Natural Semantic Metalanguage as an approach to measuring meaning

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Abstract. Do any interesting or valuable fundamental commonalities arise when measurement and linguistic methods are used to understand the same phenomena? A basis for such commonality resides in the human desire for meaning, a need manifest in all cultures and languages. However, the notion of meaning is rarely associated with measurement; it resides more comfortably in the study of language and linguistics. This exploration commences with an examination of measurement theories, principally Rasch Measurement Theory (RMT), with the aim of identifying opportunities for elucidating the meaning of objects of measurement. A brief overview of the discipline of linguistics then reveals the importance of semantics in expressing meaning. An explanation of how the Natural Semantic Metalanguage (NSM) can enable explication of linguistic meaning follows. The paper concludes with a proposal for ecological applications of invariant measurement and the NSM.

1. The meaning of measurement in the human sciences
Contemporary conceptions of measurement in the human, social, behavioral, and health sciences, are varied:
- “… the process of locating both persons and items on a line that represents a latent variable” [1];
- measures “… must be objective abstractions of equal units” [2]; and
- as being “… concerned with properties considered in terms of more or less, and measured by instruments that operate in some relevant range” [3].

Andrich [3] identified three related definitions of measurement applicable to the social sciences: classical measurement, representational measurement, and additive conjoint measurement. Classical definitions are based on the test-score tradition of measurement comprising classical test theory and true score theory [1]. Classical test theory uses the statistical methodology of correlation coefficients to solve psychometric issues related to the estimation of reliability coefficients. The function of instruments is dependent on the sample being measured, and hypothesis testing focuses on estimates of statistical significance levels. According to true score theory, the observed score for a person is the sum of a true score and an error score. The focus is on the sum of observed scores, not on item characteristics, and the error value is for the test, overall; error values for individual items or individual persons are not estimated.

The second, representational, definition of measurement in Andrich’s classification states “… the properties of objects can be assigned numbers in such a way that the relationship among the properties
is the same as the relationships among the numbers” [3]. For example, concatenation in which the extent of more or less in a property of an object is represented numerically.

Third, in additive conjoint measurement, the consistent relation between two observable variables is taken as evidence of a third, but latent, variable that is not directly measured. For instance, the property of density is not observable, but can be inferred by the relation between the observable properties of mass and volume.

A detailed examination of contemporary measurement theories, particularly Rasch Measurement Theory (RMT), reveals the following more nuanced characteristics conceived in terms amenable to the broad metrological sense of measurement [4-5].

Sufficiency: The requirement that all the information needed for measurement is available in the observed response data is articulated as a testable hypothesis in models positing statistically sufficient estimators of separable parameters. The meaning of the unit of measurement is qualified by the a priori development of a construct model or variable map tested empirically against data.

Objectivity and separability: “Objectivity requires that agent calibrations (e.g. item difficulties) be independent of the sample of objects (e.g. persons) used in the calibration procedure. Object measures must also be independent of the particular agents used to obtain them” [6]. Specific objectivity and separability of parameters in RMT meet this requirement.

Invariance: The comprehensive class of all invariant rules is essentially identical with that subclass of invariant rules based on sufficient statistics [7, 8]. In mathematics and the physical sciences, the principle of invariance refers to the property of remaining unchanged under pressure to transform, or in the case of measurement, from changes in the conditions of measurement. The principle is fundamental to understanding the application of scientific laws in different frames of reference such as stationary and moving systems. Invariance in measures developed from RMT requires invariant, linear item difficulty calibration and person measurement.

Differential item functioning: Each item is tested for differential functioning to minimize bias due to confounding or extraneous person factors. At the item level, persons or objects with a similar level of the attribute being assessed should receive equivalent item measures irrespective of differences in person factors including location, time of assessment, and gender.

Discrimination and anomalies: Implicit in the definitions of measurement was the idea of comparison of the properties of persons or objects. The metrological systems in scientific measurement use interval and ratio scales to measure properties of objects and make comparisons between objects. According to Kuhn [9], discovering and investigating anomalies arising in these comparisons is a primary aspect of scientific progress.

Philosophy: The hallmark of meaningfulness is a truth value obtained independent of the particulars of the choice of representation, within certain limits, such that formal analysis in the context of measurement theory leads to a focus on invariance under changes of scale [10, 11]. Additional philosophical justifications for measurement theory can be derived from hermeneutical phenomenology and Actor-Network Theory [12, 13].

Non-deterministic (stochastic) constructs: The object of measurement is not precisely defined but is described probabilistically in terms of self-organized, complex adaptive systems [14]. The essence of the object of measurement is systematically refined and reproduced through multiple iterations of data collection and analysis.

