SCIENTIFIC AND METHODOLOGICAL CONTEXT OF QUANTUM G BETA

Map of the Research Directions Considered in the Development of the Theoretical Construct, Task Architecture, Stimulus Design, Process-Data Layer, and the Boundaries of Valid Interpretation

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Important Notes

This document describes the broader scientific and methodological context that informed the development of the Quantum G Beta testing system. It does not replace the Technical Manual or the psychometric validation program. The reliability of the assessment, the stability of the resulting profiles, and the validity of interpretations are evaluated separately as part of the validation program.

The publications, theories, approaches, authors, organizations, journals, and publishers referenced in this document are third-party sources and are included solely to ensure methodological transparency and to describe the scientific and methodological context of the Quantum G Beta assessment system. Unless explicitly stated otherwise, these sources are not affiliated with the project, have not sponsored, endorsed, peer-reviewed, or validated the Quantum G test, its methodology, or its results.

How to Read This Document

The Quantum G methodology was developed at the intersection of several major research fields, including cognitive science, the psychology of perception and attention, developmental science and developmental neuroscience, evolutionary approaches to cognition, research on learning and individual differences, and assessment approaches that examine not only the final response but also the task-solving process (process-based assessment / response-process evidence).

Not all of these research directions serve as direct foundations for the scoring methodology. Their roles within the Quantum G framework differ. Some informed the formulation of the theoretical construct; others guided the design of the task architecture, stimulus materials, and testing conditions; while some contributed to the development of the domain model and the characterization of different modes of information processing. In addition, a number of research findings informed working hypotheses, including hypotheses

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concerning the relationship between early automatic processing mechanisms and subsequent learning, the development of individual strengths, and the potential antecedents of fundamentally novel ideas.

Relationship	How to Read
Direct Operational Foundation	This approach informed the design of the task architecture, stimulus materials, response time windows, distractors, presentation conditions, or process-level indicators.
Methodological Framework	This framework helps define the construct, the intended use, the boundaries of valid inference of results, and the logic underlying the validation process.
Domain Framework	This framework explains why each domain is conceptualized as a distinct cognitive mode for processing a particular type of information.
Neurobiological Context	This framework was used to understand information-processing mechanisms and to refine which tasks, stimuli, timing conditions, and process-level indicators could be most informative.
Secondary Interpretative Framework	It helps describe possible interpretations of patterns but does not constitute a scoring layer.
Background / Broad Scientific Context	This direction was considered as part of the broader scientific background for the development of the methodology, task stimuli, testing conditions, and working hypotheses, but it does not serve as a direct basis for scoring.

What is the object of measurement in Quantum G?

Working Definition of the PLN-P Construct

The Quantum G test methodology distinguishes three levels.

Level 1 — early neurocognitive precursors:

Fast automatic information-processing mechanisms involved in basic perceptual functioning. These can be indirectly assessed through specially designed tasks, behavioral indicators, and process-level data.

Level 2 — high-level task restructuring:

A later and more complex process involving the ability to reframe the original problem, reorganize its working representation, and discover a new

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underlying principle for its solution. Quantum G does not directly measure this mechanism.

Level 3 — manifested act of principle-level novelty:

The realized creation of a fundamentally new idea, discovery, invention, or other achievement. This is a long-term outcome shaped by development, learning, environmental influences, and sustained practice, and is therefore not something the Quantum G Test directly measures.

Within such logic, Quantum G operates only at Level 1. The test does not measure “ready-made genius,” does not observe the act of generating a new idea, and does not directly measure brain activity.

Working Construct PLN-P

The Quantum G methodology uses the working construct **Principle-Level Novelty Potential (PLN-P).** PLN-P refers to a latent, domain-differentiated neurocognitive profile representing early structural and functional predispositions for future high-level scientific, technical, research, or other forms of domain-relevant creativity.

In this context, such creativity is not simply the ability to generate unusual responses, improve existing solutions, or combine familiar elements in new ways. Rather, it refers to the potential to eventually produce solutions and ideas that transform the original framework of a problem by recognizing a new underlying principle, developing a new explanatory model, proposing a fundamentally different approach, or reorganizing the problem space itself.

PLN-P is not directly observable and does not describe a child's current ability to generate principle-level innovations. Instead, it represents an earlier level of functioning: an individual's configuration of automatic and implicit information-processing mechanisms, reflected in sensory encoding, perceptual organization, selection of relevant features, extraction of underlying structure, processing of spatial, functional, and material relationships, detection of inconsistencies, and modeling of potential changes within a task. Within the Quantum G methodology, these characteristics are viewed as the structural and functional foundations that may later support the

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ability to reframe problems and discover fundamentally new solution principles.

The PLN-P profile is derived from the aggregate of observable performance indicators obtained in specially designed testing conditions. It is composed of several component parameters, including implicit extraction of hidden structure, automatic grouping and compression of features, completion of missing elements, sensitivity to structurally similar but incorrect alternatives (near-miss) and meaningful mismatches, contextual reweighting, preservation of invariants under changes in surface form, and robustness of processing under noise, time constraints, and signal competition.

In the public materials of the project, this working construct corresponds to the proprietary terms “genius potential” and “areas of genius potential.” “Genius potential” refers to the latent PLN-P profile itself, while “areas of genius potential” refer to its domain-specific expressions—areas of content in which the child’s early automatic processes manifest most consistently, naturally, and with higher functional maturity.

Constitutive Domain Specificity: In the Quantum G methodology, PLN-P is not treated as a “pure” general ability independent of content. The computational processes are general, but they are always expressed through a specific type of processed material: numerical, spatial, physical-dynamic, material-substance, technical, or socio-pragmatic domains.

Therefore, the Quantum G result is not interpreted as a single global score, but as a profile describing which early automatic information-processing mechanisms are predominantly engaged across different domain modes.

Demarcation: PLN-P belongs to a pre-mechanistic and pre-productive level. It precedes not only the emergence of a completed creative product, but also the very stage of representational restructuring.

PLN-P is not equivalent to IQ, fluid intelligence, divergent thinking, the level of acquired knowledge and skills, academic achievement, or already manifested creative productivity.

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Boundaries of Result Interpretation: The relationship between an early domain-differentiated profile and later forms of principled novelty is treated as a developmental hypothesis. It requires further validation through longitudinal observation, assessment of profile stability over time, and evaluation of whether profile-oriented learning contributes to a more pronounced development of the corresponding strengths and to the subsequent manifestation of principle-level novelty.

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MAP OF SCIENTIFIC APPROACHES AND THEIR CONTRIBUTION TO THE QUANTUM G METHODOLOGY

I. Construct, Analytical Logic, and Boundaries of Valid Inference

1. Assessment Theory and Psychometric Framework, Justification of Results and Scope of Use

Relevance: This framework serves as the methodological foundation for positioning the assessment, defining its intended use, establishing the boundaries of appropriate interpretation, and guiding its validation program.

