MEASURING DEVELOPMENTAL SYNAESTHESIA: SOME METHODOLOGICAL CONSIDERATIONS AND CRITIQUE-BASED REFINEMENTS OF THE SYNAESTHESIA QUOTIENT INVENTORY

Anton V. Sidoroff-Dorso
Moscow Pedagogical State University, Russian Federation, anton_sidoroff@mail.ru

Abstract: Theoretical and methodological issues relevant for the construction of the Synaesthesia Quotient inventory such as first-person data integration, construct validity, respondents' comprehension, etc. are disentangled and some improvements of the measure based on expert opinion and practical feedback are introduced.
Keywords: synaesthesia, developmental synaesthesia, synaesthesia quotient, measurement, (psycho)phenotypic expressivity, psychological assessment, psychometrics, neurophenomenology

This paper should be considered as an intermediate reply in a dialogue about the notion of *Synaesthesia Quotient*, its measurement and related issues between myself the author and some of my colleagues[1] who generously provided their expert opinion in our correspondence on the topic. The reader unfamiliar with SynQ and its generative theoretical framework, provisional methodology and potential outcomes might find these lines turbid, fragmentary and incoherent. This is for a reason. After all, it is complex explications, broad commentary and extended work that make complex phenomena look simple. After all. So far, synaesthesia remains to be as complex as it probably did not used to be more than 100 years ago when it was just given a common name (MELLET, 1892).

What follows here, in the main sections, is a refined definition of developmental synaesthesia, ensuing elaborated description of the condition and a set of other notions including specification of *phenotypic expressivity of synaesthesia* that the Synaesthesia Quotient inventory is designed to target. However, reading this will not be sufficient for completely comprehending the three major sections of the paper– on methodology, validity and administration issues that came about during expert discussion and practical use of the SynQ-i. For detailed explication of the methods, concept operationalisation, measure description and a base sample of the Synaesthesia Quotient inventory, I kindly refer the reader to my other papers (SIDOROFF-DORSO 2009; 2012; 2013). An updated version of the SynQ-i as well as its previous forms can readily be retrieved from www.synaesthesia.ru/synq

For further advancement in the field of synaesthesia research it has long been acknowledged that a certain measure is needed to identify, among other things, how "stronger" is manifestation of synaesthesia in one synaesthete than the other; or whether the degree of such manifestation is statistically more commonly instantiated in this or that synaesthesia variety (such as projector vs associator types); or whether a greater number of varieties of synaesthesia positively correlates with a more distinct manifestation of another individual difference (creativity, imagery, memory, etc.). Such quantitative estimates have been exercised on a basis of intuitive assumptions derived from idiosyncratic descriptions of individual varieties (see SIDOROFF-DORSO, 2013). Therefore, investigation-wise, SynQ will be instrumental in establishing experimental paradigms with a view to revealing regularities between the degree of expressivity of developmental synaesthesia in an individual case and, for instance, peculiarities of the underlying brain structure, hypothetically co-occurring neurocognitive conditions (hypercalculia, dyslexia, autism, etc.) and psychological traits such as creative abilities, facilitation of memory and mental imagery, and other cognitive differences. In this regard, the proposed concept of Synaesthesia Quotient and the related measure scales can prove applicable in gaining a more systematic and predictive perspective on synaesthesia.

SYNAESTHESIA QUOTIENT, ITS MEASURMENT AND FOUNDING CONCEPTS

The *Synaesthesia Quotient Inventory* is a psychological assessment tool (questionnaire), a measurement instrument that is being designed to evaluate an individual degree of phenotypic expressivity of developmental synaesthesia and sum it up as an index conceptualised as *Synaesthesia Quotient*. The theory behind the SynQ-i is that developmental synaesthesia can be analytically delineated into a set of measurable propensities. On an empirically substantiated and theoretically founded basis, such propensities can be attributed to all the observable/reportable varieties of developmental synaesthesia and utilised to quantitatively characterise individual cases across their qualitative distinctions.

In particular, such an interpretation does not isolate the multiple types and varieties of the condition by *prima facie* criteria of their "difference" but infer

[1] Many discussion points for this talk should be credited to my colleagues and friends – Lawrence Marks, Sean Day, Danko Nikolic and Anna Rogowska. I gratefully acknowledge them as my invisible conversation partners in this paper.

from their subjective idiosyncrasies some informative markers for identifying a degree of synaesthesia manifestation. Thus, being "content-neutral" in its generalisation of the phenomenon of synaesthesia and the construct of synaesthesia expressivity, the SynQ measure and its framework can be applied for designing contrasting laboratory paradigms and operating statistics across varieties of developmental synaesthesia, i.e., enabling cross- or inter-type comparative data collection and experimenting.

Emphatically, the theoretical foundation and application of *the Synaesthesia Quotient inventory is orthogonal to most questionnaires and tests* in current circulation that are utilised to either reveal or/and validate synaesthesia. The SynQ-i, therefore, complements other inventories and, when and if required, capitalises on their results both for its reliability/validation and further refinement. On that account, the SynQ measurement tool is intended to be administered in alignment with other well-established instruments and only through this concordant application it can verify the genuineness of someone's synaesthesia (TOG-R; ASHER *et al*., 2006; Synesthesia Battery; EAGLEMAN *et al*., 2007).