These seven characteristics are fundamental principles for the construction of invariant measures, a lens into the meaning of measurement. Now we take up the second major construct of this project, language.

2. Language

Having language distinguishes humans from other animals. Chomsky (1972), asserted “When we study human language we are approaching what some might call the ‘human essence’ the distinctive qualities of mind that are so far as we know unique to man” [15]. The study of human language is linguistics. Linguistics provides structure for understanding the nature of language. Linguists investigate
morphology, syntax, phonetics, phonology, semantics and pragmatics. Morphology is the study of the structure of words. Syntax is the arrangement of words and phrases to create sentences, and to create the structure within sentences. The syntactical branch of language structure is also presented as prescriptive grammars. Phonetics concerns the production of speech sounds, phonology is the system and patterns of the speech sounds. Semantics is the branch of linguistics and logic concerned with the meaning of words and their meaning within sentences. Pragmatics is the study of language from the perspective of usage and context.

The thesis of the current project focuses on the fact that measurement and language have a common purpose, the expression of meaning individually and collectively. Accordingly, the following examination of meaning in language will centre on semantics. Pragmatic issues in the proliferation of proficiency testing, particularly in second language teaching and assessment, will be covered elsewhere.

Wierzbicka [16] makes clear distinctions between language, meaning, and communication. Language is essentially a tool for expressing meaning and communicating; both apply language. But in contrast to communication, meaning can be expressed without the need for an audience, as, for example, when we talk to ourselves or think aloud. However, the expression of meaning is complicated by some words having language-specific meanings and other words having a common meaning across languages. Resolution of a potential conundrum is possible by employing a two-parameter model of linguistic meaning in which meaning can be separated from language; the meaning of words is separated from their morphology. Some words will retain the same meaning cross-linguistically and cross-culturally; their meaning is invariant. Other words' meanings will be variably dependent on cultural factors. The presence of words with invariant meanings in different languages provides an anchor for cross-linguistic comparisons and semantic explication. These are features of the NSM [17].

3. Natural Semantic Metalanguage (NSM)

The philosophical orientation of the NSM was influenced by the pre-Enlightenment rational philosophers who believed all people share some simple ideas, the basic elements of thought. For example, Goddard [18] recounted Leibniz acknowledging the occurrence of concepts which could be understood in isolation but could be combined to describe more complex concepts. Similar bottom-up patterns of emergent meaning lead to the spontaneous introduction of new concept-word-thing semantic triangles as cultural systems change. Reciprocally, these complex concepts can be understood by reduction, as when complex concepts can be decomposed into a small number of simpler concepts.

Wierzbicka [16] applied a linguistic perspective to the decomposition notion and defined the semantic prime. A semantic prime is a word-meaning or concept which cannot be paraphrased (decomposed) into any simpler terms; and semantic primes are expected to be lexical universals. Universality requires that, within one language, a prime cannot be paraphrased, and that semantic primes have equivalents in other languages, there should be exponents of the prime in many languages. Every semantic prime has its own grammar of relationships involving the other primes with which it can be combined. For every prime, the other primes with which it can be combined have been identified.

The NSM currently employs 65 semantic primes; for example, substantives, determiners, speech, time and space, with equivalents in most languages. The following semantic analysis (a partial explication), illustrates how the NSM is applied to clarify the meaning of the Japanese word “kawai” (dictionary translation “cute”) [19]. “Kawaii” was chosen because although Japanese girls and women extensively use it to express positive emotions towards clothes and feminine paraphernalia, there is no equivalent in English. The corpora for the analysis were publicly available web-based information found in 50 postings.

First, Japanese dictionary definitions of “kawai” were obtained and examined in conjunction with previously proposed definitions. Next, the reductive paraphrase methodology was applied to the corpora. A textual analysis of the web-based discourse of the native speakers was conducted to reveal embedded emotion, thoughts, cultural significance, and physical attributes. For example, in the case of “kawai”, these included “small” and “positive emotion”. Simultaneously, the repertoire of 65 NSM semantic
primes was consulted to tentatively specify the semantic components of “kawaii”, the constituent semantic primes.

The process was iterative and proceeded until the components of meaning could not be further reduced. Finally, the resulting explication included only semantic primes and their respective English components for the following categories of primes: substantives (e.g. “thing”), evaluators (e.g. “good”) and descriptors (e.g. “small”) [19]. The analysis of “kawaii” illustrates how the NSM enables meaning-based cross-lingual understanding of a word, in contrast to literal translation. In literal translation, the expression of meaning is limited by reliance on synonyms and resulting circularity of argument.

