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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

CALIFORNIA: NORMAL SCIENCE AND THE ABSENCE OF REPRESENTATIONAL MEASUREMENT IN HTA EDUCATION

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ABSTRACT

Health technology assessment (HTA) depends upon quantitative claims whose scientific legitimacy requires measurement to precede arithmetic. Mathematical operations must be admissible for the measurement scale concerned, multiplication and division require ratio measurement, and manifest and latent attributes require different approaches to measurement. This study assesses whether these requirements of representational measurement provide the scientific foundation for the publicly available California HTA and health-economics program-content knowledge base.

A fixed 37-topic framework was applied across relevant university and university-affiliated teaching, research and training activities. Seventeen topics represented the requirements of representational measurement and 20 represented contemporary health economics and HTA. The result was categorical: 0/17 representational-measurement topics were explicitly identified as foundations of the program content examined, while 20/20 contemporary HTA topics were represented. California therefore demonstrates program-content inversion: economic evaluation, utilities, QALYs, cost-effectiveness analysis, decision analysis, simulation and related methods occupy the program-content framework without prior establishment of the measurement requirements governing their arithmetic.

The finding is particularly striking because California possesses an exceptionally sophisticated and influential academic health-economics environment. Programs and research activities across USC, UCLA, UCSF, Stanford and the University of California system encompass the full range of contemporary HTA methods. California also has distinguished historical connections to representational measurement through R. Duncan Luce and Patrick Suppes. Nevertheless, no explicit program-content bridge was identified between this measurement tradition and the contemporary HTA framework.

The 0/17 versus 20/20 dichotomy is therefore more than an imbalance in subject coverage. It represents an inversion of the scientific sequence required by normal quantitative science. Arithmetic and modelling are extensively represented without representational measurement first determining whether the quantities involved support the operations performed. Once representational measurement is accepted as the governing standard, the two frameworks cannot remain scientifically independent: every quantitative construct must satisfy the measurement requirements governing its arithmetic.

California consequently faces transformation rather than methodological refinement. Representational measurement must precede economic evaluation and modelling, with therapy-impact claims founded upon linear ratio measurement for manifest attributes and Rasch measurement for latent attributes. The objective is a reconstructed HTA paradigm in which measurement determines admissible arithmetic and quantitative claims are designed to be credible, evaluable, replicable and falsifiable.

INTRODUCTION

Health technology assessment (HTA) depends upon quantitative claims. These claims are scientifically defensible only when measurement precedes arithmetic and the properties of the measurement scale permit the mathematical operations performed. Multiplication and division require ratio measurement; arithmetic must respect admissible transformations and dimensional homogeneity; and manifest and latent attributes require different approaches to measurement.

Previous interrogations of HTA knowledge bases in Australia, Canada, New Zealand and the United States have identified a consistent pattern of measurement inversion [1] . The principles required for lawful measurement receive weak recognition, while utilities, QALYs, cost-effectiveness analysis and simulation modelling are strongly endorsed. Curriculum inversion reproduces the same failure educationally: students are introduced to the analytical methods of contemporary HTA without first being provided with the measurement principles required to determine whether the arithmetic underlying those methods is admissible [2].

The present investigation extends earlier research-center program-content assessments by examining the California HTA and health-economics program-content knowledge base as a whole. California provides an especially important setting because of the size, diversity and international influence of its academic healthcare environment. Major programs and research activities at USC, UCLA, UCSF, Stanford, UC Berkeley, UC Davis, UC Irvine, UC San Diego and other institutions encompass health economics, HTA, economic evaluation, outcomes research, health services research, pharmacoeconomics, patient-reported outcomes, health policy and decision modelling. California therefore provides an unusually rich environment in which to examine the scientific foundations underlying contemporary quantitative health research.

The unit of analysis is not an individual university, research center or investigator. It is the publicly available program content through which the California HTA and health-economics knowledge base is expressed and reproduced. This includes teaching and training, program and course descriptions, research priorities, methodological statements, projects, publications, seminars and other publicly available descriptions of what relevant California programs research, apply and teach. The purpose is therefore to characterize the statewide program-content knowledge base rather than to infer what individual faculty members may know or address outside that publicly presented framework.

