TECHNICAL MEMO:

AI MODELS AND DATA PROCESSING IN THE QUANTUM G BETA SYSTEM

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1 INTRODUCTION

This document describes the AI models and algorithms used in the Quantum G Beta test. The system is designed for testing children between the ages of 6 and 16 and applies a combination of neural networks and machine learning algorithms for:

- processing and analyzing individual behavioral responses and speech characteristics of the child during interactive testing;
- automatically evaluating the completion of test tasks;
- processing the final analytical findings.

2 GENERAL TESTING PROCESS

The test consists of a series of interactive tasks that the child completes using a device equipped with a camera and microphone. Throughout the session, the system collects video and audio data and records the child's interactions with the interface. It is important to emphasize that all AI components of the system are discriminative analytical models—they do not generate content or engage in dialogue with the child, but instead perform data analysis and classification. Each model is designed to carry out a narrowly specialized procedural task.

Several specialized AI subsystems operate in parallel during task completion: condition validation, models for handwriting analysis, speech analysis, gaze direction detection, and facial expressions and motor activity tracking. The results from these subsystems are sent to the primary processing module, which forms a unified matrix of test task results. At the next stage, the final report generation module uses this matrix to produce the overall testing outcome.

The testing process is conducted in three sessions, due in part to technical requirements related to input data quality: the accuracy of the analytical models directly depends on recording conditions. The multi-session approach helps minimize random fluctuations and improve the stability of the final assessments. In certain cases involving specific models or atypical results, an additional human review process is also provided.

Technical Factors Affecting Result Quality

Model accuracy is affected by the following factors:

- video signal quality (resolution, compression artifacts);
- internet connection stability (loss of video frames and audio data);
- audio and microphone quality (background noise, echo);
- lighting conditions (insufficient, excessive, or high-contrast lighting reduces the accuracy of visual models);
- device performance, since insufficient computational resources may result in dropped frames and degradation in video and audio capture quality.

To minimize these factors, guidelines for parents and technical preparation instructions have been developed for the testing process *(see Testing Process and Preparation).*

For information on the availability of the beta version of the test for children with specific developmental characteristics and functional needs, see Section 5 of the *User Agreement*.

3 CONDITION VALIDATION

This subsystem operates during the testing process and ensures several key functions.

Position verification: the system monitors whether the child is positioned correctly relative to the camera (distance, face position within the frame, and body orientation); if the parameters fall outside the acceptable range, the system prompts the child to adjust their position.

Parent presence verification: the system verifies the presence of a parent or legal guardian within the frame, without collecting their biometric data, as this is a mandatory requirement for completing the test.

Limitations. The accuracy of this subsystem may be affected by factors such as headwear, tinted glasses, high-contrast or visually complex backgrounds, and lighting conditions that interfere with face detection and segmentation.

4 AI MODELS FOR TEST TASK ANALYSIS AND EVALUATION

4.1. Calligraphy Analysis

The model analyzes the child’s handwriting input on a touchscreen and evaluates the quality of graphomotor skills. Input data includes touch coordinates (stroke data), timestamps, and movement speed data. Based on this information, raster masks are generated and compared pixel-by-pixel with a reference template. The materials are adapted to children's ages.

The model measures three aspects: accuracy of shape reproduction, speed, and orientation toward hidden rules.

At the feature level, the system uses overlap metrics, geometric characteristics, structural metrics, and hint-region coverage statistics. Handwriting evaluation is performed through a hybrid ML + algorithmic pipeline that compares the user’s strokes with a reference template.

Validation and Quality Control. Model predictions were compared with expert evaluations to verify inter-rater agreement. Since the input data consists of objectively measurable physical characteristics of the handwritten elements produced by the user, the model is not subject to the subjective biases typically associated with content-based assessments. When necessary, the AI models' outputs undergo human review. The system also includes prediction distribution monitoring, data drift control, and the collection of reviewer feedback for training future model versions.

Limitations. The model evaluates the graphomotor characteristics of strokes without accounting for the child’s situational conditions—such as fatigue, reduced concentration, or external distractions—that may affect task performance during a particular session.