4. Issues in the application of semantics in measurement

As was noted earlier, both measurement and linguistic approaches can be applied to express meaning. For example, applying RMT constructs meaningful invariant measures, and applying the NSM elucidates linguistic meaning. This commonality of intent provides a rationale for exploring the possibility of complementarity and synergy. In keeping with the remit of the project, emphasis now shifts to the opportunities afforded by the NSM for expressing meaning when constructing invariant measures in the human, social, behavioral, and health sciences. The opportunities are in response to problems that arise through the use of language.

The first problem is deficiencies in the procedures and the resources used to compare the semantics of different languages. In the case of native language instruments used in social and psychological measurement, the availability of existing definitions can enable reliable analysis of the semantics. However, when instruments use vocabulary from multiple languages, the availability of bi-lingual definitions may be limited, particularly from bilingual dictionaries. Bilingual dictionaries have been criticized for insensitivity to cultural values, an ethnocentric view of the lexis of other cultures, and circularity between definitions.

A second problem derives from the treatment of substantive matters in the design of instruments, particularly multi-language instruments, where semantic analyses are omitted when developing multi-linguistic construct models. The choice of vocabulary in multi-language instrument construction is a semantic issue and use of semantic analyses during instrument development and administration is warranted.

A third problem is exemplified by large-scale international surveys. Measuring a common construct using multiple vernaculars requires attention to the semantics of each native language.

A fourth problem centers on the use of quantification in the absence of semantic analyses. Quantitative procedures and instruments do not necessarily provide meaningful results notwithstanding the selection of large samples and statistical data analyses.

A fifth problem is myopia in the choice of linguistic and measurement approaches, not canvassing multiple theories and methodologies, in particular across qualitative and quantitative divides often wrongly assumed to make opposing philosophical commitments.

5. Applying semantic analysis for expressing meaning in Rasch measurement

The following procedure describes how NSM analyses could deal with linguistic issues in the development of a bi-lingual measure. The vernacular of a language can be analysed by the NSM approach to identify native language semantic primes that define the phenomenon of interest, as, for example, in the analysis of “kawaii”. Similarly, the meaning of the construct in another language can also be defined by an NSM analysis.

Although the NSM definitions use exponents specific to the respective native languages, the exponents have universal meaning and equivalents in most languages. Examination of the exponents enables comparison of the meaning of the phenomenon in the different languages. Depending on cultural and linguistic peculiarities, the comparison might or might not reveal common meaning. When there is common meaning, the equivalents in the common NSM definitions can comprise a construct model of the phenomenon with meaning in both languages and is applicable for the construction of instruments in accord with RMT.
The NSM approach has features analogous to aspects of invariant measurement. The reductive paraphrasing in the NSM analysis is typically conducted in the native language using examples from that language. This ensures fidelity of the NSM explication in expressing the meaning of attributes of the local culture including identifying anomalies to the NSM explication. Another analogy concerns the universality of the primes, as the function of the primes is independent of the language being analysed. Similarly, the universality of the sematic primes exemplifies specific objectivity because the development of the NSM and the testing of primes were independent of the languages being tested. These features of semantic analysis could be viewed as linguistic invariance.

6. Applying semantic analysis in ecologising

When meaning at the semantic level of word usage can be shared with fidelity in different communities, cultures, and languages, metrological networks become viable for the management of human and natural ecosystems [20-22]. A semantic approach to ecologising focusses on both the substance of what is being expressed and the mechanism for expressing meaning. The substance of expression, or the essence of the meaning, can be revealed by reductive semantic analyses that complete a return dialectic back to the patterns of phenomena that originally cohered into classes that could be named. Significantly, the notion of semantics can be extended beyond a linguistic conception to include any phenomenon or construct assigned meaning.

From an ecological perspective, a semantic analysis is a tool for understanding the constituents and dynamics within ecosystems and between ecosystems. Using semantic primes to explicate ecosystems enables cross-ecosystem system analysis. It also provides construct models for constructing invariant measures (Rasch Measurement Theory), as described in Section 5. These measures are the foundation for building metrological networks and complement the semantic approach to expressing meaning.

7. Summary

The core activity of the paper was a comparison between Rasch Measurement Theory and the Natural Semantic Metalanguage, an approach to semantic analysis. The impetus for the comparison was the possibility of synergy between the measurement theory and the linguistic theory. After a brief overview of measurement, the notion of invariant measurement was explicited in terms of seven distinguishing characteristics compatible with RMT:

- Sufficiency;
- Objectivity and separability;
- Invariance;
- Lack of differential item functioning;
- Discrimination and anomalies;
- Philosophy;
- Non-deterministic (stochastic) constructs.

