Analysis of Software Tools for Longitudinal Studies in Psychology

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Abstract—**Longitudinal studies allow to access the review of causal hypotheses directly. It means that they make possible causal relation between the order of impacts (i.e. life events, educational effects, etc.) and the consequences that then occur. Long-term data storage has specific requirements for software and methods of data storage and conversion. The paper introduces criteria for evaluating software tools in the context of their application in longitudinal studies in psychology. The study is devoted to the analysis of popular tools of psychological research based on the criteria, which were introduced.**

Keywords—Software tools for psychological research; choice of the tools for psychological research; longitudinal studies; criteria for software evaluation

I. INTRODUCTION

A longitudinal study is a type of survey aimed to study the group of people (research sample) that is monitored for a certain period of time. Longitudinal surveys usually include the repeated measurements of different variables (from health status to value orientations). For example, a study of the school-age children development may include annual measurements of intelligence, math skills and reading skills to study cognitive development and learning abilities or impaired learning abilities.

Longitudinal studies are difficult to conduct, but they provide a number of advantages in comparing with other research methods:

1) Assessment of individual changes;

2) Identification of environmental events initiating certain processes;

3) A prospective identification of environmental impacts (i.e., an assessment of the order of impacts and consequences over time);

4) Separation of time effects: cohort, period, age;

5) Cohort effects control.

Longitudinal data are key in educational sciences, because they allow to evaluate the cause-effect relationships between different educational influences and their influence on the development of a child.

It is no coincidence that large-scale longitudinal studies all over the world occupy an important place not only in fundamental science, but also in educational practice. For example, the famous longitudinal study of the effectiveness of the preschool education program on the further personal achievements of its students (HighScope program [1]) served as a basis for policy makers in many countries to make crucial management decisions, in particular, to transform scattered preschool services into preschool education. One of the oldest longitudinal studies of 1000 intellectually gifted children [2] was started in 1921 and is still ongoing. The longitudinal study of 13,687 humans born from March 3 to March 9, 1946 in England, Wales and Scotland has been going on for over 70 years. The results of this study gave a number of important results for understanding not only the physical, but also the cognitive development of children. Thus, 80% of this sample is over 70 years old and the data of these people currently help to determine the factors contributing to the preservation of physical and mental health, cognitive skills, social and psychological well-being in old age.

Interdisciplinary research allows to identify a full range of different factors not only of mental development disorders, but also of personality formation, motivation, value orientations and success in learning educational programs. These factors may be associated with the characteristics of prenatal and early child development, morphofunctional maturation of the brain and the systemic brain organization of cognitive functions, language environment, genetic profile, lifestyle, etc.

The results of longitudinal interdisciplinary research provide huge data sets, that opens for new opportunities to use the intelligent analysis methods for assessing both global and local systemic effects (for example, assessing the impact of various educational technologies on the mental development of children), as well as to understand the characteristics of individual response on these factors. Without big data analyzing, it is impossible to research fundamental childhood, scientifically based administrative and managerial decisions.

The use of Web technologies significantly expands opportunities for psychological research. For such usage organization, it is important to solve the problem of the tools

for psychological research choice. The paper is devoted to the analysis of popular tools for psychological research. The second part introduces evaluation criteria and analyzing of software. The third one describes the software development based on the analysis of functionality.

II. CRITERIA FOR SOFTWARE EVALUATION

To analize existing software solutions used for psychological researches, it is required to structure the information in such a way that it allows to compare different tools.

The list of criteria used to evaluate software for psychological researches is described below:

- **Web-site**–web-site address of software solution in Internet;

- **License**–term of use, cost and type of license (commercial, free license, open source etc.);

- **Platform**–list of supported platforms on which the application runs (web browser, web-service SaaS (Software as a Service), desktop, mobile application etc.);

- **Country of production–**country in which the application was developed;

- **Functional purpose–**what tasks the application is focused on, how developers are positioning their tool;

- **Test types**–the types of tests supported by application (questionnaires, cognitive tests);

- **Data storage resource**–the resource storing data (local data storage, remote data storage, SaaS storage (Software as a Service));

- **Country of data storage**–location of application servers for data storage (for SaaS solutions);

- **Personal data storage features**–techniques of data collection, techniques of users identification, the need of researches registration, opened and closed access to researches completion;

- **Techniques of tests creation–**which tests creation techniques are supported by application (tests constructors, tests description format, programming);

- **Test playing**–support opportunities of tests reuse, coping and portability;

- **Programming knowledge–**the need of programming skills for application use and test creation;

- **Complexity**–complexity of using the application, what is needed for start use, the problems that may arise, interface features;

- **Tools for data analyses**–existing tools for data processing and research results analyses;

- **Opportunities for data export–**techniques and formats of test results storing (.txt, .csv etc.);

- **Integration tools**–opportunities for functionality expansion supported by application (API, modules, plug-ins, integration with third-party solutions etc.);

- **Solutions relevance**–application updates, compliance with current trends and standards;

- **Solutions features–**features of application and what to take note of.

Functionality opportunities described systems was analyzed and checked by authors.

A. PsychoPy

PsychoPy is an open source project that allows to carry out experiments in the field of neurobiology, psychology and psychophysics [3, 4]. PsychoPy supports many constructors of psychological tests: Builder (visual test constructor shown in the Fig. 1) and Coder (test programming).

By start the experiment from visual constructor, PsychoPy translates the code into Python code and then executes is. The code written in PsychoPy Builder can be saved separately and then executed. It should be noticed that backward compatibility does not exist. It means that there is no opportunity to create visual view from the code. In the presence of programming skills it is possible to develop any types of tests.

PsychoPy supports its own format of experiment file (.psyexp) that is based on xml format and displays the structure of experiments built using the Builder GUI, which generally makes it platform independent.