What this line of research studies:

This field examines how the meaning of an assessment result is justified. It addresses the construct on which the instrument is based, the intended purpose of the results, the response processes that should correspond to the proposed interpretation of those results, and the limits of the conclusions that may legitimately be drawn.

How this is applied in Quantum G:

Within Quantum G, this framework is used to describe the system as a construct-centered assessment that incorporates process-based evidence within a predefined interpretive model. It establishes that Quantum G is not an IQ test, an achievement test, a diagnostic instrument, or an arbitrary AI output. Instead, each result is produced through a predefined analytical pipeline consisting of established data-processing rules, calculation of methodology-defined parameters, quality control procedures, and automated generation of a report according to an approved structure. The framework also defines which claims about the results are appropriate at the current stage of development and which require further empirical confirmation through the validation program.

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Boundaries of valid inference:

The existence of a psychometric/assessment framework does not, by itself, establish the validity of Quantum G. Rather, it defines the rules under which such validity must be demonstrated.

2. Process-Based Assessment and Response-Process Evidence — assessment during task execution

Relevance: Methodological framework and direct basis for the process-level data layer.

What this line of research studies:

Process-based assessment examines how task performance data—such as response time, selection trajectories, gaze patterns, delays, errors, self-corrections, and strategy shifts—can be used as response-process evidence. In other words, it focuses on how the final answer is formed within a given testing context.

How this is applied in Quantum G:

In Quantum G, this supports the analysis of not only final responses but also the full task-solving process. Process-level data are used as an additional layer of evidence: they help clarify how the child selected information, allocated attention, responded to competing signals, stabilized decisions, and managed constraints such as time pressure, uncertainty, or informational noise.

Gaze data can be used as one of the process-level channels. They help describe which elements the child attends to first, whether they return to structurally relevant features, whether they linger on salient distractors, and how the exploration trajectory of the task evolves over time.

Rapid facial expression and behavioral signals may be used only as auxiliary indicators of processing load, overload, loss of engagement, technical issues, or conditions in which the data require additional quality control.

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These data connect the testing procedure, specialized AI subsystems, quality control mechanisms, and result generation into a unified analytical pipeline.

Boundaries of Valid Inference:

Process indicators must not be interpreted in isolation. A single gaze pattern, facial expression marker, or type of error does not constitute independent evidence of the profile.

Such data are meaningful only when interpreted within the context of the specific task architecture, the participant's final response, the quality of the input data, and the predefined rules of the analytical pipeline.

Facial expression markers are not intended to provide emotional diagnostics, medical conclusions, psychological assessment of the child’s condition, or biometric identification.

Relevance: Methodological framework and direct basis for the process-level data layer.

What this line of research studies:

Process-based assessment examines how task performance data—such as response time, selection trajectories, gaze patterns, delays, errors, self-corrections, and strategy changes—can be used as response-process evidence. In other words, it treats these data as indicators of how the final response is formed under specific testing conditions.

How this is applied in Quantum G:

In Quantum G, this framework supports the analysis of not only the final response but also the full task-solving process. Process-level data are used as an additional layer of evidence: they help clarify how the child selected information, distributed attention, responded to competing signals, stabilized choices, and coped with constraints such as time limits, uncertainty, or informational noise.

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Gaze data can be used as one of the process-level channels. They help describe which elements the child attends to first, whether they return to structurally relevant features, whether they linger on salient distractors, and how the task exploration trajectory changes over time.

Rapid facial expression and behavioral markers may be used only as auxiliary signals of processing cost, cognitive overload, loss of engagement, technical issues, or conditions in which the data require additional quality control.

These data connect the testing procedure, specialized AI subsystems, quality control processes, and result generation into a unified analytical framework.

Boundaries of Valid Inference:

Process indicators must not be interpreted in isolation. A single gaze pattern, facial expression marker, or error type does not constitute independent evidence of the profile.

Such data are only meaningful when considered together with the structure of the specific task, the final response, the quality of input data, and the predefined rules of the analytical framework.

Facial expression markers are not used for emotional diagnosis, medical conclusions, psychological assessment of the child's state, or biometric identification.

II. EARLY COGNITIVE SYSTEMS, NEURODEVELOPMENT, AND INDIVIDUAL DIFFERENCES

3. Core Knowledge and Developmental-Cognitive Foundations—basic systems of cognition

Relevance: Domain framework for understanding early cognitive prerequisites and their role in development (developmental foundation).

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What this line of research studies:

Research on Core Knowledge systems suggests that children do not begin development as a “blank slate.” From an early age, they possess structured systems for representing objects, number, space, and agency. These systems guide subsequent learning and interaction with the environment.

How this is applied in Quantum G:

In Quantum G, this line is used in part to support the concept of an early cognitive foundation. The test does not assess school knowledge or acquired skills; instead, it examines how basic perceptual and information-processing systems manifest in children under specially designed conditions. This perspective also supports the early-age applicability of the test and the domain-based architecture of Quantum G “areas.”

Boundaries of valid inference:

Core Knowledge systems do not, by themselves, demonstrate the existence of already formed “areas of genius.” Rather, this framework supports the existence of early cognitive foundations upon which later development may build. The individual Quantum G profile, however, requires its own empirical validation.

4. Developmental Predictors and Early Antecedents—early predictors and precursors of further development

Relevance: Empirical precedent.

What this line of research studies:

This line investigates whether early nonverbal or implicit indicators may be associated with later learning ability, domain-specific competence, and developmental trajectories.

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How this is applied in Quantum G:

For Quantum G, these studies are important as empirical precedent. They indicate that early indicators not reducible to acquired knowledge or academic achievement may be related to later domain-specific development. Particularly relevant are findings linking preverbal number sense with later mathematical development, and spatial ability with subsequent trajectories in science, technology, engineering, and mathematics (STEM fields).

Within the Quantum G methodology, this line supports the interpretation of the test as a developmental potential assessment instrument and provides a reference point for its own longitudinal validation program.

Boundaries of Valid Inference:

These studies do not establish the predictive validity of Quantum G. Rather, they establish a precedent and define the standards against which the test itself must be evaluated.

5. Neural Reuse, Neuronal Recycling, and Mixed Selectivity—evolutionary reuse of neural resources

Relevance: Neurocognitive framework for understanding evolutionarily older resources, functional biasing of neural circuits, and the non-strict modular organization of complex cognitive functions.

What this line of research studies:

Neuronal recycling describes how culturally recent skills—such as reading, writing, symbolic counting, and arithmetic—reuse evolutionarily older, pre-existing neural circuits and cortical maps. These skills do not emerge on an entirely new neural substrate; instead, they are mapped onto pre-existing systems, leveraging their computational capacities while also inheriting their structural constraints.

Neural reuse extends this logic further. Local neural circuits, formed through evolution or development for specific functions, can participate in new

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functional coalitions and be recruited for different tasks, often without losing their original role.