4.2. Voice Analysis

The voice analysis subsystem processes audio recordings of the child’s responses and includes two components: speech-to-text (conversion of speech into text) and prosody analysis (analysis of prosody—intonation, pausing, speech melody, and rhythm). The system measures speech accuracy and speed, as well as prosodic characteristics.

A pretrained multilingual model is used for speech recognition. To improve results, several variations of this model are used in parallel. Specialized acoustic feature-extraction algorithms are applied to prosody analysis. At the feature level, the model relies on linguistic (utterance content and structure), acoustic (pitch, volume, and tempo), and prosodic (intonation patterns, rhythm, and pausing) characteristics.

Training and calibration. The model’s output data is passed to an analytical pipeline that implements mathematical algorithms for extracting target features in accordance with the analysis methodology for the corresponding test task.

Validation and quality control. A preliminary performance evaluation of the prosodic algorithms was conducted using children’s voices from various demographic groups. Based on this evaluation, no significant systematic differences were identified across the applied metrics. The model analyzes the acoustic characteristics of speech and does not use race or gender attributes of the test subject as direct input features. When necessary, the AI models' outputs undergo human review. The system also monitors speech recognition accuracy, transcription quality, the distribution of prosody assessments, and audio signal characteristics.

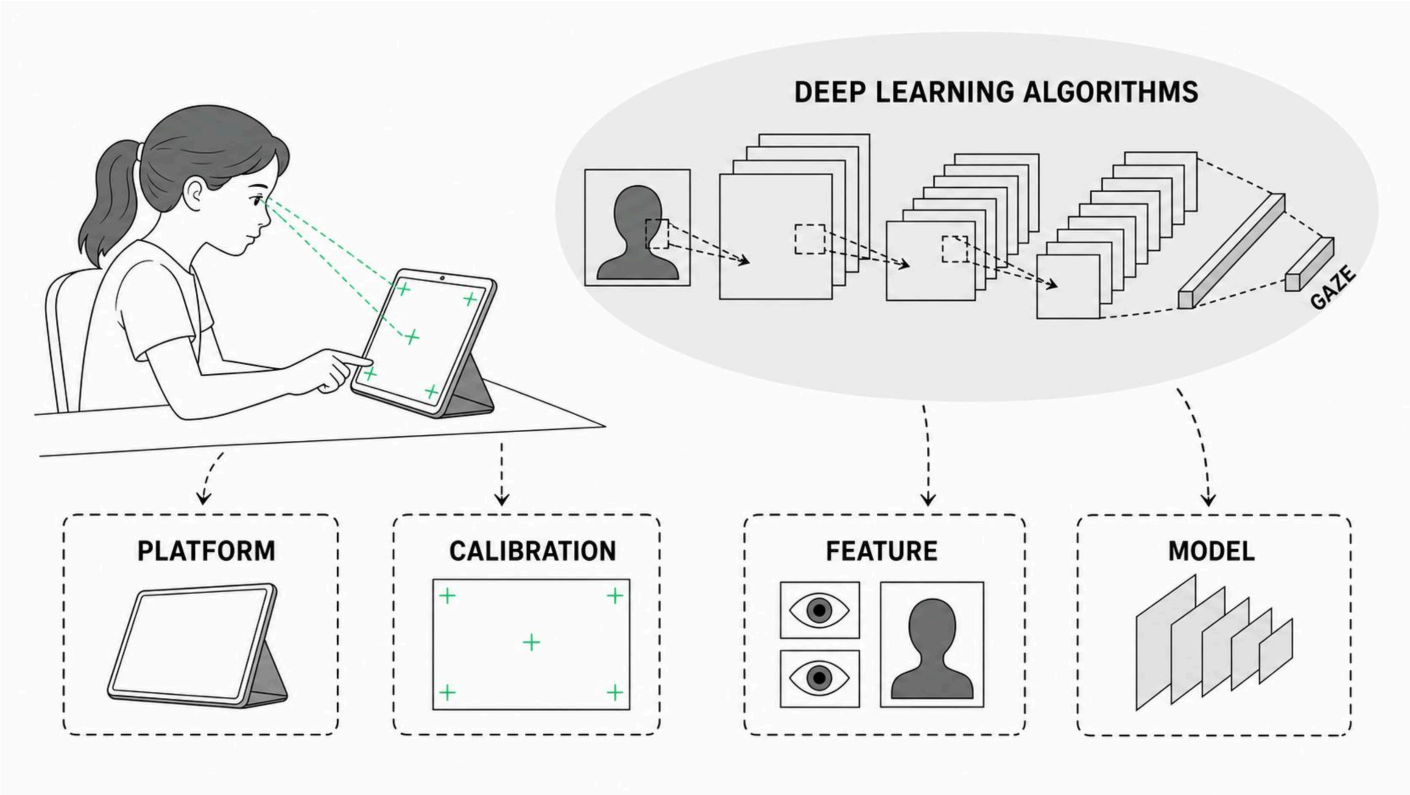
Limitations. The speech-to-text model was trained primarily on adult speech, which may reduce recognition accuracy for certain pediatric age groups; human review helps identify and correct such cases.