PsychoJS [5] was created in 2016 as a project that provides an opportunity to run researches developed in PsychoPy Builder in web browser. It should be noticed that PsychoPy cannot export all possible experiments into PsychoJS scripts. Researches created using standard components will work, but the researches created using third-party components or code won't. But according to completed tests and feedback, PsychoJS does not work well and has a number of problems.
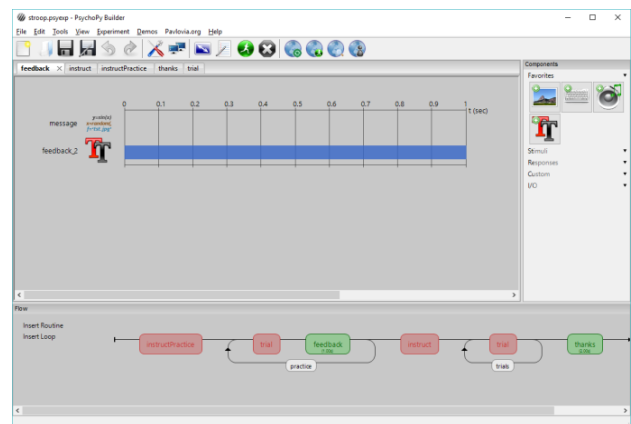

Fig. 1. Visual Test Constructor PsychoPy Builder.

The detailed characteristics of PsychoPy are presented below:

- **Web-site**–http://www.psychopy.org/

- **License**–open source (GNU GPL 3+)

- **Platform**–desktop (Windows, MacOS, Linux), web browser (based on PsychoJS)

- **Country of production**–Great Britten (with the support of the University of Nottingham)

- **Functional purpose**–experiments in the field of neurobiology and psychology

- **Test types**–cognitive tests

- **Data storage resource**–own local storage

- **Country of data storage**–no

- **Personal data storage features**–data is collected and stored locally, researcher is responsible for its storing

- **Techniques of tests creation**–test constructor, description format, programming

- **Test playing**–yes (format of .psyexp)

- **Programming knowledge**–not required for basic use of test constructor

- **Complexity**–installation is carried out using the installer or installation package, the interface is easy, some actions require reading documentation

- **Tools for data analyses**–no

- **Opportunities for data export**–data export in .csv format

- **Integration tools**–API support, integration with outside research tools

- **Solutions relevance**–popular and relevant, beeing supported and developed

- **Solutions features**–visual editor generates code in Python, support of outside tools

B. OpenSesame

OpenSesame is a tool for experiments creation and running in the field of psychology, neurobiology and experimental economics [6, 7]. The application contains an advanced and multifunctional graphical test editor, which is shown in Fig. 2.

The main feature of OpenSesame is the Backend, which is a software level that processes the input (keyboard, mouse, etc.) and output (presentation presentation, sound playback, etc.). There is many libraries that provide this type of functionality, OpenSesame can use every type. Currently there is four type of Backend: Legacy (PyGame functionality is a set of libraries for developing computer games and multimedia applications), Psycho (PsychoPy functionality), Droid (Android functionality) and Xpyriment (Expyriment functionality).
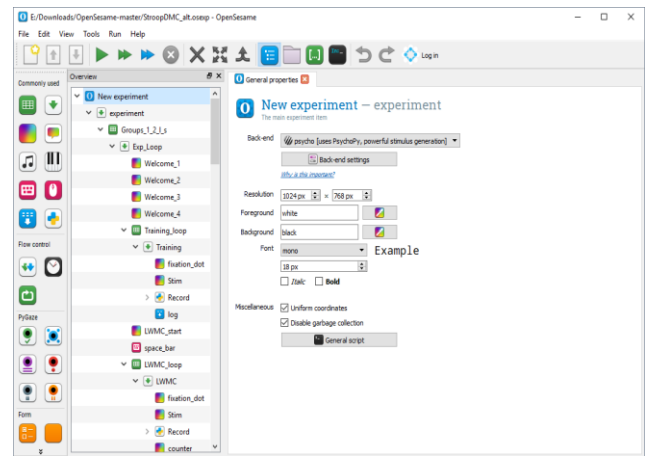

Fig. 2. The Main Test Constructor Window of OpenSesame.

Characteristics of OpenSesame:

- **Web-site**–http://osdoc.cogsci.nl/

- **License**–open source (GNU GPL 3)

- **Platform**–desktop (Windows, MacOS, Linux), modile (Android)

- **Country of production**–Holland

- **Functional purpose**–experiments in the field of neurobiology and psychology

- **Test types**–cognitive tests

- **Data storage resource**–local storage

- **Country of data storage**–no

- **Personal data storage features**–data is collected and stored locally, researcher is responsible for its storing

- **Techniques of tests creation**–test constructor, description format, programming

- **Test playing**–yes (.osexp format)

- **Programming knowledge**–not required for basic use of test constructor

- **Complexity**–installation is carried out using the installer or installation package, the interface is easy, some actions require reading documentation

- **Tools for data analyses**–no

- **Opportunities for data export**–data export in format of .csv

- **Integration tools**–API, OpenSesame Script (simple language for experiment description), plug-ins and extensions (package manager pip), integration with outside research tools (Mouse tracking, Emotiv EEG, Oculus rift etc.), integration with Open Science Framework (OSF)

- **Solutions relevance**–popular and relevant, beeing supported and developed

- **Solutions features**–application is a superstucture (backend) over other tools (PyGame, PsychoPy и Expyriment), quality documentation.

C. jsPsych

jsPsych is not complete application, but is library on JavaScript for web browser. It is developed for behavior experiments creation [8]. Thus, programming knowledge is required for experiment creation using JavaScript libraries. Fig. 3 shows main page of jsPsych.

jsPsych provides a framework for experiments development using a set of flexible plug-ins that create different tasks. Using different plug-ins combination, it is possible to create many types of experiments. It should be noticed that jsPsych library is a part of some software solutions or can be used as extension and is recommended to use.