Within this framework, the brain is neither understood as a set of rigid modules with fixed functions nor as a completely undifferentiated general-purpose system. Instead, individual circuits exhibit functional bias—i.e., a predisposition toward specific types of input, processing, and output—while still being able to participate in multiple cognitive configurations.

Mixed selectivity complements this picture at the level of neural coding: individual neurons and neural populations may respond not to a single isolated feature, but to combinations of task parameters.

This increases computational flexibility and supports the view of complex cognitive functions as distributed and context-dependent rather than rigidly localized to a single module.

How this is applied in Quantum G:

In Quantum G, this line is used as a neurocognitive context for explaining why complex cultural and domain-specific forms of thinking should not be viewed as emerging de novo or as being localized to isolated anatomical regions of the brain.

It supports a model in which later-acquired skills and domain-specific patterns of information processing are built upon evolutionarily older, already organized neurocognitive systems with their own functional biases and constraints.

Boundaries of Valid Inference:

Quantum G does not measure neural reuse, neuronal recycling, mixed selectivity, or activity in specific neural networks. These approaches do not directly validate a child's profile.

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Their role is explanatory and demarcational: they provide a neurocognitive context in which Quantum G domain profiles are not reducible either to school subjects or to specific anatomical brain localizations.

6. Developmental Neurobiology — plasticity, maturation of neural systems, and sensitive periods

Relevance: Neurodevelopmental context; not a direct scoring layer.

What this line of research studies:

This field examines the plasticity of the developing brain, synaptic overproduction and synaptic pruning, myelination, sensitive periods, maturation of cortical and subcortical systems, and the influence of the environment on the rate and profile of development.

How this is applied in Quantum G:

In Quantum G, developmental neurobiology is used as a contextual framework to justify early assessment and subsequent developmental support. Childhood and adolescence are viewed as periods of high neuroplasticity. Therefore, early assessment is interpreted as a way to observe individual information-processing characteristics at a stage when development is particularly sensitive to environmental input, learning, and targeted support.

This line also supports age-sensitive task design and the need for longitudinal validation of profile stability.

Boundaries of valid inference:

Quantum G does not directly measure synaptic pruning, myelination, or sensitive periods. These processes provide a developmental context rather than measurable test variables.

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III. SENSORY ENCODING, PERCEPTUAL PROCESSING, AND VISUOSPATIAL–ACTION ORGANIZATION

7. Computational and Bayesian Theories of Visual Perception — visual perception as computational scene construction and probabilistic inference

Relevance: Scientific context for the design of visual conditions, handling incomplete and ambiguous input, and analyzing task performance processes.

What this line of research studies:

This line of work views vision not as passive registration of sensory input, but as active construction of a representation of scene structure.

The idea of unconscious inference, originating with Helmholtz, describes perception as an active process of constructing the most probable interpretation of a scene: the visual system does not simply receive an image, but completes it based on incomplete and ambiguous input.

Computational vision, particularly in the Marr tradition, treats vision as a computational problem of building representations—from early image descriptions to more structured representations of objects, surfaces, depth, and scene layout.

Bayesian perception formalizes this logic through probabilistic inference: perception is understood as estimating the most likely cause of a sensory signal given uncertainty, prior expectations, and incoming data.

How this is applied in Quantum G:

In Quantum G, this framework is taken into account in the design of tasks with fragmented, degraded, ambiguous, or conflicting visual input.

Such conditions are important because they make it possible to observe differences in how a child's visuo-perceptual system groups elements, reconstructs missing structure, extracts underlying principles, responds to inconsistencies, and stabilizes responses under time constraints.

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At a broader methodological level, this line supports the view of the test as an instrument that operates not only on final choices, but also on the early stage of internal model construction of incoming visual information.

Boundaries of valid inference:

Quantum G results may be used as indirect indicators of certain modes of visual information processing, but not as direct measurements of brain activity, the state of specific neural networks, or the functioning of particular physiological mechanisms in the child.

8. Psychophysics and Signal Detection Theory

Relevance: Direct operational basis for the basic sensory layer, stimulus parameterization, control of signal discriminability, and reduction of construct-irrelevant variance.

What this line of research studies:

Psychophysics examines how physical properties of stimuli (e.g., contrast, duration, intensity, discriminability, noise, spatial frequency, color, sound intensity, or rhythm) relate to perceptual experience and behavioral responses.

Signal Detection Theory (SDT) distinguishes between sensitivity to a signal and response criteria, for example, cautiousness, impulsivity, risk-taking, or conservative decision strategies under conditions of uncertainty.

How this is applied in Quantum G:

In Quantum G, this line is particularly important for test modules in which tasks place relatively isolated demands on fundamental visual and auditory processing.

Psychophysical principles informed the design of stimuli with systematically controlled discriminability, including variations in orientation, spatial frequency, contrast, color differences, texture, presentation duration, sound intensity, rhythm, and fine-grained temporal dynamics of the signal.

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In practical terms, this supports the use of degraded, noisy, near-threshold, and near-miss stimuli, as well as tasks requiring the child to extract a structurally relevant signal from competing features.

Within this logic, psychophysics and Signal Detection Theory help distinguish reduced sensitivity to the relevant stimulus feature from impulsivity, response caution, random guessing, technical testing conditions, or response strategy.

This layer provides measurement discipline for the basic level of operationalization of PLN-P. It is essential for stimulus calibration, quality control, parametric design, error analysis, and measurement fairness. Stimuli and presentation conditions must be sufficiently controlled to load the target computational parameter rather than reflect incidental differences in screen quality, sound, lighting, motor speed, fatigue, or general anxiety.

Boundaries of valid inference:

Psychophysics and Signal Detection Theory do not, by themselves, demonstrate the presence of genius potential and do not directly measure domain-differentiated PLN-P. They describe the lower measurement layer of the procedure: how accurately a stimulus conveys a signal, how responses are affected by noise, and how to separate signal sensitivity from response criteria.

Quantum G should not be interpreted as a clinical assessment of vision or hearing. Basic sensory tasks are used as controlled windows into early information processing, not as medical diagnostics of sensory systems.

9. Gabor-like Patterns, Orientation and Spatial-Frequency Processing — low-level visual structural encoding

Relevance: Operational neurovisual framework for individual tasks within the basic visual block.

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This line is related to research on early visual processing, particularly the sensitivity of the visual system to orientation, spatial frequency, contrast, local texture organization, and regularities.

Gabor-like patterns and filters are commonly used as a mathematical approximation of receptive fields of simple cells in early visual cortex, and as a tool for studying how the visual system extracts local structure from incoming input.

How this is applied in Quantum G:

In Quantum G, this framework is applied in the design of individual tasks within the first visual module, where the goal is to selectively engage early extraction of structural axes, regularities, pattern violations, or weak local signals.

Such stimuli help reduce the influence of subject knowledge, cultural familiarity, and previously acquired academic skills, since the child is not working with recognizable content but with basic parameters of visual organization.

Within this logic, Gabor-like and spatial-frequency stimuli belong to the foundational layer of the procedure. They make it possible to observe differences in early visual structural coding prior to the transition to more complex domain-specific or semantic tasks.