The features were advocated as the principles for expressing meaning when constructing measures. Attention was then given to linguistics and the role of semantics. The Natural Semantic Metalanguage (NSM) approach was introduced and the process for semantic analysis using the NSM was explained. The principal analytic procedure is defining the construct of interest by reductive paraphrasing and then using semantic primes to define the construct. Semantic primes (65) have universal meaning, are independent of language and culture, and enable stable cross-linguistic and cross-cultural comparisons. The invariant nature of the NSM framework of primes was described as “linguistic invariance”.

Linguistic issues impacting measurement stem from limitations in the attention given to semantics in instrument development, particularly in cross-language studies. NSM could be used to ameliorate these limitations and provide construct models for the design of measures.

Applying the NSM to define constructs by explications comprising semantic primes appears to be a potentially powerful method for understanding the functioning of ecosystems and the design of ecologising, particularly when complemented by application of Rasch Measurement Theory.
In conclusion, we argue for more use of semantic analysis in human science measurement. While the NSM and RMT theoretical approaches appear dissimilar, there is significant similarity and important complementarity to warrant more investigation. Future work will design and implement a study to test the proposed methods.

References
[1] Engelhard G J 2012 *Invariant Measurement* (New York: Routledge Academic) p 28
[2] Bond T G and Fox C M 2001 *Applying the Rasch Model: Fundamental Measurement in the Human Sciences* (New Jersey: Lawrence Erlbaum) p 2
[3] Andrich D 2018 Advances in social measurement: A Rasch measurement theory In F Guillemin, A Leplege, S Briancon, E Spitz and J Coste (Eds) *Perceived Health and Adaptation in Chronic Disease* pp 66-91 (New York: Routledge) pp 66-68
[4] Mari L and Wilson M 2014 An introduction to the Rasch measurement approach for metrologists *Measurement* 51 315-327
[5] Pendrill L and Fisher W P Jr. 2015 Counting and quantification: Comparing psychometric and metrological perspectives on visual perceptions of number *Measurement* 71 46-55
[6] Stenner A J 1990 Objectivity: specific and general *Rasch Measurement Transactions* 4 111
[7] Hall W J, Wijsman R A and Ghosh J K 1965 The relationship between sufficiency and invariance with applications in sequential analysis *Ann. Math. Stat.* 36 575-614
[8] Arnold S F 1985 Sufficiency and invariance *Stat. Probabil. Lett.* 3 275-279
[9] Kuhn T 1970 *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press)
[10] Mundy B 1986 On the general theory of meaningful representation *Synthese* 67 391-437
[11] Roberts F S 1994 Limitations on conclusions using scales of measurement. In A. Barnett, S. Pollock and M. Rothkopf (Eds) *Operations research and the public sector* (Amsterdam, The Netherlands: Elsevier) pp 621-671
[12] Fisher W P Jr 2004. Meaning and method in the social sciences *Hum. Stud.: A Journal for Philosophy and the Social Sciences* 27 429-454
[13] Fisher W P Jr and Cavanagh Y 2016 Measurement as a medium for communication and social action, I & II. In Q Zhang and H Yang (Eds) *Pacific Rim Objective Measurement Symp. (PROMS) 2015 Conf. Proc.* pp 153-182 (Berlin: Springer-Verlag)
[14] Fisher W P Jr and Stenner A J 2017 Towards an alignment of engineering and psychometric approaches to uncertainty in measurement: Consequences for the future *18th Int. Congr. of Metrology* 12004 1-9
[15] Chomsky N 1972 Language and mind https://www.sk.com.br/sk-chom.html
[16] Wierzbicka A 1992 *Semantics, Cultures and Cognition* (New York: Oxford University Press)
[17] Goddard C and Wierzbicka A 2014 *Words & meaning* (Oxford: Oxford University Press)
[18] Goddard C 2017 *Ten Lectures on Natural Semantic Metalanguage* (Leiden: Brill)
[19] Asano-Cavanagh Y 2014 Linguistic manifestation of gender reinforcement through the use of the Japanese term kawaii *Gender Lang.* 8 341–359
[20] Fisher W P Jr and Stenner A J 2016 Theory-based metrological traceability in education: A reading measurement approach *Measurement* 92 489-496
[21] Fisher W P Jr 2009 Invariance and traceability for measures of human, social, and natural capital: Theory and application *Measurement* 42 1278-87
[22] Fisher W P Jr and Stenner A J 2015 The role of metrology in mediating and mobilizing the language and culture of scientific facts *J. Phys.: Conf. Ser.* 588 012043