Characteristics of jsPsych:

- **Web-site**–http://www.jspsych.org/

- **License**–open source (MIT)

- **Platform**–web browser

- **Country of production**–USA

- **Functional purpose**–JavaScript library for cognitive tests creation

- **Test types**–questionnaires, cognitive tests (on the basis of JavaScript it is possible to create every test)

- **Data storage resource**–depending on the code

- **Country of data storage**–no

- **Personal data storage features**–data is stored depending on the code

- **Techniques of tests creation**–programming

- **Test playing**–no

- **Programming knowledge**–required for test creation

- **Complexity**–it is required to learn documentation of library and write code on JavaScript

- **Tools for data analyses**–no

- **Opportunities for data export**–no

- **Integration tools**–use of third-party libraries on JavaScript

- **Solutions relevance**–being supported and updated

- **Solutions features**–tools is not application, but library, the functionality should be developed by researcher.

D. PEBL

PEBL (Psychology Experiment Building Language) is free software that realize psychological test batteries [9, 10]. They are designed to develop a wide range of computer psychological tests that are of interest for neuropsychometric,

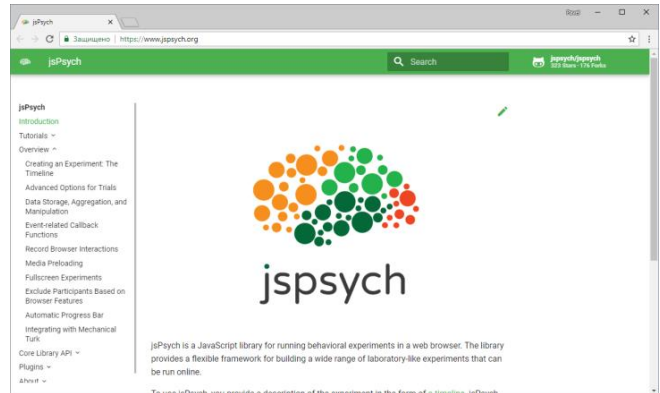cognitive and clinical community [11]. Fig. 4 shows main window of PEBL.
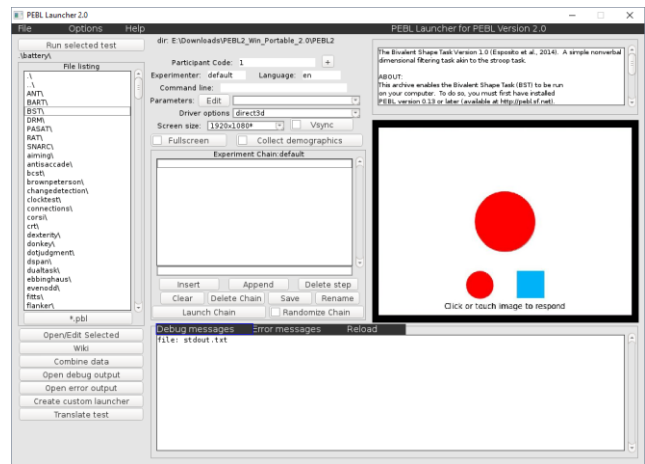

Fig. 3.   Main page of jsPsych.

Fig. 4.   Main Window of PEBL.

PEBL offers a simple programming language for creating and conducting many standard experiments written in C++. To launch the test, it is necessary to choose it in the catalog, set up and run. Hidden launch is not provided. PEBL launcher is used for test running (Fig. 4).

It should be noted that PEBL has some problems with support of Cyrillic. Thus, ASCII characters are use default. To resolve the issue following is required: use the font available in PEBL with Cyrillic support; repeatedly save PEBL script in UTF-8 format without BOM (UTF-16 is not supported) using corresponding text editor.

Although the application is being still supported, it is recommended to use modern solutions (i.e., PsychoPy or OpenSesame described earlier in this paper).

Characteristics of PEBL:

- **Web-site**–http://pebl.sourceforge.net/

- **License**–open source (GNU GPL 2)

- **Platform**–desktop (Windows, MacOS, Linux)

- **Country of production**–USA

- **Functional purpose–**experiments in the field of psychology
- **Test types–**cognitive tests
- **Data storage resource–**local storage
- **Country of data storage–**no
- **Personal data storage features–**data is collected and stored locally, researcher is responsible for its storing
- **Techniques of tests creation–**programming
- **Test playing–**yes (test is created in the own .pbl format)
- **Programming knowledge–**required for test development
- **Complexity–**installation is carried out using the installer or installation package, interface is not convenient and does not meet the modern requirements
- **Tools for data analyses–**no
- **Opportunities for data export–**data export in .txt and .csv format
- **Integration tools–**no
- **Solutions relevance–**interface looks outdated, application is being supported and used
- **Solutions features–**there is a library with prepared tests, there are problems with support of Cyrillic.

E. JATOS

JATOS (Just Another Tool for Online Studies) is developed for creation and completion of online researches on the own server (local or remote) [12]. It means the researcher saves full control over the access to test results. Fig. 5 shows interface of JATOS.

JATOS is client-server application based on server and the work with application is carried out in the browser. There is 2 use-cases: start the server locally and install it on the server. An installation package for Windows, MacOS and Linux is available for local installation. For installation on server, JATOS has another package that does not contain JAVA and a configured server for a concrete OS. The actual JATOS instance on the server is not different from the local one, the main difference is a need to configure manually the server and install necessary libraries.
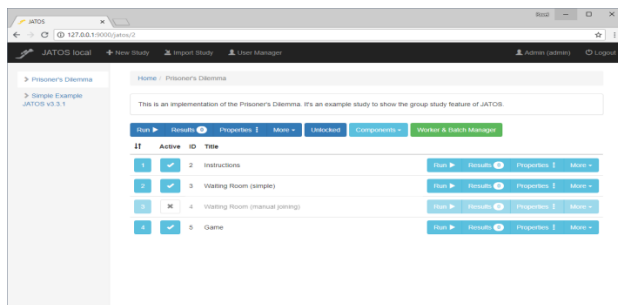

Fig. 5. Interface of JATOS.