Boundaries of Valid Inference:

Gabor-like tasks do not, by themselves, measure PLN-P, the domain profile, or the so-called “area of genius potential.” They provide one controlled channel for assessing early visual structural encoding and must be interpreted only in conjunction with other tasks, process-level indicators, and the predefined outcome model.

Quantum G is not a method for direct neurophysiological measurement of primary visual cortex activity, the functioning of simple cells, or other visual neural mechanisms. These tasks are used as behavioral and psychophysical probes of early visual processing.

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10. Color Vision, Cone-Opponent Coding, and Context-Sensitive Color Perception—color as a computational feature

Relevance: Operational basis for stimulus design in which color is used as a relevant feature, salient distractor, grouping element, or contextual modulator.

What this line of research studies:

Research on color vision describes cone-opponent coding, color constancy, and the influence of contrast, illumination, surrounding context, and environmental conditions on the perception of hue and color meaning.

More broadly, color can contribute to object recognition, material and state identification, group membership assignment, signal salience, and the affective interpretation of a stimulus.

How this is applied in Quantum G:

In Quantum G, color is used as a controlled processing parameter. It can function as a relevant feature, a salient distractor, a grouping mechanism, or a context-dependent signal whose meaning changes depending on the task structure.

This allows the system to test whether the child follows superficial color salience or instead maintains a deeper structural organization of the material.

Within this logic, the color layer belongs to stimulus design, feature binding, attention prioritization, and context-sensitive perception.

Boundaries of Valid Inference:

The color layer should not be interpreted as a test of artistic taste, emotional reactions to color, or a child's personal preferences. Color is used as a controlled parameter of perception, attention, and feature grouping, rather than as an independent indicator of the domain profile or psychological state.

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11. Material Perception and Texture Statistics

Relevance: Operational basis for individual tasks within the material/chemical processing layer; not an exhaustive description of the chemical domain.

What this line of research studies:

Research on material perception examines how the visual system infers properties of materials or substances from optical cues such as glossiness, transparency, roughness, texture, haze, subsurface scattering, color, illumination gradients, and image statistics.

Research on texture statistics shows that regularity, element distribution, local deviations, and small surface irregularities can carry information about quality, state, defects, impurities, or different material phases.

How this is applied in Quantum G:

In Quantum G, this line is used for the material-chemical processing mode. The test does not assess chemistry as a discipline or knowledge of chemical concepts; instead, it may engage a more basic layer of “material vision,” focusing on how surface and material properties are perceptually inferred.

Boundaries of valid inference:

Material perception indicators do not demonstrate future chemical competence and are not an independent measure of a material-chemical profile. Any relationship between these early indicators and later domain development requires empirical validation.

12. Auditory Processing, Harmony, Rhythm and Prosody—early auditory processing layer

Relevance: Operational basis for the auditory, speech, and multimodal layers of the test.

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Research on auditory perception shows that the brain rapidly extracts pitch, timbre, rhythm, regularity, expectancy violations, harmony, temporal segmentation, and prosodic patterns.

In developmental science, early auditory indicators are considered relevant for later language development, speech processing, temporal prediction, and auditory grouping.

How this is applied in Quantum G:

In Quantum G, sound, speech, and auditory cues are treated as a separate information-processing channel. This line supports tasks and process-level indicators related to how the child groups sounds, perceives rhythm and temporal structure, processes intonation and pauses, and responds to expectancy violations.

It is also relevant in cases where auditory signals must be integrated with visual stimuli, choice behavior, motor responses, or hidden rules embedded in the task structure.

Within this logic, the auditory component is considered part of the foundation layer of the testing procedure, speech-related process data, and multimodal test design.

Boundaries of valid inference:

Auditory tasks in Quantum G are not a clinical hearing test, a speech-language assessment, or a diagnostic tool for speech disorders. They are used as controlled conditions for analyzing auditory and multimodal processing patterns within the test procedure and must be interpreted only in conjunction with other tasks, the quality of the input data, and the predefined outcome model.

13. Motion, 3D Structure and Spatial-for-Action Processing — movement, three-dimensional structure, and action in space

Relevance: Operational and domain-specific basis for physical-dynamic, spatial, and engineering-structural tasks.

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What this line of research studies:

This line examines how the perceptual system extracts motion, depth, trajectory, direction, support relations, stability, spatial relationships, and action-relevant coordinates for behavior.

A key role is attributed to the dorsal visual stream, which is associated not only with encoding object location ("where an object is"), but also with spatial processing for action (spatial-for-action): how an object is positioned, how it may move, how it can be interacted with, and which relations support the stability of a scene.

How this is applied in Quantum G:

In Quantum G, this line is used in the design of tasks involving trajectories, movement, stability, assembly, action selection, prediction of future states, and reasoning about spatial configurations.

Such tasks allow the system to engage not only object recognition, but also the processing of relationships between objects, directionality, support structures, potential motion, and possible actions.

Within the test methodology, this layer is particularly important for physical-dynamic, macro-engineering, and micro-engineering tasks, where the child works with future states of a scene, structural stability, or the functional possibility of action.

Boundaries of Valid Inference:

Within the Quantum G context, this line is not used to evaluate motor abilities, dexterity, or physical coordination as independent traits. It refers to cognitive-perceptual processing of motion, space, action, and structural scene organization within the framework of test tasks.

Such indicators must not be interpreted in isolation and are only meaningful in combination with other test data and the predefined outcome model.

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14. Internal Models and Forward Simulation — internal models and prediction of possible states

Relevance: Theoretical framework for tasks in which it is important not only to recognize the current stimulus, but also to work with potential transformations, hidden structure, or future states of a system.

What this line of research studies:

This line integrates research on mental imagery, mental rotation, intuitive physics, mechanical reasoning, forward simulation, and scene/event construction.

Across different fields, these processes describe the ability to build internal models: mentally rotate objects, predict trajectories, simulate how mechanisms operate, reconstruct scenes, evaluate structural stability, and infer how a change in one element may affect the state of the whole system.

How this is applied in Quantum G:

In Quantum G, this framework is taken into account when designing tasks that require the child to work not only with what is currently presented on the screen, but also with possible future states of a material or system. For example, identifying which element completes a structure or how a change in one component affects the system as a whole.

This layer is associated with structural completion, forward prediction, structural stability assessment, trajectory anticipation, part–function inference, physical-dynamic reasoning, and micro- and macro-engineering logic.

Boundaries of valid inference:

Quantum G does not measure mature mental simulation, constructive imagination, or mechanical reasoning as standalone abilities. This line is used as a theoretical context for earlier behavioral and process-level prerequisites of internal modeling, rather than as a direct object of measurement.

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15. Affordance Theory and Functional Action — affordances and functional possibilities for action

Relevance: Operational and domain framework for tasks in which it is necessary to recognize possible actions, object functions, or critical relationships between elements of a scene.