Two contrasting bodies of content are assessed using the fixed 37-topic framework. The first comprises 17 topics representing the requirements of representational measurement, including measurement preceding arithmetic, scales of measurement, admissible transformations, ratio measurement, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement and Rasch measurement. The second comprises 20 topics representing contemporary health economics and HTA, including health economics, economic evaluation, utilities, QALYs, cost-effectiveness and cost-utility analysis, patient-reported outcomes, decision analysis, simulation and microsimulation, uncertainty analysis, value-of-information analysis, budget impact and related methods.

The question is deliberately narrow: does the California HTA and health-economics program-content knowledge base establish representational measurement as the foundation for quantitative claims before introducing or applying the arithmetic of contemporary HTA? If the requirements of representational measurement are absent while conventional HTA methods are extensively represented, the result is program-content inversion: an educational and research environment in which arithmetic and modelling proceed without first establishing that the quantities involved possess the measurement properties required to support the operations performed.

California adds a particularly striking dimension to this question because representational measurement has important historical roots within the state itself. R. Duncan Luce at UC Irvine and Patrick Suppes at Stanford were major contributors to the axiomatic foundations of measurement. The issue is therefore not whether representational measurement has ever existed within California academia. It is whether that scientific tradition has been incorporated into the program-content framework of California health economics and HTA as the governing standard for quantitative claims.

This distinction is fundamental. Representational measurement is not another methodology that can simply be added to contemporary HTA. It establishes the scientific rules governing the admissibility of arithmetic itself. Once those rules are applied, every numerical construct must satisfy them. The California review therefore assesses whether lawful measurement provides the scientific foundation for its HTA and health-economics program content or whether the legacy framework of contemporary HTA occupies that space without it. Given the scale and influence of California's academic health-economics environment, the assessment provides an unusually demanding test of whether contemporary HTA program content is grounded in the measurement requirements of normal quantitative science.

.FOUNDATIONS OF QUANTITATIVE ANALYSIS

Before examining California program content, it is important to identify the scientific principles against which that content is assessed. These are not matters of methodological preference. They are the requirements of representational measurement that determine whether quantitative claims and the arithmetic operations supporting them are admissible [3 4] .

Two principles are fundamental. First, measurement must precede arithmetic. Numerical operations cannot create measurement where measurement does not exist. Second, the arithmetic performed must be admissible for the measurement scale concerned. Operations involving multiplication, division and ratios require ratio measurement. For claims of therapy impact in HTA, this requires linear ratio measurement for manifest attributes or Rasch measurement for latent attributes.

These requirements establish the boundary between the manipulation of numbers and lawful quantitative measurement. Contemporary California HTA and health economics, by contrast, are organized around economic evaluation, utilities, QALYs, cost-effectiveness and cost-utility analysis, decision analysis and modelling. Over some forty years, these methods have become deeply embedded within California's extensive university and research environment, including major programs at USC, UCLA, UCSF, Stanford and across the University of California system.

Institutional acceptance, methodological sophistication and longevity, however, do not determine measurement status. The prior scientific question remains whether the quantities entering these analyses possess the measurement properties required for the arithmetic performed.

The California program-content review therefore asks a straightforward question: does the publicly available California HTA and health-economics knowledge base recognize representational measurement as the foundation for quantitative claims, or does it proceed directly to the methods and arithmetic of contemporary HTA without first establishing their measurement admissibility? This is the criterion governing the analysis that follows.

MEASUREMENT BEFORE ARITHMETIC

Before students are introduced to health technology assessment, health economics, cost-effectiveness analysis or decision modelling, they should understand the scientific conditions that determine whether quantitative claims are possible. The governing principle is straightforward: measurement must precede arithmetic. Numbers cannot be manipulated legitimately merely because they have been assigned to observations. The properties of the measurement scale determine which arithmetic operations are admissible.

Representational measurement provides this foundation. The target attribute must first be identified and defined, its measurement properties established, and the appropriate scale constructed. Only then can arithmetic proceed. Multiplication and division require ratio measurement, admissible transformations must be respected, and dimensional homogeneity must be maintained. Reversing this sequence allows arithmetic to precede measurement and produces numerical constructions that cannot be interpreted as lawful quantitative measures.

For HTA claims of therapy impact, the distinction between manifest and latent attributes is fundamental. Manifest attributes are directly observable. Examples include survival time, hospital days, emergency department visits, treatment administrations and walking distance. Where a defined unit and non-arbitrary zero are established, these attributes support linear ratio measurement and the arithmetic permitted by a ratio scale.