Tests is being developed manually with the help of HTML, CSS and JavaScript. The use of jsPsych is proposed for developers.

Characteristics of JATOS:

- **Web-site–**https://www.jatos.org/
- **License–**open source (Apache 2 License)
- **Platform–**web browser, server (Windows, MacOS, Linux)
- **Country of production–**no information
- **Functional purpose–**a tool for psychological online researches
- **Test types–**questionnaires, cognitive tests (it is possible to create any tests based on JavaScript)
- **Data storage resource–**local storage
- **Country of data storage–**no
- **Personal data storage features–**data is collected and stored locally, researcher is responsible for its storing
- **Techniques of tests creation–**programming (JavaScript code along with setting in the application interface)
- **Test playing–**yes (export and import from zip format)
- **Programming knowledge–**required for test creation and updating
- **Complexity–**server is required to run, it is necessary to develop every page of test on JavaScript
- **Tools for data analyses–**no
- **Opportunities for data export–**data export in txt format
- **Integration tools–**use of third-party libraries on JavaScript, integration with Amazon Mechanical Turk (MTurk), Prolific and analogues
- **Solutions relevance–**application is being supported and updated
- **Solutions features–**group researches supported, there is library of prepared research examples, use of the jsPsych library, support of researches with a number of researchers (i.e., Prisoner's dilemma).

F. PsyToolkit

PsyToolkit is free tool for creation and completion of questionnaires and cognitive-psychological experiments and tests [13, 14]. PsyToolkit is used by researches and students all over the worlds. They use it for their own projects. PsyToolkit has many versions: online (in web browser) and offline (Linux version). Fig. 6 shows main page of PsyToolkit web version.
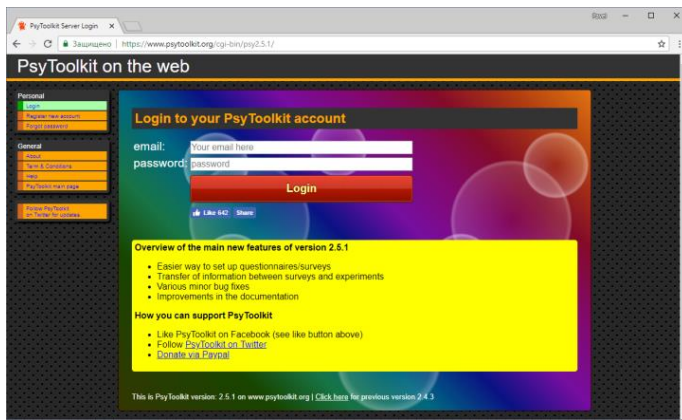
Fig. 6.   Main Page of PsyToolkit.

PsyToolkit does not have any GUI for creating the questionnaires. To do this, it is required to use system format for the description of tests, which is entered on the corresponding page of the system. To create cognitive tests the internal language is used. This language contains a number of command and looks like programming language.

PsyToolkit allows to run own questionnaires and cognitive tests on mobile devices (in web browser), but it should be noticed that response time of touch screens is less accurate than the keyboard.

It is worth to pay attantion that it is prohibited to use PsyToolkit for commercial purposes or business unless direct consent has been obtained from the project author. Students can use PsyToolkit for study and own researches without additional extensions.

Characteristics of PsyToolkit:

- **Web-site–**http://www.psytoolkit.org/

- **License–**web version (Creative Commons Attribution-NonCommercial-ShareAlike 3.0), Linux (GNU GPL 3), commercial use prohibiled, free for students

- **Platform–**web service (SaaS), desktop (Linux)

- **Country of production–**no information

- **Functional purpose–**tool for cognitive-psychological experiments and questionnaires

- **Test types–**questionnaires, cognitive tests

- **Data storage resource–**on service servers (SaaS storage), locally (for Linux version)

- **Country of data storage–**France (Strasbourg)

- **Personal data storage features–**data is collected and stored on service servers (only for SaaS version), registration of researchers is necessary, there is an opportunity to remove account, the anonymity of the data collected depends on the researcher

- **Techniques of tests creation–**own test format (questionnaires), scripts programming (cognitive tests)

- **Test playing–**yes

- **Programming knowledge–**required for the use of questionnaire format and cognitive tests development

- **Complexity–**registration is required, interface looks outdated, easy use of prepared tests, difficult to create questionnaires and cognitive tests (required to develop sctipts)

- **Tools for data analyses–**no

- **Opportunities for data export–**text as output, export to .csv format

- **Integration tools–**Amazon Mechanical Turk, Qualtrix, Sona

- **Solutions relevance–**supported, the design is not updated and looks outdated

- **Solutions features–**there is library of experiments, demo tests, complete documentation, there is YouTube channel with training videos

G. 1ka

1ka is free web service (SaaS) of open source, that allows creation and online research completion. Web service includes questionnaire constructor with a large number of functions and opportunities. Interface of application is presented on Fig. 7.

1ka allows to create complex questionnaires that can include conditioning, blocks, loops and about 30 different types of questions. 1ka allows to send invitations and reminders to an unlimited number of potential respondents to participate in questionnaires and also allows to manage the database of respondents. In addition, it allows the user not only to use the public library of questionnaires, but also to create his own. 1ka includes embedded system of troubleshooting system for the created questionnaires and provides recommendations based on the methodological guidelines of the most common errors.