What this line of research studies:

The affordance approach describes how humans perceive the environment not only as a set of visual features, but also as a field of possible actions.

An object or scene is perceived in terms of what can be done with it: grasped, connected, bypassed, used as support, modified, transmitted, repaired, or integrated into a larger structure.

Research on action selection complements this framework by showing that multiple possible actions can compete within a situation, and that selection depends on goals, context, the functional role of objects, and task constraints.

How this is applied in Quantum G:

In Quantum G, this framework is used in the design of technical, engineering, social, and action-oriented tasks where the child must do more than recognize an object or scene. Instead, they need to infer what action is possible, which element is functionally critical, which structure supports the action, and which disrupts it.

This is important for tasks involving macro- and micro-engineering logic, social affordances, action selection, functional interpretation of a scene, and analysis of decision trajectories.

Boundaries of valid inference:

In Quantum G, affordances are not treated as indicators of motor skill or physical coordination. Instead, they are interpreted as cognitive-perceptual extraction of possible actions, functional roles of objects, and constraints of the scene.

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IV. PERCEPTUAL ORGANIZATION, ATTENTION, AND EXTRACTION OF HIDDEN STRUCTURE

16. Gestalt Principles, Perceptual Organization, and Part–Whole Completion

Relevance: Direct operational foundation for the tasks in the first assessment block.

What it studies:

This line of research examines how the brain automatically organizes incoming information: grouping elements into stable configurations, distinguishing figure from ground, perceiving wholes rather than isolated parts, completing incomplete patterns, and favoring the most coherent and efficient organization of perceptual input.

How this is applied in Quantum G:

Within Quantum G, this line of research informed the design of a number of tasks aimed at analyzing early-stage perceptual organization: what the child groups together, where they perceive a coherent whole, which anomalies they detect, which structures they maintain under conditions of perceptual noise, and how consistently they stabilize the organization of incoming information under time constraints. Within the Quantum G framework, this layer primarily relates to the tasks included in the foundational assessment block.

Boundaries of valid inference:

These tasks do not measure principle-level novelty itself and do not, on their own, demonstrate the presence of a domain-differentiated Principle-Level Novelty Potential (PLN-P).

17. Amodal Completion and Pattern Completion — Completion of Missing Information

Relevance: Operational foundation for tasks involving structural completion.

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What it studies:

Research on amodal completion examines how the visual system reconstructs the hidden or occluded parts of an object, even though they are not directly represented in the sensory input. Pattern completion refers to the broader cognitive mechanism by which the brain reconstructs a coherent whole from partial, fragmented, or degraded patterns.

How this is applied in Quantum G:

Within Quantum G, completion tasks are used to observe early capacities for reconstructing coherent structures, maintaining underlying organization, and progressing from fragmentary information to a more complete representation.

Boundaries of valid inference:

Within the Quantum G framework, amodal completion and pattern completion are not interpreted as direct indicators of imagination, creative thinking, or future capacity for generating novel ideas. Performance on these tasks is meaningful only as one component of the overall cognitive profile and is not interpreted in isolation.

18. Hidden Structure Extraction and Statistical / Structural Learning — Extraction of Hidden Regularities

Relevance: Operational foundation for tasks involving hidden rules, micro-sequences, and the extraction of latent structure.

What it studies:

Statistical learning demonstrates that even infants can extract hidden regularities from streams of stimuli without being explicitly instructed to search for underlying rules. Structural learning examines how the brain identifies, stabilizes, and utilizes the latent organization of information to support prediction, decision-making, and adaptive behavior.

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How this is applied in Quantum G:

Within Quantum G, some tasks are designed so that the underlying rule is never stated explicitly. Instead, it must be inferred from the structure of the stimuli, the sequence of frames, the rhythm of presentation, recurring regularities, or choices among distractors. This design supports the assessment of early, implicit information-processing mechanisms rather than conscious rule-searching strategies.

Boundaries of valid inference:

The extraction of hidden structure within the assessment should not be interpreted as an established capacity for principle-level novelty. Rather, it reflects an earlier, automatic level of information processing that may support subsequent learning and cognitive development.

19. Perceptual Learning, Unitization, and Differentiation — Perceptual Learning and the Development of Expertise

Relevance: A methodological bridge between early characteristics of perceptual processing and the subsequent development of domain-specific sensitivity, specialization, and expertise.

What it studies:

Perceptual learning examines how experience reshapes perception. As learning progresses, individuals become better at distinguishing task-relevant features, integrating elements into larger meaningful units, differentiating between highly similar stimuli, and detecting subtle deviations that novices typically overlook. In the development of expertise, what changes is not only declarative knowledge or explicit understanding of rules, but perception itself: experts perceive configurations, defects, nuances, relationships, and structurally significant features differently from novices.

How this is applied in Quantum G:

Quantum G does not measure established expertise. Instead, this line of research serves as a methodological bridge between a child's early information-processing profile and the subsequent development of high domain-specific sensitivity. If a child more rapidly and consistently identifies meaningful distinctions, groups related elements, detects anomalies, or maintains coherent structural representations under conditions of perceptual noise, these characteristics may be viewed as potential developmental predispositions that can support future learning and specialization. This framework is particularly relevant to the Chemical–Material domain, Technical Reasoning, and the Visual–Spatial and Engineering–Structural domains.

Boundaries of valid inference:

Strong performance on early perceptual or structural tasks does not indicate that expertise has already developed. It may only suggest the presence of developmental predispositions that require sustained learning, extensive practice, an appropriate developmental environment, and subsequent validation over time.

20. Insight, Frame Release, and Representational Change — Insight as Problem Reframing

Relevance: A theoretical layer describing the mechanism through which principle-level novelty may emerge.

What it studies:

Research on insight shows that sudden solutions often arise not from simply searching through alternatives within an existing framework, but from changing the representation of the problem itself. This may involve releasing an incorrect constraint, reinterpreting the elements of the problem, decomposing a familiar conceptual unit into new components, or shifting to an entirely different problem framework. From this perspective, insight is associated not only with arriving at the correct answer, but also with restructuring the way the problem is mentally represented.

How this is applied in Quantum G:

Within Quantum G, this line of research is used to distinguish talent, general creativity, and Principle-Level Novelty Potential (PLN-P). In the Quantum G

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methodology, PLN-P is associated not with the number of ideas generated, overall problem-solving speed, or the demonstration of insight during the assessment itself, but with earlier neurocognitive predispositions that may support future restructuring of problem representations. Insight is therefore treated not as a measurable outcome of the test, but as one possible mechanism through which fundamentally novel ideas may later emerge, by changing the representation of a problem, releasing an incorrect constraint, or shifting to a different organizing principle.

Boundaries of valid inference:

Quantum G does not directly measure insight, the "Aha!" moment, or the neurophysiological correlates of insight. The test does not draw conclusions about the functioning of specific neural networks, the suppression of external sensory input, or the child's brain activity during problem solving. Insight research describes a higher-level target mechanism, whereas Quantum G evaluates earlier behavioral and process-level predispositions that, within the methodology, are regarded as potential components of a future capacity for representational change and the generation of fundamentally novel ideas or solutions (Principle-Level Novelty).