Latent attributes, such as pain, fatigue, physical function or need fulfilment, cannot be observed directly. Assigning numbers to questionnaire responses or adding item scores does not establish measurement. A measurement model is required to construct a unidimensional continuum and demonstrate invariant measurement. For this purpose, Rasch measurement provides person-item conjoint measurement, specific objectivity and a logit continuum upon which possession of the latent attribute can be assessed.

The educational requirement can therefore be stated simply. Claims concerning manifest attributes require linear ratio measurement; claims concerning latent attributes require Rasch measurement. Students should understand these requirements before being introduced to utilities, QALYs, cost-effectiveness ratios or simulation models. Numerical constructions do not acquire measurement properties merely through arithmetic, statistical analysis or incorporation into increasingly sophisticated models.

This sequence provides the criterion for assessing California's HTA and health-economics program-content knowledge base. The question is not how sophisticated its teaching, research, economic evaluation or modelling may be, nor how firmly established these methods have become across institutions such as USC, UCLA, UCSF, Stanford and the wider University of California system. It is whether students and researchers are first provided with the measurement principles required to determine whether the arithmetic they subsequently perform is admissible. If representational measurement, ratio measurement and the distinction between manifest and latent attributes are absent while economic evaluation, utilities, QALYs and modelling are extensively represented, the result is program-content inversion. In California, the significance is heightened by the scale, diversity and influence of its academic health-economics and HTA environment: the issue concerns not a single course or institution, but the scientific foundations of a major statewide program-content knowledge base.

THE CRITICAL ROLE OF RATIO SCALES

The California program-content assessment rests upon a fundamental requirement of representational measurement: arithmetic operations are determined by the properties of the measurement scale. Numerical values cannot legitimately be multiplied, divided or otherwise manipulated merely because numbers have been assigned. Measurement must first be established and the proposed arithmetic must be admissible for the scale concerned.

The distinction between nominal, ordinal, interval and ratio scales is therefore critical. Nominal scales classify; ordinal scales establish order; interval scales provide equal intervals but lack a non-arbitrary zero. Only ratio scales possess both equal units and a non-arbitrary zero and therefore support meaningful ratios and the multiplicative arithmetic required for quantitative claims.

This requirement has immediate consequences for California HTA and health economics. QALYs multiply health-state values by time; incremental cost-effectiveness ratios divide differences in costs by differences in outcomes; and decision models combine probabilities, utilities, durations and other numerical inputs. These methods are extensively represented across California's academic health-economics and HTA environment. Where the quantities involved lack the measurement properties required for these operations, however, the arithmetic is inadmissible. Subsequent statistical analysis, modelling or simulation cannot correct that prior failure.

For claims of therapy impact, two forms of ratio measurement are relevant. Manifest attributes require linear ratio measurement. Latent attributes require Rasch measurement to construct an invariant quantitative continuum. This distinction provides the foundation for determining whether subsequent arithmetic is admissible.

The California assessment therefore applies a straightforward criterion. Does the publicly available statewide HTA and health-economics program-content knowledge base recognize ratio measurement, admissible arithmetic, dimensional homogeneity and the different measurement requirements of manifest and latent attributes before introducing the quantitative methods of contemporary HTA? Or does it proceed directly to economic evaluation, utilities, QALYs, cost-effectiveness analysis and modelling without first establishing the measurement properties required for their arithmetic?

Ratio measurement is therefore not simply another topic within an HTA curriculum or research program. It establishes the boundary between admissible quantitative analysis and the manipulation of numbers without the measurement properties required to support that analysis. For California, this criterion applies across a particularly large and influential academic environment encompassing major universities, health-economics programs, HTA research, outcomes research and decision-science activities. The issue is therefore not whether California possesses sophisticated quantitative expertise. It is whether that expertise is founded upon the measurement requirements necessary to support the quantitative claims being made.

THE KNOWLEDGE BASE: PROGRAM CONTENT AND COVERAGE

The assessment uses the large language model interrogation framework applied in previous studies of measurement and curriculum inversion. The present analysis differs in one important respect: rather than estimating categorical probabilities of endorsement, it examines whether specified scientific and methodological topics are explicitly represented in the publicly available program content of the California HTA and health-economics knowledge base.