Characteristics of 1ka:

- **Web-site–**https://www.1ka.si/

- **License–**free (open source)

- **Platform–**web service (SaaS), mobile (Android)

- **Country of production–**Slovenia

- **Functional purpose–**creation and completion of online researches based on questionnaires

- **Test types–**questionnaires

- **Data storage resource–**on service sesrvers (SaaS storage)

- **Country of data storage–**Slovenia, Ljubljana (Centre of Social Informatics)

- **Personal data storage features–**data is collected and stored on service servers (by installation on the own server data will stored locally), application complies with GDPR, researchers registration is necessary, there is an opportunity to remove account

- **Techniques of tests creation–**test constructor

- **Test playing–**yes (by copping questionnaire)

- **Programming knowledge–**not required

- **Complexity–**easy, required to register and start test creating (by using application as SaaS), interface is outdated and tangled, test constructor is convenient and there is many settings

- **Tools for data analyses–**no (basic statistical data analysis)

- **Opportunities for data export–**data export into .csv format

- **Integration tools–**API support, modules

- **Solutions relevance–**relevant, supported, popular among online questionnaire systems

- **Solutions features–**support of different design themes, public library of tests, installation on own server, uploading test results into paper format (.pdf and .rtf), complete documentation

H. Labvanced

Labvanced is commercial Internet platform for creation, completion and sharing of online experiments based on questionnaires and cognitive tests [15, 16]. Project was planned as "all-in-one" to combine different types of testing, methods, capabilities and data analysis into one single platform using the latest web technologies. Fig. 8 shows interface of test constructor.
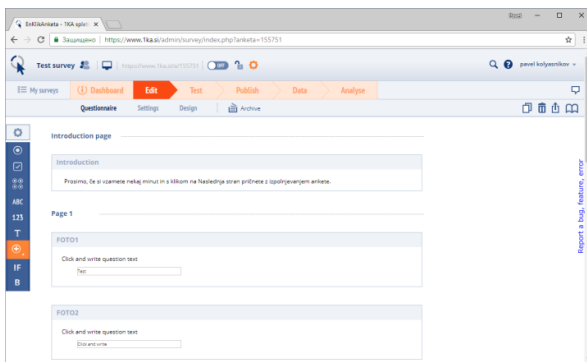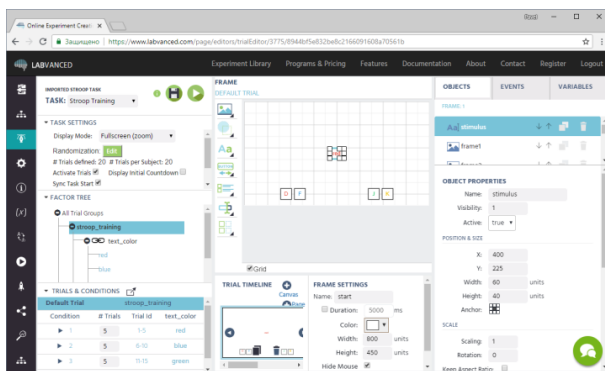

Fig. 7.   Interface of 1ka.

Fig. 8.   Interface of Labvanced Test Constructor.

Researches in Labvanced consist of a task (an instance in the research), a block (a group of related tasks), a session (the session includes several blocks) and a group (used to define several groups of subjects in one research).

Labvanced allows to create the pages of different types: Canvas (a page of cognitive test with a free object replacement) and Page (a page of questionnaire). It allows to combine questionnaires and cognitive tests in one research. In Canvas, it is possible to add media objects (images, movies, audio content, eye tracking and sound recording). It should be noticed that it is not allowed to add images as object, but they can be added in text editor. Furthermore, Labvanced supports dynamic behavior due to the embedded event system (loops, conditions, callback, arrays, and mathematical expressions).

One of the interesting features of the platform is the support of real-time multiplayer experiments to study cooperative behavior, collaborative solutions etc. This feature requires two or more participants to simultaneously begin the same study.

Characteristics of Labvanced:

- **Web-site–**https://www.labvanced.com/

- **License–**chargeable, there is free tariff (1 active research, 10 uploads per month), open source planned for the future

- **Platform–**web service (SaaS)

- **Country of production–**Germany

- **Functional purpose–**online researches

- **Test types–**questionnaires, cognitive tests

- **Data storage resource–**on service servers (SaaS storage)

- **Country of data storage–**Germany

- **Personal data storage features–**data is collected and stored on service servers, required to register researchers (account removing and email changing are not possible), research participants are not required to register

- **Techniques of tests creation–**advanced constructor with support for both questionnaires and cognitive tests

- **Test playing–**yes (test coping in the system)

- **Programming knowledge–**not required

- **Complexity–**usage requires registration, the interface is thoughtful and looks good, increased learning curve due to the large number of features and settings, some actions are not intuitive

- **Tools for data analyses–**data review, filters, automated data analyses and visualization are planned in the future

- **Opportunities for data export–**data export into .csv and .json

- **Integration tools–**Amazon Mechanical Turk, API is planned in the future

- **Solutions relevance–**relevant, supported and updated

- **Solutions features–**combination of questionnaires and cognitive tests in one research, support of web cam for eye tracking and audio recording, support of cooperative researches (two and more participants), teamwork on one research (one person at a time), experiments can be compiled and loaded for offline research (premium users), there is a public library of experiments

I. *Gorilla*

Gorilla is a commercial web service, allowing to conduct online behavioral researches based on questionnaires and cognitive tests. For each type of test, GUI constructor is used and opportunities of visual programming shown in Fig. 9 are available. Gorilla also allows to develop some task with the use of JavaScript.

Web service Gorilla provides a large number of graphic constructor for creating experiments. All changes made are saved. The questionnaire constructor shows changes in real time, and the experiment constructor contains a graphic tree for visual programming of tasks. Gorilla includes different opportunities for development such as code editor, task builder, questionnaire builder. Furthermore, the integration with third-party libraries (i.e., JSPsych) is possible.

Gorilla supports different methods for participant invitation (email, link etc.). The application provides collaboration and sharing tools that allow users to share work with colleagues and co-workers.