21. Attention as Selection, Feature Binding, and Biased Competition — Attention as a Mechanism of Selection, Feature Integration, and Signal Competition

Relevance: An operational framework for tasks involving feature grouping, salient distractors, signal conflict, gaze indicators, and time-constrained response windows.

What it studies:

This line integrates research on how attention supports feature selection and feature binding. Feature Integration Theory has shown that individual features (such as color, shape, orientation, and spatial position) can be processed separately and must be integrated into a unified perceptual object. Feature-binding errors demonstrate that, without attention, features do not always become associated with the correct object.

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More recent models of attention as selection and biased competition, describe how different elements of a visual scene compete for processing resources, while salience, task goals, expectations, and contextual factors bias this competition by enhancing some features and suppressing others.

The active sampling framework further emphasizes that attention is expressed not only through internal modulation of sensory signals, but also through gaze behavior, fixation patterns, visual scanning, and the sequence in which a scene is explored.

How this is applied in Quantum G:

Within Quantum G, this framework is used in the design of tasks in which the child is required not merely to detect an isolated feature, but to integrate the correct features into a coherent structure, while resisting the pull of salient, large, familiar, or superficially attractive distractors. This is particularly relevant in tasks involving grouping, near-miss distractors, hidden structure detection, conflict between informational channels, stimulus sequencing, and conditions in which the correct answer does not correspond to the most salient stimulus.

Within this logic, the system analyzes context-specific selection of relevant signals within a given task: what the child treats as relevant, which features are bound together, how visual attention is allocated, where the first fixation occurs, how scanning trajectories evolve, and how consistently structurally relevant information is maintained under feature competition.

Boundaries of valid inference:

Quantum G does not measure attention as a clinical construct and does not make any diagnostic inferences regarding attentional disorders or impairments. This line is used exclusively to describe how selection, binding, and prioritization of features occur within the context of specific task conditions. Indicators from this layer must not be interpreted in isolation; they are meaningful only in combination with task architecture, final responses, process-level data, and the predefined model of expected outcome.

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22. Chunking, Temporal Segmentation, and Sequence-Based Design — Chunking, Temporal Segmentation, and Micro-Sequences

Relevance: An operational framework for temporal task structure, micro-sequences, stimulus presentation order, and time-constrained response windows.

What it studies:

Research on chunking and temporal / event segmentation shows that the brain does not process information as a continuous and uniform stream of isolated elements. Instead, it organizes incoming input into larger units, identifies event boundaries, links elements into sequences, and uses prior context to prepare the processing of subsequent input.

As a result, the order of stimulus presentation, duration of exposure, pauses, transitions between stimuli, and the timing of relevant feature emergence can significantly influence how a response is formed.

How this is applied in Quantum G:

Within Quantum G, this line of research is implemented in the design of micro-sequential tasks, time-constrained presentation and response windows, stimulus sequences, and conditions in which a single micro-stimulus establishes the processing context for the next one.

This design enables the observation not only of static knowledge or final choice, but also of the dynamics of switching, structural maintenance, updating of expectations, and response stabilization over time. Within the test methodology, this layer is associated with temporal task design, micro-sequences, sequential priming, response-window architecture, and situations in which the order of events is an integral part of the measurement logic.

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Boundaries of valid inference:

Chunking and temporal segmentation are not measured in Quantum G as separate neurophysiological processes or standalone outcome variables. Rather, they are treated as observable behavioral and process-level indicators of how a child processes sequences, maintains temporal structure, and responds within constrained response windows.

V. PROCESSING MODES, MISMATCH, AND PROFILE STABILITY

23. Automaticity and Decompositional Automaticity — Automaticity as a Parameterized Construct

Relevance: A methodological foundation for short temporal windows and for a precise descriptive language of rapid automatic processes.

What it studies:

Contemporary models of automaticity conceptualize it not as a binary property, but as a set of partially independent parameters, including speed, effort, controllability, intentionality, awareness, and goal dependence. The same process may be fast, low-effort, and weakly verbalizable, while still not being fully unconscious or fully uncontrollable.

How this is applied in Quantum G:

Within Quantum G, this framework is used to precisely describe the processing layer targeted by the assessment. The system does not assume strictly subliminal processing: the child consciously perceives instructions and stimuli. However, critical operations such as structure extraction, selection of relevant signals, and response stabilization may unfold rapidly, implicitly, and with limited accessibility to explicit verbal report.

For this reason, the temporal logic of the test, short presentation and response windows, and the conceptual language of the construct are grounded in a view of automaticity as a multidimensional property, rather than as a state of complete unawareness of processing.

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Boundaries of valid inference:

Not every fast response constitutes a valid indicator of the construct. Only responses that emerge within a specifically designed task context, with controlled input quality and a predefined model of expected outcome, are considered meaningful.

24. Active and Predictive Perception / Predictive Processing — Predictive Framework as an Additional Descriptive Language

Relevance: A secondary interpretative framework.

What it studies:

Predictive processing describes perception as an active process in which the brain continuously generates predictions and updates its internal model when incoming sensory information differs from those predictions. In its broader formulations, this framework integrates perception, action, attention, and learning.

How this is applied in Quantum G:

Within Quantum G, the language of predictive processing is used as a supplementary framework for describing selected aspects of the process-level layer. It provides a conceptual vocabulary for interpreting hidden structure, near-miss stimuli, mismatch detection, prediction error, uncertainty, cue weighting, updating of the working task representation, and active sensing. This framework is particularly useful for tasks in which the child encounters incomplete, ambiguous, or conflicting input and must reorganize their mode of processing.

Boundaries of valid inference:

Quantum G does not implement scoring based on formally specified models of predictive coding, active inference, or the free-energy principle. The system does not define mathematical priors, prediction errors, precision weights, or variational free energy as computational variables. The predictive framework

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is used strictly as an auxiliary interpretative vocabulary rather than as the sole theoretical basis of the assessment.

25. Mismatch and Structural Anomaly Detection — Significant Mismatch and Anomaly Detection

Relevance: An operational foundation for tasks involving structurally close incorrect alternatives (near-miss), anomalies, and structural violations.

What it studies:

This line integrates research on how individuals detect deviations from an expected or already inferred structure: violations of regularity, anomalies, structurally close incorrect alternatives (near-miss), feature conflicts, and mismatches between superficial similarity and underlying rules.

How this is applied in Quantum G:

Within Quantum G, this line is used in the design of tasks involving structurally close distractors and anomalies (near-miss and anomaly tasks): alternatives that are visually or superficially similar to the correct pattern but violate its underlying principle. In such tasks, what is meaningful is not the reaction to novelty or salience per se, but the ability to detect structural violations: deviations from regularity, breakdowns in grouping logic, changes in invariants, or conflicts between surface similarity and underlying rules.