The California knowledge base comprises the publicly accessible teaching, research and training environment associated with universities and university-affiliated programs in health economics, health technology assessment, outcomes research, comparative effectiveness research, health services research, pharmacoeconomics, decision science and health policy. Material considered includes program descriptions, research priorities, methodological statements, projects, publications, seminars, training activities and related publicly available evidence. Relevant activities at USC, UCLA, UCSF, Stanford, UC Berkeley, UC Davis, UC Irvine, UC San Diego and other identifiable California programs contribute to this statewide knowledge base. The objective is not to evaluate individual investigators, courses or institutions, but to characterize the methodological framework represented across California as a whole.

As noted above, two contrasting groups of content are examined. The first represents representational measurement. It includes measurement preceding arithmetic, scales of measurement, the axioms of representational measurement, ratio measurement, admissible transformations and arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement for manifest attributes, and Rasch measurement for latent attributes.

The second represents contemporary HTA. It includes health economics, economic evaluation, utilities and preference-based outcomes, QALYs, incremental cost-effectiveness ratios, decision analysis, decision trees, Markov models, simulation and microsimulation, probabilistic sensitivity analysis, value-of-information analysis and related modelling methods. California provides particularly extensive representation of these methods through its university programs, dedicated health-economics and HTA research centers, pharmaceutical and outcomes-research activities, and health-policy research.

The interrogation asks a single question: does the California HTA and health-economics program-content knowledge base establish representational measurement as the foundation for quantitative

claims before presenting the analytical methods of contemporary HTA? The criterion is the presence or absence of explicit program content rather than a probability of endorsement.

This distinction is important. Earlier interrogations demonstrated the relative strength with which knowledge bases endorsed the propositions associated with measurement inversion and curriculum inversion. Program-content interrogation provides a more direct test. If representational measurement is absent while the methods of contemporary HTA are extensively represented, the result is program-content inversion. Arithmetic, modelling and simulation are taught, researched and applied without representational measurement being established as the prior framework determining whether those operations are admissible.

The California assessment therefore focuses on a narrow issue: whether the scientific requirements governing measurement are present in the statewide program-content knowledge base through which contemporary HTA and health economics are taught, researched and transmitted. The purpose is to determine whether lawful measurement provides the scientific foundation for quantitative analysis in California or whether the methods of the legacy HTA framework are represented without the prior measurement standards required to establish their arithmetic admissibility. Given the size, diversity and international influence of California's academic health-economics environment, the statewide knowledge base provides a particularly substantial test of that question.

ASSESSMENT FRAMEWORK

For this assessment, the California program-content knowledge base was defined as the publicly available material describing relevant teaching and training in health economics, HTA, outcomes research, pharmacoeconomics and related fields. Sources included program and curriculum descriptions, courses and modules, syllabi where available, learning objectives, seminars, workshops, teaching resources and associated educational material. The purpose was to establish what students and trainees are expected to encounter across the California HTA and health-economics educational environment, not what individual faculty members may know or address in their independent research.

The relationship between the two components is the critical issue. Contemporary HTA methods cannot be taught independently of the measurement requirements governing their arithmetic. If students are taught that measurement precedes arithmetic, that multiplication and division require ratio measurement, and that manifest and latent attributes require different measurement strategies, they possess the scientific criteria required to judge whether subsequent HTA methods are admissible. Where these foundations are absent, utilities, QALYs, cost-effectiveness ratios and simulation models can be introduced without confronting the measurement properties required for their arithmetic.

Program-content inversion is therefore identified where contemporary HTA methods are comprehensively represented (20/20 topics) while the prior requirements of representational measurement are absent (0/17 topics). This is more than an imbalance in program content. It reverses the scientific sequence: arithmetic and modelling are introduced without first establishing the measurement conditions governing their admissibility.

Program-content inversion places contemporary California HTA in direct conflict with the standards of normal quantitative science. Scientific status does not follow from generating numbers, employing sophisticated statistical methods or constructing increasingly complex models. Quantitative science requires lawful measurement, admissible arithmetic, empirical evaluation, replication and the possibility of falsification. If the foundational requirements of representational measurement are absent while utilities, QALYs, ICERs and simulation models are represented without first establishing that their arithmetic is admissible, HTA is operating outside those requirements. The 0/17 versus 20/20 result therefore identifies more than an educational deficiency. It signals separation between California's HTA program-content framework and the measurement standards required by normal quantitative science.