Characteristics of Gorilla:

- **Web-site–**https://gorilla.sc/

- **License–**chargeable (charged for each respondent)

- **Platform–**web service (SaaS)

- **Country of production–**Republic of Seychelles

- **Functional purpose–**online behavior experiment completion

- **Test types–**questionnaires, cognitive tests

- **Data storage resource–**on the service servers (SaaS storage, Microsoft Azure)

- **Country of data storage–**Holland

- **Personal data storage features–**data is collected and stored on service servers, researchers registration required, there is an opportunity to remove account

- **Techniques of tests creation–**advanced graphic constructor

- **Test playing–**yes

- **Programming knowledge–**not required (only by use of scripts for functionality extension)

- **Complexity–**registration required, the interface is thoughtful and looks good, there are hints for new

users, visual programming is used, the test constructor is overloaded in some places, there is a preview and good documentation

- **Tools for data analyses–**no

- **Opportunities for data export–**data export into .csv format

- **Integration tools–**integration with different systems (Prolific, Sona Systems, Amazon Mechanical Turk and Qualtrics), third-party libraries (i.e., JSPsych) and programming (JavaScript)

- **Solutions relevance–**relevant, supported and being updated

- **Solutions features–**creating an experiment in the form of visual programming, co-working on projects, saving versions of all the changes

J. *Indigo*

Testing application Indigo is a tool of automated test and results processing. This tool is developed to solve a wide range of tasks: testing and student knowledge control, determining the professional level of employees, psychological testing, conducting questionnaires, organization of competitions and contests. Fig. 10 shows the interface of the administration panel.
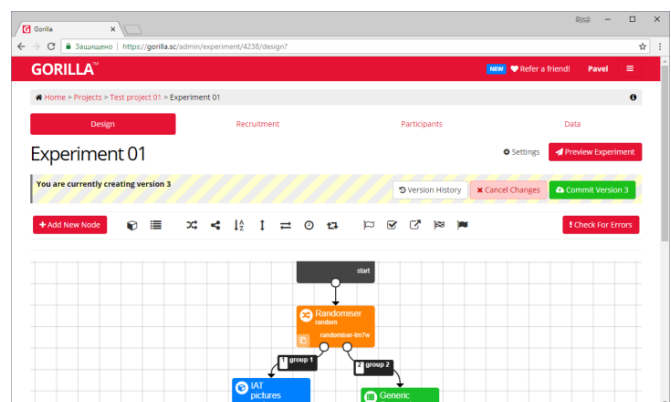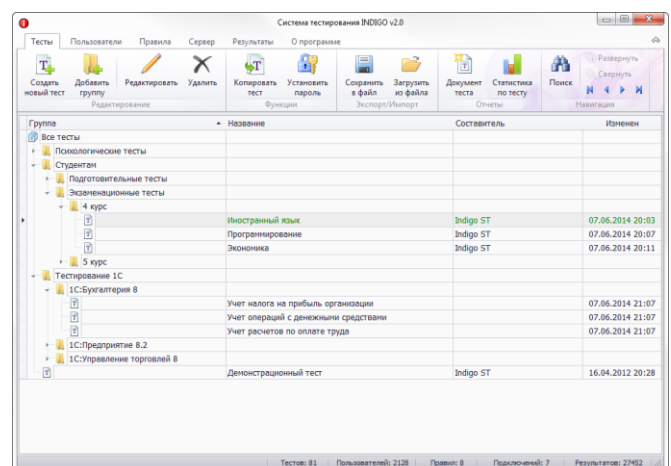

Fig. 9. Interface of Gorilla.

Fig. 10. Interface of Indigo Administration Panel.

The testing system is being installed on a single server using an installation package. The system can work both on an isolated computer and in a local network or via the Internet. Research participants work through web browsers, including on mobile devices.

One license allows working the testing system on one computer. The number of administrators is unlimited. The required maximum number of simultaneously tested users (number of connections) determines the cost of the license.

Characteristics of Indigo:

- **Web-site**–https://indigotech.ru/

- **License**–chargeable (depends on number of concurrent connections, permanent)

- **Platform**–client side is web browser, server and administration panel are Windows

- **Country of production**–Russian Federation

- **Functional purpose**–testing of students and staff, psychological testing, conducting questionnaires, organizing competitions and contests

- **Test types**–questionnaires

- **Data storage resource**–own local storage (installation on own server)

- **Country of data storage**–no

- **Personal data storage features**–data is collected and stored locally, researcher is responsible for its storing, anonymous testing is not provided (registration of respondents is required)

- **Techniques of tests creation**–test constructor

- **Test playing**–yes (test export and import in .itest format)

- **Programming knowledge**–not required

- **Complexity**–simple, it is enough to install the application using the installer and configure the system, the interface is thoughtful and looks beautiful

- **Tools for data analyses**–table of test results, statistics, diagrams are not realized

- **Opportunities for data export**–generating different reports and statistics, data export into .xls

- **Integration tools**–no

- **Solutions relevance**–relevant, being updated and used in a large number of organizations, schools and institutions

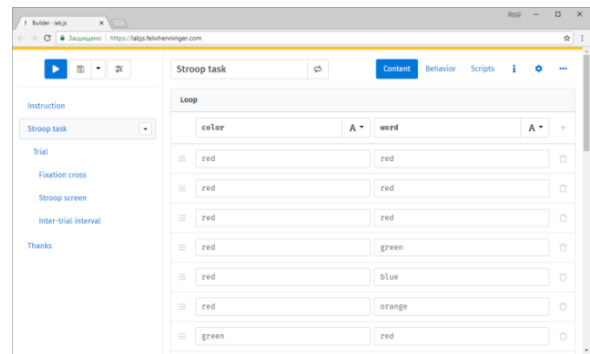- **Solutions features**–includes a wide range of prepared tests, it is possible to order own configuration

Fig. 11. Interface of Test Constructor in Lab.js.

K. *lab.js*

lab.js is a tool allows to create any researches in browser in the field of social and cognitive science [17]. The researches can be created with the use of visual constructor or with the help of programming code [18]. Fig. 11 shows the interface of test constructor in lab.js.

lab.js was primarily focused on building experiments from scratch on HTML and JavaScript. The software solution is developed for people with programming skills. Lab.js includes a visual test constructor and JavaScript library.