Within the test methodology, this layer is associated with sensitivity to mismatch, anomaly detection, and conditions that may trigger revision of the current task representation.

Boundaries of valid inference:

Quantum G does not rely on neurophysiological markers of mismatch and does not require EEG, ERP, fMRI, or any other direct brain imaging methods for interpretation of these tasks. The assessment is based on behavioral and process-level indicators of how the child operates with structural violations. Within the Quantum G framework, near-miss is understood strictly as a structurally close incorrect alternative (structural near-miss) that resembles the

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correct pattern but violates its organizing principle. It does not refer to motivational or reward-related “almost correct” effects.

26. Circadian and State-Dependent Variability — Time-of-Day Effects, Child State, and Profile Stability

Relevance: A methodological context for the three-session design, control of testing conditions, and analysis of profile stability.

What it studies:

This line of research addresses the fact that cognitive task performance depends not only on stable individual characteristics, but also on the child’s current state. Factors such as alertness level, fatigue, cognitive load, time of day, stress, motivation, and testing conditions can all influence performance. The same child may show variations in processing speed, attentional stability, exploratory behavior, and response accuracy depending on when and under what conditions the task is completed.

How this is applied in Quantum G:

Within Quantum G, this framework is primarily used in the design of the three-session protocol. The purpose of this design is to reduce the risk that the final profile is overly influenced by transient state-dependent fluctuations occurring in a single session, such as fatigue, suboptimal time of day, temporary reductions in attention, cognitive overload, or external testing conditions.

Accordingly, the child’s state is treated as a factor that must be considered in structuring the testing procedure, ensuring data quality, and analyzing cross-session profile stability.

Boundaries of valid inference:

Quantum G does not directly measure physiological state. The three-session design is not intended to assess circadian rhythms or biological cycles, but rather to reduce the impact of short-term state variability on the stability and reliability of the resulting cognitive profile.

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VI. DOMAIN ARCHITECTURE OF QUANTUM G: EVOLUTIONARY AND COGNITIVE FOUNDATIONS

27. Evolutionary Frameworks

Relevance: A broad evolutionary and cultural-evolutionary background for explaining the logic of the Quantum G domain model; not a scoring layer and not an independent validation of individual results.

What it studies:

This block integrates several evolutionary and cultural-evolutionary research programs, including niche construction theory, studies of tool use, food acquisition, cooking and resource extraction, the social brain hypothesis, language evolution, cultural evolution, cumulative culture, and shared intentionality.

Collectively, these approaches suggest that human cognition evolved around stable classes of adaptive problems: navigation and interaction with environments, quantitative and spatial reasoning, prediction of motion and causality, processing of materials and resources, construction of tools and structures, social coordination, communication, and transmission of accumulated action patterns.

How this is applied in Quantum G:

Within Quantum G, this framework provides the conceptual foundation for the domain architecture. Test domains are interpreted as different modes of interacting with stable classes of problems. Accordingly, mathematical, physical-dynamic, material-chemical, micro-engineering, macro-engineering, and socio-communicative domains are described as distinct modes of processing material, action, environmental structure, and social coordination.

Boundaries of valid inference:

The evolutionary plausibility of the domain architecture does not validate individual-level results and does not replace empirical validation of the assessment system.

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28. Cognitive Foundations of Domain Modes

Key Research Lines:

Early mathematical cognition and the development of numerical representations; spatial and geometric reasoning; intuitive physics and causal-dynamic reasoning; perception of materials, substances, and latent object properties; technical and mechanical reasoning; spatial-systemic and scene-based reasoning; social cognition; pragmatic communication; early language and communicative precursors; social learning and transmission of norms.

Relevance: A domain-level background for constructing Quantum G areas; not a standalone scoring model and not an exhaustive description of each domain.

What it studies:

This block integrates research lines with strong empirical grounding in cognitive science, developmental science, perception research, action systems, social cognition, and early domain-specific abilities. These include studies of number and magnitude, spatial and geometric reasoning, intuitive physics, perception of materials and substances, technical reasoning, spatial-structural cognition, social cognition, and pragmatic communication.

In aggregate, these approaches suggest that different types of material and tasks may require distinct modes of processing: quantity, order, invariance, motion, causality, substance, transformation, tool use, construction, scene-based reasoning, action, social roles, intentions, norms, and the transmission of meaning between individuals. For several of these lines, there is also empirical evidence linking early indicators to later development of domain-specific skills, learning capacity, or specialization.

How this is applied in Quantum G:

Within Quantum G, these research lines were used in constructing the domain architecture of the assessment. They support the interpretation of domains as different modes of processing material, including numerical, spatial,

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physical-dynamic, material-chemical, technical, engineering-structural, and socio-communicative domains.

At the same time, no single research tradition is treated as a complete explanation of any given domain. The mathematical domain is not reducible solely to approximate number sense, the physical-dynamic domain is not reducible solely to intuitive physics, the material-chemical domain is not reducible solely to material perception, the engineering domains are not reducible solely to technical reasoning, and the communicative domain is not reducible solely to social cognition or language evolution.

These research lines are used as converging evidence for structuring Quantum G domains around types of processing involving material, action, structure, and social coordination, but they do not replace the internal model of results within Quantum G.

Boundaries of valid inference:

The existence of a research foundation for the domain architecture does not validate individual Quantum G results and does not replace empirical validation of the assessment. A child’s profile must be justified by test-derived data and subsequently verified using independent sources, including observed developmental trajectories, educational records, expert evaluations, and later performance outcomes in relevant domains.

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Appendix A. Summary Map of Approaches

The table below serves as a quick navigation guide to the scientific approaches, theories, and research directions that were taken into account in the development of the Quantum G assessment.