This finding is particularly striking in California because the issue cannot plausibly be attributed to a lack of quantitative expertise or academic resources. California contains some of the most sophisticated university-based health-economics, outcomes-research and decision-science programs in the United States. The program-content inversion identified here occurs within that highly developed environment. The problem is therefore not insufficient analytical sophistication, but the absence of the prior measurement framework required to determine whether that sophistication is being applied to quantities capable of supporting the arithmetic performed.

The two frameworks are consequently incompatible as foundations for quantitative analysis. Representational measurement requires arithmetic to be constrained by measurement. Once that principle is accepted, every subsequent quantitative method must satisfy its requirements. Numerical constructions cannot be exempted simply because they are established components of contemporary HTA, extensively taught across California, or supported by decades of methodological convention. Conversely, where representational measurement is absent from the organizing framework, there is no corresponding measurement constraint preventing such constructions from being taught, researched and applied. The California **0/17 versus 20/20** result captures this incompatibility in its starkest form.

ASSESSMENT RESULTS

PROGRAM CONTENT REVIEW

Jurisdiction
California, United States

Knowledge Base
California Health Technology Assessment, Health Economics and Outcomes Research Program-Content Knowledge Base

Purpose
This review evaluates publicly available program content associated with HTA, health economics, economic evaluation, outcomes research, health services research, pharmaceutical economics and related quantitative health research in California against the fixed 37-topic framework. The criterion is whether representational measurement is explicitly established as the scientific

foundation for quantitative claims before the methods of contemporary HTA and health economics are taught, researched or applied.

The statewide knowledge base includes major activities associated with UCLA and its Health Economics and Evaluation Research Program; USC's Department of Pharmaceutical and Health Economics and Leonard D. Schaeffer Center; UCSF; Stanford; UC Berkeley; UC Davis; UC Irvine; UC San Diego; and other identifiable California university programs and courses with relevant health-economics, pharmacoeconomics, outcomes-research and health-policy content. UCLA, for example, explicitly identifies economic analysis, cost-effectiveness, forecasting and simulation, while USC offers a PhD in Health Economics with training in cost-effectiveness analysis and health-status measurement and has a major dedicated HTA research program. UC Davis explicitly teaches economic evaluation and cost-effectiveness, and UCSF offers dedicated cost-effectiveness training including decision trees, health outcomes, uncertainty and sensitivity analysis.

Topic results are presented in Table 1 for representational measurement

TABLE 1: REPRESENTATIONAL MEASUREMENT

Topic	Explicitly recognized	California program evidence
Representational measurement	No evidence identified	—
Scales of measurement as constraints on arithmetic	No evidence identified	—
Measurement precedes arithmetic	No evidence identified	—
Axioms of representational measurement	No evidence identified	—
Ratio measurement as prerequisite for multiplication and division	No evidence identified	—
True zero and equal units	No evidence identified	—
Admissible transformations	No evidence identified	—
Admissible arithmetic by scale type	No evidence identified	—
Dimensional homogeneity	No evidence identified	—
Manifest and latent attributes as distinct measurement classes	No evidence identified	—
Linear ratio measurement for manifest attributes	No evidence identified	—

Topic	Explicitly recognized	California program evidence
Possession of latent attributes	No evidence identified	—
Rasch measurement as requirement for latent attributes	No evidence identified	—
Person–item conjoint measurement	No evidence identified	—
Specific objectivity and invariance	No evidence identified	—
Rasch logit ratio measurement for latent attributes	No evidence identified	—
Two admissible ratio measures for therapy impact	No evidence identified	—

Result: 0/17 representational-measurement topics explicitly recognized as foundations of the publicly available California HTA/health-economics program-content knowledge base reviewed.

This result is particularly striking because representational measurement is not foreign to California academia. Luce at UC Irvine and Suppes at Stanford were leading figures in the field. Yet the searches did not identify evidence that this tradition has been incorporated as the governing measurement framework within the California HTA and health-economics program content examined.

Topic results for contemporary HTA are presented in Table 2.