The visual tool simplifies many aspects by research building. However, to use the constructor, it is needed to have basic programming skills and knowledge of HTML. The constructor includes various components: Canvas (visual placement of elements), Screen (page in HTML code), Sequence (shows components sequentially) and Loop (repeating component). In addition, full access to the base code is available. It will allow to adapt the research to any requirements.

The JavaScript library is the primary one used to build and run research lab.js. This allows to develop own researches without constructor from scratch.

The feature of the application is quite flexible possibilities of using a software solution: exporting an experiment for local use without a server, exporting an experiment with a server part in PHP, and also exporting to JATOS (in the zip archive format).

Characteristics of lab.js:

- **Web-site**–https://lab.js.org/

- **License**–open source (library of Apache License, constructor and interface of GNU Affero General Public License)

- **Platform**–web

- **Country of production**–Germany

- **Functional purpose**–tools for creation of social and cognitive tests

- **Test types**–cognitive tests

- **Data storage resource**–own local or remote storage

- **Country of data storage**–no

- **Personal data storage features**–data is collected and stored locally, researcher is responsible for its storing

- **Techniques of tests creation**–constructor (graphic interface), programming (HTML, CSS, JavaScript)

- **Test playing**–yes (experiments are saved in .json format)

- **Programming knowledge**–required (for basic understanding by using constructor and programming)

- **Complexity**–complex, test constructor contains some specific terms, the use of some features requires programming skills and reading the documentation

- **Tools for data analyses**–no

- **Opportunities for data export**–data export into .csv or .json format

- **Integration tools**–JATOS (import from lab.js), uploading to Netlify, integration with LimeSurvey, Qualtrics, SoSci

- **Solutions relevance**–relevant, the library is buing used and updated, but there is not any planning in the future

- **Solutions features**–there is a good flexibility due to the possibility of programming, supports the export of the test for local or online use (PHP, Netlify), there are training video materials.

L. Pavlovia

Pavlovia is new service launched by PsychoPy developers in July 2018 [19]. The service is a community of researchers and a place for launch, exchange and study of experiments if the field of behavior science. Initially, the service was planned as a place for storing and launching researches created in PsychoPy. However, it was developed as an open solution that is aimed to support third-party tools such as jsPsych and lab.js. Fig. 12 shows a list of public and private prepared tests.

Pavlovia is not a service for research creation, but a service for storing, start and managing the experiments created with a help of PsychoPy (in visual tool PsychoPy Builder a test is being created, then it is presented on web page based on PsychoJS), jsPsych (high-level library on JavaScript), lab.js and other experiments, written on JavaScript.

All researches (projects) are stored in the Git version control system based on the free GitLab repository management system. Thus, the researcher needs to understand the principle of working with version control systems and a number of specific terms. Each project in GitLab is a research that will be displayed in Pavlovia (in an public or private list).

In Pavlovia there are demonstration tests that can be passed. It is possible to check their program code. It is worth noting that all the data obtained as a result of passing the test is stored in the same Git repository in the appropriate directory.
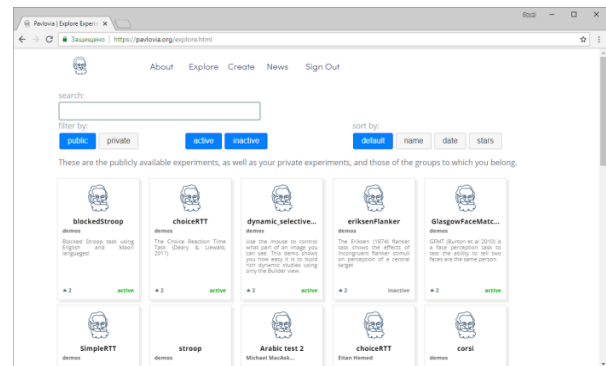

Fig. 12. Window of Prepared Tests in Pavlovia.

Characteristics of Pavlovia:

- **Web-site**–https://pavlovia.org/

- **License**–free

- **Platform**–web service

- **Country of production**–Great Britten (with support of University of Nottingham)

- **Functional purpose**–community of researchers and a place to start, exchange and study experiments in the field of behavioral sciences

- **Test types**–cognitive tests

- **Data storage resource**–on service servers

- **Country of data storage**–no information (domain is replaced in Nottingham, Great Britten)

- **Personal data storage features**–system complies with GDPR, authorization is required to create research (only e-mail is necessary), all data is not stored anywhere else by removing, the responsibility for data collection is borne by the researcher

- **Techniques of tests creation**–interface (PsychoPy Builder creates JavaScript with the use of PsychoJS library), programming (HTML, JavaScript, jsPsych, lab.js etc.)

- **Test playing**–yes (based on the git technology, there is an opportunity to move and copy, there is a revision history)

- **Programming knowledge**–required for test creation, git system knowledge is needed

- **Complexity**–difficult, because for the creation of tests, it is required to have a number of knowledge (programming and working with version control systems that programmers use)

- **Tools for data analyses**–no

- **Opportunities for data export**–data is collected and saved in .csv format

- **Integration tools**–no

- **Solutions relevance**–started in July 2018

- **Solutions features**–Git used, based on the Gitlab system, application can use PsychoPy Builder, jsPsych, lab.js and JavaScript for test creation, there is public research library.

M. Google Forms

Google Forms is online service for creation of feedback form creation, online testing and questionnaires. Tests can be created, edited and completed both on the computer and mobile device. Fig. 13 shows form editor in Google Forms.
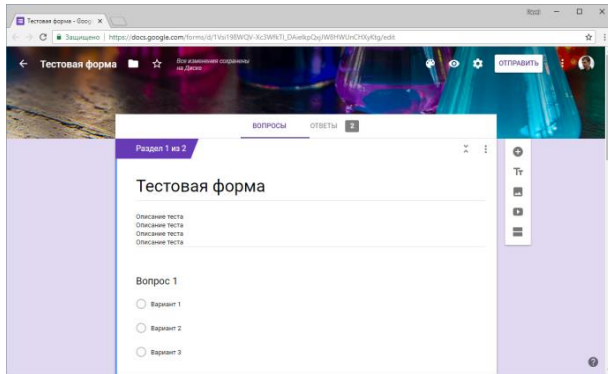

Fig. 13. Editor of Google Forms.

