the doctoral student to each publication prepared during scientific research.** The author independently completed all aspects of the dissertation's volume, including selecting research methods and addressing tasks aligned with research objectives. The doctoral student contributed to formulating theoretical conclusions from published works and analyzing practical materials. Task

assignments related to the research topic and discussions on obtained results were conducted in collaboration with scientific advisors.