TABLE 2: CONTEMPORARY HEALTH ECONOMICS AND HTA FRAMEWORK

Topic	Explicitly represented	California program evidence
Health economics	Yes	USC, UC Davis, UCLA and other California programs
Health technology assessment	Yes	USC Schaeffer dedicated HTA program and research
Economic evaluation	Yes	USC, UCSF, UC Davis, UCLA and associated programs
Cost-effectiveness analysis	Yes	USC, UCSF, UC Davis, UCLA, Stanford and others
Cost-utility analysis	Yes	UCSF, Stanford and related research/program content

Topic	Explicitly represented	California program evidence
Pharmacoeconomics	Yes	USC pharmaceutical and health economics and pharmacy-related programs
Utilities and preference-based outcomes	Yes	Health-status, outcomes and economic-evaluation research
Quality-adjusted life-years (QALYs)	Yes	USC, Stanford, UCSF, UC Davis and associated analyses
Incremental cost-effectiveness ratios (ICERs)	Yes	Stanford, USC and other economic-evaluation research
Measurement and valuation of health outcomes / patient-reported outcomes	Yes	USC explicitly identifies health-status measurement and PRO research
Decision analysis	Yes	UCSF decision-tree instruction; USC decision-analysis/modeling activities
Decision-tree modelling	Yes	UCSF; USC
Markov modelling	Yes	Stanford, UCSF, USC and associated research
Simulation and microsimulation modelling	Yes	UCLA HEER; USC; Stanford
Probabilistic sensitivity and uncertainty analysis	Yes	Stanford, UCSF, USC and related economic evaluation
Value-of-information analysis	Yes	USC research and modeling instruction
Budget impact analysis	Yes	USC and associated health-economic research
Health care priority setting and resource allocation	Yes	Health-policy, economics and value-assessment programs statewide
Value-for-money / value assessment	Yes	USC Schaeffer and pharmaceutical/health-economics research
Policy, reimbursement and decision use of economic evaluation	Yes	USC, UCLA and broader California health-policy programs

Result: 20/20 contemporary health-economics and HTA topics represented in the publicly available California program-content knowledge base reviewed.

ASSESSMENT OF THE CALIFORNIA RESULT

The California program-content interrogation produces an exceptionally clear result: 0/17 for representational measurement and 20/20 for contemporary health economics and HTA. Across the publicly available university, research-center and associated program content examined, no evidence was identified that any of the 17 fixed topics defining representational measurement provides an explicit organizing foundation. In contrast, every one of the 20 topics defining

contemporary health economics and HTA is represented. The result is therefore not one of modest imbalance or differing emphasis. Under the fixed assessment framework, it represents categorical separation between the two bodies of content.

The breadth of the contemporary HTA component is particularly striking. California has one of the most extensive academic health-economics environments in the United States. USC provides dedicated graduate education in pharmaceutical and health economics together with research in HTA, economic evaluation, comparative effectiveness, patient-reported outcomes and value assessment. The Schaeffer Center provides an especially visible concentration of HTA and health-policy research. UCLA's Health Economics and Evaluation Research program identifies economic evaluation, cost-effectiveness, forecasting and simulation. UCSF provides explicit instruction in cost-effectiveness analysis and decision modelling. UC Davis teaches economic evaluation and cost-effectiveness, while Stanford-associated research encompasses QALYs, ICERs, Markov models, microsimulation and uncertainty analysis. The 20/20 result therefore reflects a substantial and diverse statewide analytical environment rather than dependence upon a single institution or program.

The representational-measurement result is the mirror image. None of the 17 fixed topics was identified as an explicit foundation within the program content examined. These include representational measurement itself, measurement preceding arithmetic, scales of measurement as constraints upon arithmetic, the axioms of representational measurement, ratio measurement as the prerequisite for multiplication and division, true zero and equal units, admissible transformations, admissible arithmetic by scale type and dimensional homogeneity. The absence extends equally to the distinction between manifest and latent attributes and to the specified measurement approaches for each: linear ratio measurement for manifest attributes and Rasch measurement for latent attributes.

The significance of the result lies in the completeness of this contrast. Earlier knowledge-base interrogations based upon categorical probabilities can demonstrate strong or weak endorsement while necessarily retaining some possibility of overlap. Program-content assessment asks a different question: whether the specified topics can actually be identified within the publicly presented intellectual framework. For California, the resulting profile is not 4/17 against 18/20, or even 1/17 against 20/20. It is 0/17 against 20/20. Under the criteria adopted for the interrogation, there is no observable program-content bridge between the two frameworks.