Section / Approach	Type of Contribution	Key Authors and Research	Role in the Quantum G Methodology
I. Construct, Analytical Logic, and Boundaries of Valid Inferences **Assessment Theory and Psychometric Framework**	Methodological Framework	Messick, Kane, AERA/APA/NCME Standards, Cronbach	It establishes the logic of validity, the intended use of the instrument, the boundaries of permissible inferences, and the requirements for evidential support of results.
I. Construct, Analytical Logic, and Boundaries of Valid Inferences **Process-Based Assessment and Response-Process Evidence**	Methodological and Operational Framework	Embretson, Mislevy, Pellegrino, Leighton & Gierl	It justifies the use of process-level data as an additional source of information about the problem-solving strategy, rather than relying solely on the final response.
II. Early Cognitive Systems, Neurodevelopment, and Individual Differences **Core Knowledge and Developmental-Cognitive Foundations**	A Domain Framework for Understanding Early Developmental Foundations	Spelke, Carey, Baillargeon, Wynn, Gelman	It is used as a foundation for designing tasks based on early representational systems of objects, quantity, space, causality, and agency.
II. Early Cognitive Systems, Neurodevelopment, and Individual Differences **Developmental Predictors and Early Antecedents**	Empirical Precedent	Moffitt, Caspi, Bornstein, Rose, Colombo	It supports the idea of identifying early cognitive precursors potentially associated with later developmental trajectories.
II. Early Cognitive Systems, Neurodevelopment, and Individual Differences **Neural Reuse, Neuronal Recycling and Mixed Selectivity**	Neurocognitive Background	Anderson, Dehaene, Rigotti, Fusi	It is used as a theoretical explanation for why complex domain-specific abilities may be built upon the reuse of more general computational mechanisms.
II. Early Cognitive Systems, Neurodevelopment, and Individual Differences **Developmental Neurobiology**	Neurodevelopmental Context	Johnson, Knudsen, Hensch, Stiles	It supports age-appropriate task adaptation, accounts for neural and cognitive plasticity, and constrains the interpretation of results in early developmental stages.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Computational and Bayesian Theories of Visual Perception**	Scientific Context of Visual Design	Marr, Knill, Kersten, Yuille, Friston	It supports tasks in which the child does not merely recognize a stimulus, but actively reconstructs the underlying structure, identifies the most probable organization of the material, and operates under conditions of incomplete, ambiguous, or conflicting input.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Psychophysics and Signal Detection Theory**	Direct Operational Foundation	Fechner, Stevens, Green & Swets, Macmillan & Creelman	It is used to control stimulus complexity, signal discriminability, noise level, and to analyze sensitivity to relevant features.

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Section / Approach	Type of Contribution	Key Authors and Research	Role in the Quantum G Methodology
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Gabor-Like Patterns, Orientation and Spatial-Frequency Processing**	Operational Neuroimaging Framework	Hubel & Wiesel, Daugman, Field	It supports tasks involving extraction of local structure, orientation, spatial frequency, and weak visual regularities.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Color Vision, Cone-Opponent Coding and Context-Sensitive Color Perception**	Operational Foundation	Young, Helmholtz, Land, Gegenfurtner	It is used in the design of tasks where color functions as a structural feature, a grouping cue, a contextual signal, or a distractor.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Material Perception and Texture Statistics**	Operational Foundation for the Material–Chemical Layer	Gibson, Adelson, Fleming, Motoyoshi	It supports tasks involving recognition of material properties, surface states, latent physical properties, and material anomalies.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Auditory Processing, Harmony, Rhythm and Prosody**	Operational Foundation	Bregman, Patel, Trainor, Goswami	It is used in the design of auditory and multimodal tasks related to rhythm, segmentation,
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Motion, 3D Structure and Spatial-for-Action Processing**	Operational and Domain Foundation	Gibson, Goodale & Milner, Warren, Cutting	It is used in the design of tasks involving trajectories, stability, spatial relationships, motion, assembly, and the analysis of future states of spatial configurations.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Internal Models and Forward Simulation**	Project and Theoretical Framework	Shepard, Kosslyn, Wolpert, Battaglia, Hegarty	It is used in tasks requiring prediction of system changes, structural completion, assessment of stability, and modeling of possible states of an object or scene.
III. Sensory Encoding, Perceptual Processing, and Spatial–Action Organization **Affordance Theory and Functional Action**	Operational and Domain Framework	Gibson, Norman, Cisek, Tucker & Ellis	It is used in tasks that require identifying the functional role of an object, a possible action, a critical system component, or a constraint within a scene.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Gestalt Principles, Perceptual Organization and Part–Whole Completion**	Direct Operational Foundation	Wertheimer, Köhler, Koffka, Palmer	It is used in the design of tasks involving grouping, figure–ground organization, holistic integration, and structural pattern completion.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Amodal Completion and Pattern Completion**	Direct operational foundation	Kanizsa, Kellman, Shipley	Supports tasks that require reconstructing hidden, occluded, or partially missing structures.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Hidden Structure Extraction and Statistical / Structural Learning**	Direct operational basis	Saffran, Aslin, Newport, Fiser, Turk-Browne	Used in tasks with hidden rules and in tasks where the underlying rule must be inferred from the structure of the stimuli without explicit instruction.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Perceptual Learning, Unitization and Differentiation**	Methodological bridge	Gibson, Goldstone, Kellman	Supports the concept of the gradual development of sensitivity to structural differences and the hidden features of the material.

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Section / Approach	Type of Contribution	Key Authors and Research	Role in the Quantum G Methodology
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Insight, Frame Release and Representational Change**	Additional theoretical context	Duncker, Ohlsson, Knoblich, Schooler	Used as a theoretical framework for understanding representational shifts in problem solving.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Attention as Selection, Feature Binding and Biased Competition**	Operational Framework	Treisman, Desimone, Duncan, Kastner	Supports tasks that require identifying relevant features, suppressing competing signals, and maintaining the underlying task structure.
IV. Perceptual Organization, Attention, and Hidden Structure Extraction **Chunking, Temporal Segmentation and Sequence-Based Design**	Operational Framework	Miller, Gobet, Simon, Zacks	Used in the design of micro-sequences, the temporal structure of stimulus presentation, and hidden dependencies between events.
V. Processing Modes, Resources, and the State of the Cognitive System **Automaticity and Decompositional Automaticity**	Methodological foundation	Schneider & Shiffrin, Logan, Moors	Provides a framework for describing rapid, low-effort, and partially automated processing components used across a range of Quantum G tasks.
V. Processing Modes, Resources, and the State of the Cognitive System **Active and Predictive Perception / Predictive Processing**	Secondary interpretive framework	Helmholtz, Rao & Ballard, Friston, Clark	Used as a general framework for describing prediction, uncertainty, hypothesis updating, and the processing of prediction errors.
V. Processing Modes, Resources, and the State of the Cognitive System **Mismatch and Structural Anomaly Detection**	Operational Foundation	Näätänen, Winkler, Chao, Summerfield	Supports tasks involving the detection of structural violations, structurally similar counterexamples (near-miss variants), feature conflicts, and hidden anomalies.
V. Processing Modes, Resources, and the State of the Cognitive System **Circadian and State-Dependent Variability**	Methodological context of the procedure	Schmidt, Monk, Carskadon, Dahl	Used to control for the effects of the child's state, time of day, fatigue, and situational variability on assessment results.
VI. The Domain Architecture of Quantum G: Evolutionary and Cognitive Foundations **Evolutionary Framework.**	Evolutionary and cultural-evolutionary background	Tooby & Cosmides, Boyd & Richerson, Henrich, Tomasello	They are used in forming domain architecture as a system of stable classes of tasks that humans have encountered throughout evolution and cultural development.
VI. The Domain Architecture of Quantum G: Evolutionary and Cognitive Foundations **Cognitive foundations of domain modes.**	Domain background and convergent scientific foundations.	Dehaene, Carey, Spelke, Baillargeon, Gelman, Tomasello	They integrate data on number, space, physics, material properties, technical reasoning, social cognition, and communication as the foundation of Quantum G's domain structure.

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APPENDIX B. SELECTED REFERENCES BY BLOCKS

I. Assessment, psychometrics and response-process evidence

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