The proprietary prosodic algorithms in the current version are designed specifically for children’s voices within the 6–16 age range.

Factors specifically affecting the quality of analysis in this subsystem include significant background noise, poor microphone quality, and high levels of anxiety in the child. In adolescents experiencing puberty-related voice changes, acoustic characteristics may fall outside the prosodic algorithm's trained range, reducing the accuracy of prosodic analysis.

4.3. Gaze Tracking

The subsystem determines the direction of the child’s gaze and calculates the screen location the child is looking at during specific test tasks. The process operates in two stages: first, a neural network determines the gaze vector along the yaw and pitch axes; then, the system converts it to screen coordinates.



A two-level pipeline is used to determine gaze direction. At the first level, a pretrained neural network performs real-time extraction of facial landmarks, head pose estimation, gaze vector computation, distance-to-camera estimation, and blink detection. At the second level, gaze calibration is performed during test task execution, enabling an ML model to map the gaze vector to normalized screen coordinates while accounting for device position, camera distance, and the individual geometry of the face. Based on the resulting time series of gaze point coordinates, the system analytically extracts visual behavior characteristics, including fixation duration, saccade frequency and amplitude, and gaze movement patterns.

The gaze tracking system measures the direction and focus of the child's attention, visual screen-scanning patterns, fixation time on specific areas, and the speed of attention shifting.

Validation and quality control. The system's results are compared with manual evaluations performed by specialists using a specially developed mathematical model for the corresponding test task. In addition, the module's performance stability is evaluated across different user subgroups, including age, ethnicity, device type, eye color, and the presence of glasses. In this case, human review is conducted for each testing session, and the results are used to further train the proprietary model. The system also monitors gaze point estimation error and video data quality.

Limitations. The accuracy of the results is highly dependent on lighting conditions: excessive or insufficient lighting reduces the quality of the input data. Reflections in glasses and significant head movements make gaze direction detection more difficult. The highest accuracy is achieved when the head remains stable and positioned at a moderate distance from the camera.