The 20/20 result also demonstrates that the finding cannot reasonably be characterized as a lack of methodological sophistication. California programs represent economic evaluation, cost-effectiveness analysis, cost-utility analysis, pharmacoeconomics, utilities, QALYs, ICERs, health-outcome measurement, decision analysis, decision trees, Markov models, simulation and microsimulation, probabilistic sensitivity analysis, value-of-information analysis, budget impact, priority setting, value assessment and policy use of economic evaluation. The contemporary framework is therefore represented from basic health-economic concepts through advanced modelling and decision applications. What distinguishes the 0/17 side is not relative technical complexity but the absence of a different type of content: the prior measurement rules governing what numerical operations are legitimate.

California adds an unusual historical dimension to this result. The state has major intellectual connections to the development of representational measurement. R. Duncan Luce at the University of California, Irvine, was one of the central figures in modern measurement theory and a co-author of the foundational *Foundations of Measurement*. Patrick Suppes at Stanford made similarly fundamental contributions to measurement theory and the axiomatic foundations of science. Representational measurement is therefore not an intellectual tradition without roots in California academia. The striking feature of the interrogation is the apparent separation between this distinguished measurement tradition and the contemporary health-economics and HTA program-content knowledge base.

This makes the California result particularly informative. The 0/17 finding does not establish that individual California academics are unaware of measurement theory, nor does it claim that concepts related to measurement can never be found in individual publications. The unit of analysis is the publicly available program-content knowledge base. The finding is narrower and more specific: representational measurement was not identified as the explicit scientific framework governing the health-economic and HTA methods represented by the programs examined. By contrast, contemporary HTA concepts are readily identifiable, repeatedly represented and institutionally embedded across the statewide knowledge base.

The overall California profile can therefore be characterized unambiguously as program-content inversion. One side of the fixed framework is comprehensively represented; the other is entirely absent under the stated criterion. The result replicates the 0/17 versus 20/20 pattern identified in the corresponding Australian and New Zealand assessments while arising within a particularly large, diverse and methodologically sophisticated academic environment. California therefore provides a strong statewide demonstration that contemporary HTA program content and representational-measurement content do not merely differ in degree of emphasis. Within the publicly available knowledge base examined, they occupy categorically different positions: 20/20 representation for contemporary health economics and HTA and 0/17 explicit representation for the measurement framework against which its quantitative operations would be assessed.

CONCLUSION: THE CHALLENGE OF TRANSFORMATION

Now that the measurement problem has been exposed, the challenge facing California universities, research centers and the wider HTA and health-economics community is substantial. The issue is no longer whether contemporary HTA might benefit from greater attention to measurement theory. The California program-content findings, together with the accompanying evidence of measurement inversion, identify a foundational problem: the central analytical framework of contemporary HTA depends upon arithmetic operations that are inadmissible under the requirements of representational measurement and the standards of normal quantitative science. The measurement cat is now out of the contemporary HTA litter box. It cannot simply be put back.

There is therefore no scientific basis for defending the status quo. The relevant question is no longer whether utilities, QALYs and economic models have proved useful, gained widespread acceptance or been employed for decades in research and healthcare decision-making. Longevity and institutional acceptance do not establish quantitative validity. Once the requirements governing admissible arithmetic are applied, the problem becomes transparent. Multiplication

requires ratio measurement. Arithmetic operations are constrained by scale properties. Dimensional homogeneity must be maintained. Numerical assignment cannot substitute for measurement. Where these requirements are violated, the resulting arithmetic is inadmissible. No degree of methodological refinement, statistical sophistication, simulation modelling or sensitivity analysis can alter that conclusion.

The challenge for California is therefore one of transformation: how should the California HTA knowledge base be reconstructed to satisfy the requirements of lawful measurement? California universities and research centers occupy particularly influential positions within American health economics, outcomes research, pharmacoeconomics, comparative effectiveness research and health-services research. Through graduate education, methodological research, professional training and collaborations with healthcare systems, government agencies and the pharmaceutical and biotechnology industries, they shape analytical practice far beyond the state's borders. **The** 0/17 versus 20/20 program-content finding provides an opportunity to reconsider not simply the content of California HTA programs but the scientific sequence in which that content is presented. Measurement must become the foundation upon which subsequent quantitative methods are built rather than an omitted prerequisite.