Google Forms contains one link for all research participants. Therefore, by turning on the option "Send the form no more than once", log in into Google account is required to participate in the questionnaires. It may also affect the anonymity of the data provided. At the beginning of the research, it is possible forcibly to ask for email addresses.

Google Forms provides a script editor in its language called Google Apps Script that is based on JavaScript.

Test results are being added to the table in real time. A respondent sends the answer that is saved in the table automated. Then it is possible to download the results in .csv format.

Characteristics of Google Forms:

- **Web-site**–https://www.google.com/forms/about/

- **License**–free

- **Platform**–web service (SaaS)

- **Country of production**–USA

- **Functional purpose**–creation of feedback form, online tests and questionnaires

- **Test types**–questionnaires

- **Data storage resource**–Google servers (SaaS)

- **Country of data storage**–no information provided (USA and disturbed servers all over the world)

- **Personal data storage features**–data is collected and stored on service servers, Google account required for test creation and sometimes for test completion, data collecting depends on the test

- **Techniques of tests creation**–visual test constructor

- **Test playing**–yes (by coping forms to Google Drive)

- **Programming knowledge**–not required

- **Complexity**–easy, all actions are performed in graphical mode with a preview, a small number of settings reduces the threshold for entry into the system, themes are supported

- **Tools for data analyses**–general summary of the answers (with diagrams), view of the results for each answer

- **Opportunities for data export**–data export into .csv format and Google Tables

- **Integration tools**–extensions, script editor (Google Apps Script)

- **Solutions relevance**–relevant, popular, used all over the world for questionnaires, testing and also for academic purposes

- **Solutions features**–teamwork on the creation, support of themes, editing the test after the start of the research, email notifications

Google Forms was chosen as the main and most well-known service for conducting online questionnaires. There is also a large number of similar services that provide similar functionality. They are not developed to conduct psychological researches, but may well be used for this purpose. It is also worth to note that these applications have a fairly simple data processing system.

III. DEVELOPMENT PSYCHOLOGICAL TOOLS

Software analysis made it possible to formulate the development requirements for a specialized tool for longitudinal studies. Based on them, a Digital psychological platform was developed.

Digital psychological platform is a project started in 2017 and being developed [19, 20]. The tool specializes in the field of psychology: psychological testing, data collection and analysis, support for mass and longitudinal researches. Fig. 14 shows the interface of Digital psychological platform.

Currently, some of the planned features of the platform have not been implemented, and since the application is under development, it is early to speak of its effectiveness. Expected that the application will be used in the following areas: online and offline psychological researches conducting, mass researches at educational institutions, longitudinal surveys. The moderation is planned to verify the compliance of research ethical standards.

Characteristics of Digital psychological platform:

- **Web-site**–https://digitalpsytools.ru/

- **License**–free (registration requires approve from the service administrator)

- **Platform–**web-service (SaaS), desktop planned (Windows, Linux, MacOS) and mobile (Android, iOS)

- **Country of production–**Russian Federation

- **Functional purpose–**online questionnaires

- **Test types–**questionnaires, cognitive tests planned

- **Data storage resource–**on service servers

- **Country of data storage–**Russian Federation

- **Personal data storage features–**data is collected and stored on service servers, researchers registration is requires (confirmed by the administration of the service), anonymous testing is supported (an authorization mechanism is planned for a previously created set of logins/passwords without using personal data)

- **Techniques of tests creation–**test description format

- **Test playing–**yes (test export and import into .zip format)

- **Programming knowledge–**required for test creation

- **Complexity–**medium, the system interface requires a more detailed design, creating tests requires knowledge of the provided JSON format

- **Tools for data analyses–**output results table

- **Opportunities for data export–**data export into .csv and .json format

- **Integration tools–**API

- **Solutions relevance–**under development

Proposed an approach to conduct researches in the condition of an unstable and slow Internet connection, proposed a mechanism for ensuring reproducible research (transmission in unchanged form), and developed its own format of tests on based JSON.
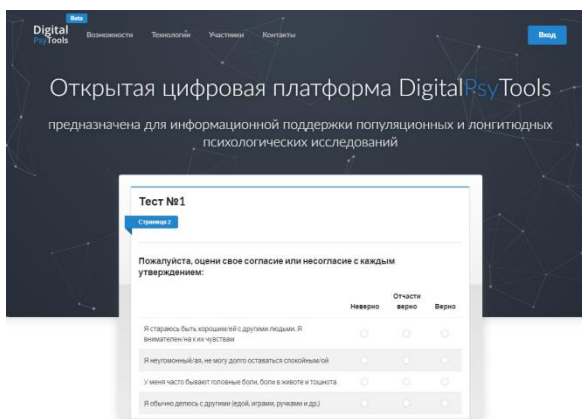

Fig. 14. Interface of Digital Psychological Platform.

IV. CONCLUSION

This digital platform was used for project of the "Cross-cultural Longitudinal Analysis of Student Success" (CLASS). The aim of this longitudinal genetically informative project is the study of the factors and mechanisms of success in learning throughout the school years. Cross-cultural longitudinal study is aimed to study the whole period of schooling - from 1 to 11 grade. A longitudinal research involves 11 stages of measurements (each year of study - one stage of research). Schoolchildren from two states (the Russian Federation and the Kyrgyz Republic), who are similar in organization of the education system, but differ in language, culture, structural and institutional characteristics of the society, take part in the study. The research sample includes 1300 schoolchildren from Russia and 1700 from Kyrgyzstan (including schoolchildren with a native Kyrgyz language and schoolchildren with a native Russian language). In total, 3,000 schoolchildren will take part in the study, the age range of the participants covers the entire period of schooling (from 6.5 to 18 years).

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