4.4. Facial Expressions

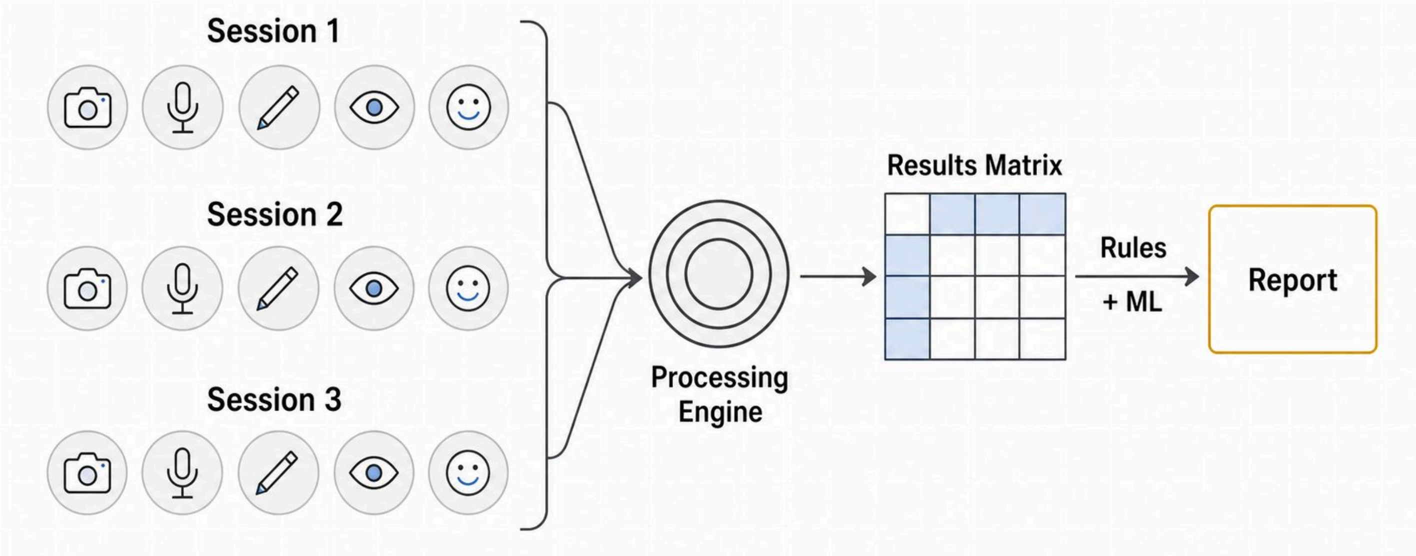
The subsystem tracks the child's facial expressions and movements within the frame, recording the number and types of facial reactions, the volume and nature of movements, and the overall level of motor activity. For this purpose, a pretrained neural network is used to perform real-time extraction of three-dimensional facial landmarks.

Based on the extracted landmarks, the subsystem identifies facial reactions and motor events and determines their volume and characteristics. This data is then passed to an algorithmic model as supplementary information, followed by scoring within the framework of each test.

A pretrained model is used for facial landmark extraction. Proprietary counting and classification algorithms developed specifically for the testing system are applied on top of its features. The results are reviewed by specialists when necessary. Validation is also conducted to ensure correct performance across different age groups, skin tones, and device types.

Limitations. Accuracy depends on lighting conditions, distance from the camera, and viewing angle. Quantitative indicators of reactions serve only as supplementary information. The system records observable facial expressions and movements but does not interpret the child's internal emotional states. The results are not intended for psychological or emotional profiling or diagnostic purposes.

5 FINAL DATA PROCESSING



Quantum G Beta is based on clear algorithms, controlled data processing, and a transparent report generation procedure. Final result processing is implemented using a hybrid Rules-in-ML architecture (hybrid approach) that combines a rule-based inference system with machine learning (an ML model). Data derived from the test subject's responses, some of which is processed by AI models, is aggregated into a unified feature vector for each session. This information does not contain the test subject's personal data. The expert rule system then applies information encoding in accordance with the testing methodology. The ML component processes this data, and the resulting output is subsequently used to generate the final testing results.

The hybrid approach ensures that results are calculated based on predefined rules and improves accuracy through the application of a machine learning component.

6 DELIVERY OF TESTING RESULTS

Preparation of testing results takes up to 3 days.

At this stage, the Quantum G Beta assessment does not use an instant automated result delivery system. After the child completes the testing process, the data undergoes several stages of processing, including quality verification of the collected information, individual calibration of gaze-tracking and graphomotor skill parameters, data processing via an ML-based pipeline, and additional human review when necessary.

AI data processing algorithms compare the child's responses with their personalized calibration profile, allowing the system to account for individual perceptual characteristics and improve the accuracy of the final analysis.

Below is a description of the data flow from the completion of the test to the generation of the final report.

1

Test Completion → Automatic Data Collection

The system receives:

- video stream data (for gaze tracking and behavioral signals),
- voice data (only for completing specific tasks),
- responses to visual stimuli (images, hieroglyphs, and tasks).

All data is captured automatically. No human involvement occurs at this stage.

2

Initial processing: data preparation

The data undergoes:

- automatic cleaning (AI quality filters),
- automatic validation (the system determines that the child has actually completed the task).