The starting point is straightforward. Representational measurement must become the organizing scientific principle for HTA rather than an optional addition to existing programs. Students and researchers must first learn to define the target attribute, distinguish manifest from latent attributes, establish the appropriate form of lawful ratio measurement, determine which arithmetic operations are admissible for each scale type, and formulate claims capable of empirical evaluation, replication and falsification. Only after these requirements have been satisfied should further quantitative procedures be considered.

This transformation does not abandon HTA. It places HTA within the accepted standards of normal quantitative science. California universities and research centers therefore face a clear choice: continue reproducing a legacy framework whose arithmetic fails the requirements of representational measurement or lead the reconstruction of HTA around lawful measurement. Given California's national and international prominence in health economics, outcomes research, medicine, pharmacy, public health, comparative effectiveness research, biotechnology and healthcare policy, such a transformation would extend far beyond individual universities or California itself.

Faculty necessarily have the leading educational role in this transition. This does not imply that investigators have knowingly disregarded representational measurement. Most faculty members were themselves educated within the contemporary HTA paradigm and continue to teach the methodological framework transmitted through universities, textbooks, journals, professional organizations and established research practice. The **0/17** finding demonstrates the extent to which representational measurement is absent from the publicly presented California program-content knowledge base. Transformation must therefore begin by providing faculty with the scientific knowledge and practical tools required to reconsider the foundations of what they teach. Once measurement failure has been documented, continuing to reproduce it for another generation of graduate students is impossible to defend.

It is precisely this gap that the **Maimon Research nine-unit transformation program** is intended to address. The program is designed as more than a sequence of educational materials. Comprising approximately **45,000 words of structured instructional material**, it provides a systematic template for faculty, researchers and practitioners seeking to understand and implement the transition from legacy HTA to a framework grounded in representational measurement. The nine units progress from measurement preceding arithmetic through attributes, scales of measurement, admissible arithmetic and dimensional homogeneity to the distinction between manifest and latent attributes, linear ratio measurement, Rasch measurement, attribute possession and the construction of empirically evaluable therapy-impact claims.

The program can therefore support individual faculty preparation, reconsideration of existing graduate teaching, or development of a new postgraduate course in the quantitative assessment of therapy impact organized around lawful measurement and normal science. As far as can presently be ascertained, it is the only program available internationally designed specifically to support the transition from legacy HTA to the new HTA grounded in representational measurement**.**

An important feature is that participants are not left simply to work through the material independently. Those enrolled have access to continuing 24/7 online Q&A support, both while studying the units and, importantly, as they begin applying the framework in teaching, research and therapy evaluation. Questions concerning particular attributes, proposed measures, Rasch applications, therapy-impact claims, protocols or curriculum development can be raised as they occur. This continuing interaction is particularly important for faculty whose previous education did not include representational measurement. The objective is not simply completion of nine units but development of the capability to apply the measurement framework independently and introduce it confidently to students and colleagues.

The program can also provide a starting point for broader institutional engagement. Where California universities, research centers, academic departments or professional groups wish to explore the implications of the new HTA in greater depth, additional activities can be developed around their requirements, including seminars, faculty discussions, workshops, small-group sessions, curriculum-development support and presentations addressing specific measurement or therapy-evaluation problems. These activities allow institutions to move beyond individual enrollment toward reconsideration of how quantitative therapy evaluation is taught and applied.

A fee is charged for access to the nine-unit program to support the maintenance, administration, updating and continuing availability of the system, including participant support. This should not obscure the larger purpose. The objective is transformation: to provide faculty and institutions with an accessible and supported pathway for replacing the legacy of measurement failure with graduate education grounded in lawful measurement, admissible arithmetic and empirically evaluable claims.

The nine-unit program is therefore offered as a template for faculty preparation and development of a post-legacy graduate HTA program. California universities do not have to reconstruct the measurement framework independently from first principles. The framework already exists. The immediate question is whether faculty and graduate programs are prepared to use it to begin

building a new curriculum for the quantitative assessment of therapy impact grounded in lawful measurement, admissible arithmetic and the standards of normal science.

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