In some cases, human quality control is used, but:

- The quality control specialist can only view technical fragments, such as video frames or audio recordings, but they do not know who they belong to.
- They do not influence future analytical results (their task is only to ensure that the system has correctly processed the data).

3

Data protection

Before transmission to the analytical system:

- All personal information about the child is removed,
- Only a non-identifiable ID token remains, with no link to the individual’s identity; all data is encrypted.

After this stage, the data no longer contains any personal information and is further processed in this de-identified form.

4

Transmission to the analytical module

Encrypted, anonymized data is sent to the analyzer:

- The analyzer receives only numerical data and a technical ID; no personal data is included.
- A rule-based ML/AI algorithm is launched.
- The algorithm calculates the result.

The algorithm does not process any personal data about the child; it operates only with coded identifiers.

5

Return of the result (also anonymized and encrypted)

The analytical system returns data:

- encrypted sets of codes (numbers),
- with no text and no interpretations.

It’s like a Rubik’s cube made of numbers that needs to be solved.

6

Final report assembly

- the technical ID is linked to the child's name,
- the system decodes combinations of codes into meaningful blocks,
- a report is generated according to a predefined approved structure.

At this stage, a specialist with a specific access level can:

- verify the correctness of the assembly,
- compile a visual document (design layout).

However:

- they do not modify the data,
- they do not interpret it,
- they do not generate conclusions manually.

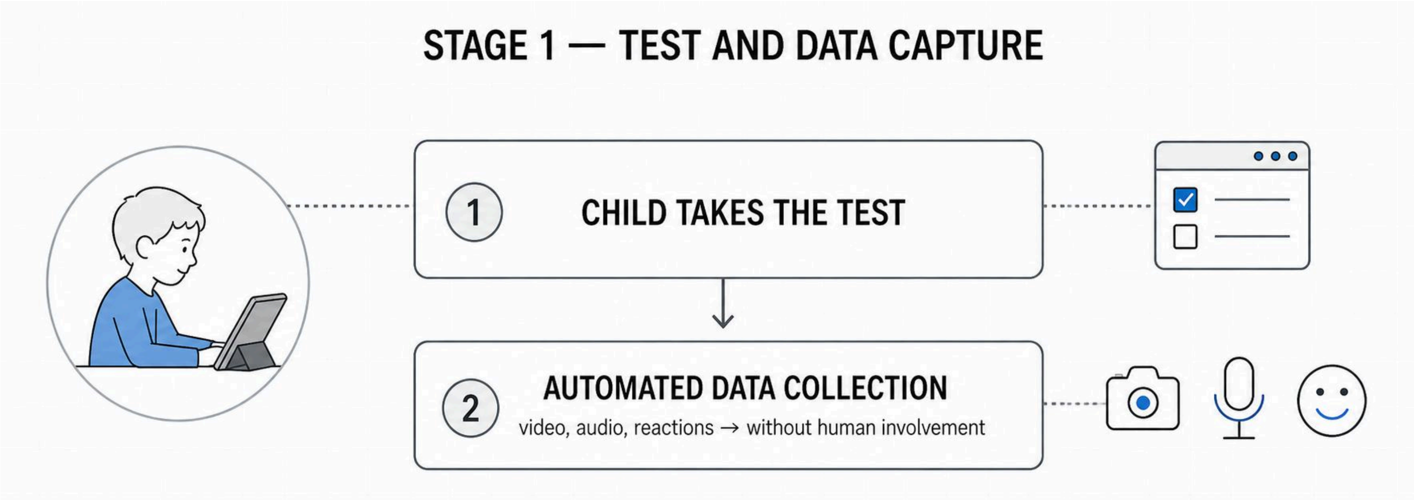
The report is always generated strictly in accordance with the algorithm.

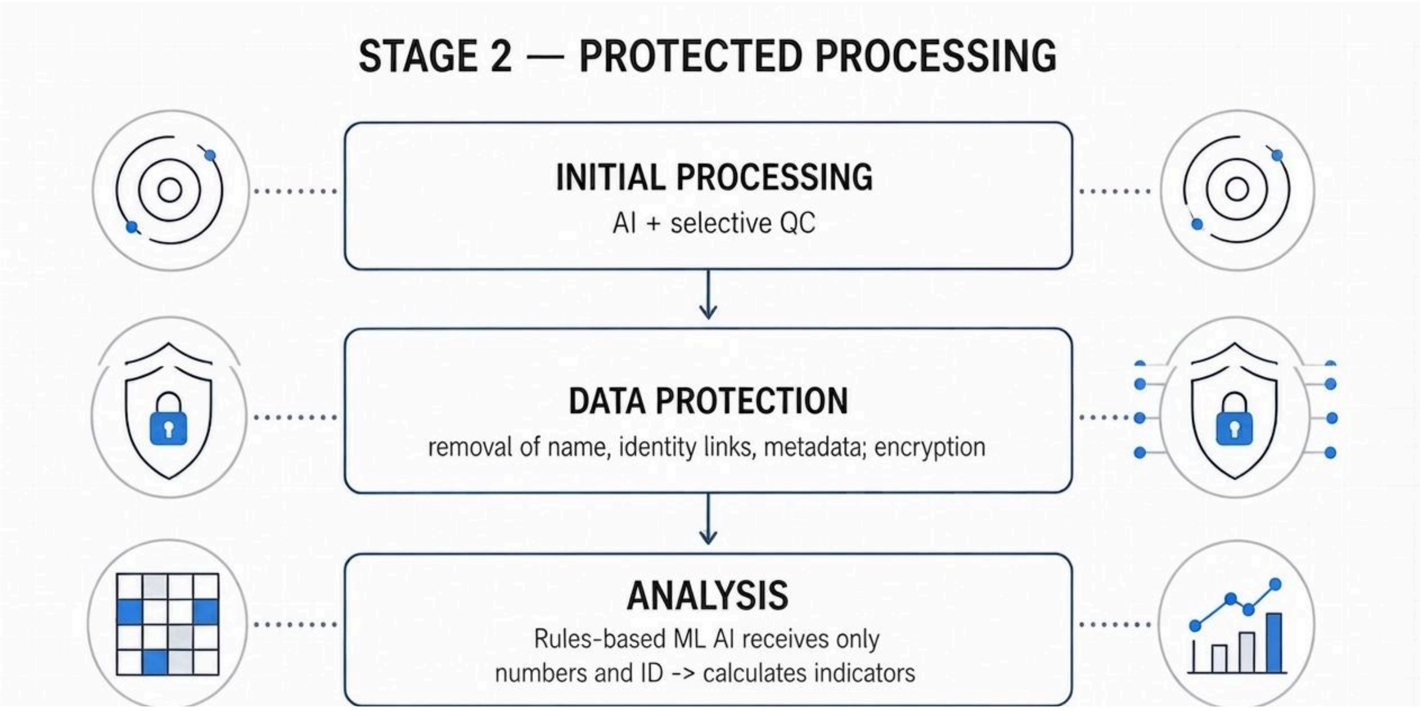
7 DELIVERY OF TEST RESULTS TO PARENTS

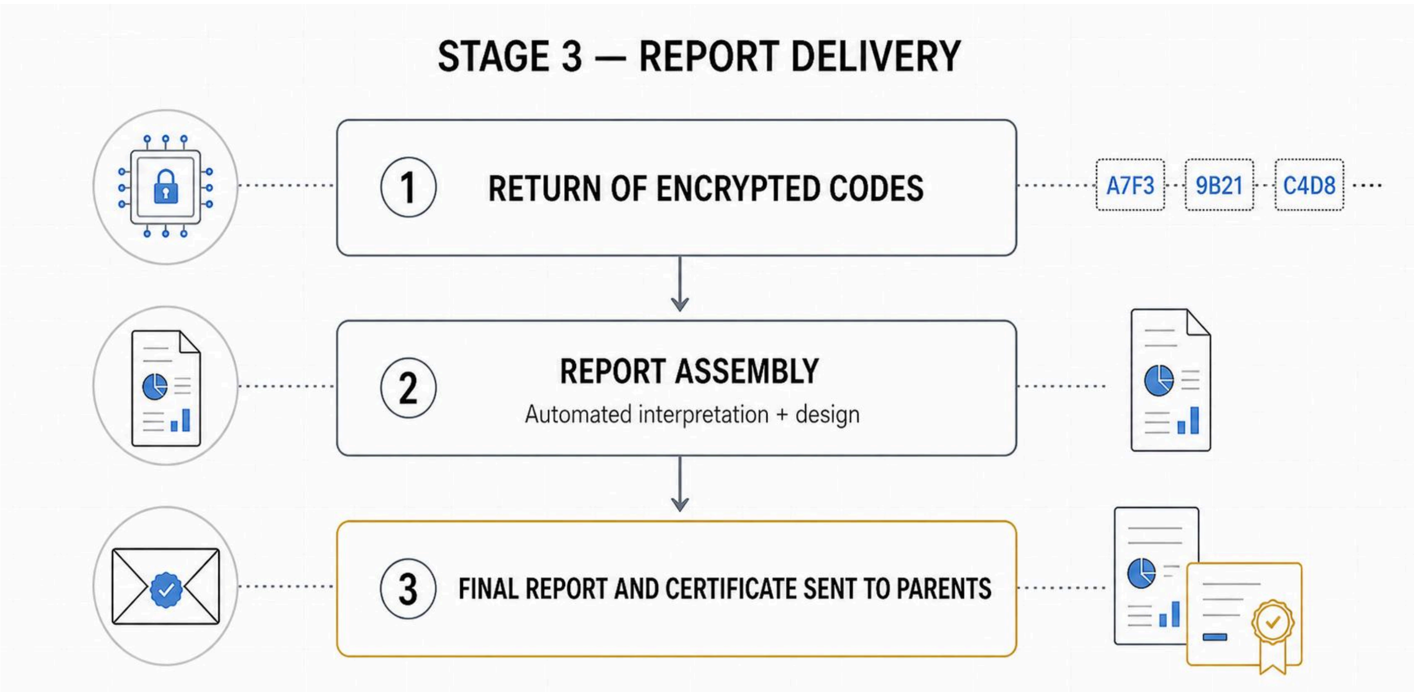
Parents receive:

- an electronic certificate and its accompanying insert,
- an extended report containing information about areas of potential genius, talents, dominant cognitive characteristics of the child, and general recommendations for parents.

The report is always generated strictly in accordance with the algorithm.


STAGE 1 — TEST AND DATA CAPTURE
1 CHILD TAKES THE TEST
2 AUTOMATED DATA COLLECTION
video, audio, reactions → without human involvement


STAGE 2 — PROTECTED PROCESSING
INITIAL PROCESSING
AI + selective QC
DATA PROTECTION
removal of name, identity links, metadata; encryption
ANALYSIS
Rules-based ML AI receives only
numbers and ID -> calculates indicators


STAGE 3 — REPORT DELIVERY
1 RETURN OF ENCRYPTED CODES
A7F3
9B21
C4D8
2 REPORT ASSEMBLY
Automated interpretation + design
3 FINAL REPORT AND CERTIFICATE SENT TO PARENTS

8 SCOPE AND LIMITATIONS

The AI components of Quantum G Beta are not intended for psychological, clinical, or medical diagnostics, psychological analysis, or profiling.

9 CONFIDENTIALITY AND DATA PROTECTION:

We take the privacy and confidentiality of children's data extremely seriously and comply with all applicable legal requirements. All data are encrypted and protected against loss, misuse, or unauthorized access. No child's personal data is sold, transferred, or rented to third parties. The parents retain complete control over the child's information.

Each stage of data processing is designed to prevent unauthorized access to personal information, minimize the human factor in processing test results, and ensure maximum data security.

Key principles:

- Data minimization: only necessary data is collected and processed. Data is deleted as soon as it is no longer required.
- Full encryption of personal data during storage and transmission. Anonymization of personal data when children's responses are passed to AI processing algorithms.
- No selling, exchanging, renting, or transferring data to third parties for profit purposes.
- The parent retains full control: data can be requested, corrected, deleted, and the user may opt out of further use by the company.
- Minimization of the human factor: no human can influence the test results in any way.
- All registrations and payments are conducted exclusively on the websites of official Quantum G distributors.