Developmental synaesthesia is defined as an inborn (or very early epigenetically developed) statistically atypical but non-pathological condition in which tending to, being aware and/or thinking of *a category-based* or, on a continuum of perceptual categorisation, *category-embedded entity*, such as a sensory standard, phoneme, letter, numeral, name of a person or place, etc. triggers on a *consistent, automatic and involuntary* basis, following the principle of *categorial correspondence* (supervenience), an *additional, perception-like objectless property* (or a merger of such), for example, colour, taste, smell, etc. of endogenous, consciously impenetrable origin.

The derivative dimensions subsuming the content of the construct that substantiated the items in the base version of the SynQ-i are the following properties– attributes of the inducer sets (cognitive aspects of letter system, names, tastes/flavours, etc.); attributes of the concurrent sets (projectors vs associators; versatility of the concurrent sensory substrate; subjective localisation of the projected reaction, etc.); character of the inducer category (width, precision, abstraction, functionality, etc.); number of inducer categories within an individual; number of concurrent sets within an individual; difference or functional relation among the inducer sets within an individual (single, multiple or poly-aspectual); difference among the concurrent sets (disjoint, mixed, etc.); functional relation among the inducer and concurrent sets within an individual (unidirectional, bidirectional or mixed); flexibility, malleability of the experience with lifespan (attrition, emergence, transfer, dilation, etc.); degree of interference with veridical perception; modifiability through conscious wilful acts (see also the five subfactors of developmental synaesthesia in SIDOROFF-DORSO, 2012).

Taking into consideration from the functional-experiential and ontogenetic-epigenetic perspectives, it can be concluded that neither in terms of inducer selectivity nor the inductive dynamics of its experience (functional coupling between inducers and concurrent "association"), nor, even, in the characteristics of its concurrents–in none of all these aspects synaesthesia is a *genuinely sensory* or *conceptual* phenomenon (see detailed analysis in SIDOROFF-DORSO, 2012). Rather, from different angles of analysis, synaesthesia should be characterised differently. Ontogenetically, the phenomenon seems to develop as part of the process of covert or overt cognitive categorisation while immediate experiential analysis reveals its *compoundly perceptual* nature. To specify the latter, depending on its type, synaesthesia's cognitive realm straddles higher-level or/and lower-level perception embracing the spectrum from category-engrained/all-modality to mode-embedded to category-embedded to symbol system-based (scopes of modularisation-differentiation-categorisation).

All in all, developmental synaesthesia can be characterised as a *perception-like* or *quasi-sensory* endogenously generated phenomenon that is embedded in the neurocognitive mechanisms of primary categorisation and experientially actualised on the basis of causal categorial correspondence (causally *supervenient*). Synaesthesia accompanies the two types of categorisation – rule-based and exemplar-based ("fuzzy-inferential" and "category-inferential", see below). Importantly, although all synaesthesia-inducing substrates seem to presuppose the cognitive tasks of open-type categorisation, synaesthesia manifests itself even with no situation-sensitive meaning-generation, thus, being *automatic, non-referential and far from ideational*.

The selectivity of synaesthetic reactions can take the earliest and shortest period (35-50 ms) of SOT but, as was described above, it allows characterising the phenomenon as functionally unique with its own distinct cognitive load. However, against the backdrop of ongoing cognitive processes that 'host' synaesthesia (200 ms or more), in each individual type the *synaesthetic moment* can be integrated at unique time and level of hierarchy and run parallel to the activities of the instantiated process – either almost sensory (sounds, tastes, etc.) or pre-conceptualised (music, language, etc.). It is this relative duration ("rolling" embeddedness specific for each type) and impossibility to discriminate the onset/offset time of synaesthesia induction against the backdrop of host neurocognitive process that lead some researchers to the false dilemma of "sensory vs conceptual" (cf. WARD, SIMNER, 2003; HUBBARD *et al*., 2011; SIMNER, 2012; NIKOLIĆ et al., 2011).

With its onset time, synaesthesia accompanies the early phase of cognitive analysis (recognition)/synthesis (incorporation). Thus, it seems implausible to stick to the division into "synthetic" and "analytical" synaesthesiae. Herewith, synaesthetic inducers are mental

representations, with various degrees of explicitness, of the cognitive skills of (rule-based) manipulations of symbolic systems or/and (exemplar-based) segregation of the sense-modality substrate, with both spectrum extrema representing cognitive activity with open-ended ongoing hypothesis-driven adaptive value: from time-units and names through speech/languaging and music to pain, taste or sound.
The division within the cognitive synaesthetic spectrum, from all-modality to category-embedded, emphasises the degree of sensory entrenchment/conceptual abstraction of a particular synaesthesia variety *relative* to other sets of cognitively enskilled selectivity (perceptual and symbolic categories), *not* the synaesthetic mechanisms themselves. This relative cognitive elaboration correlates with the qualitative complexity of concurrents (SIDOROFF-DORSO, 2012), which in turn can serve as a certain marker of the ontogenetic (critical) period of development of each type of synaesthesia.

The described functional transpositions in-between the cognitive and sensory imbue synaesthesia with its unique properties and excludes explanation based on solely sensory or conceptual processes. The very dispute whether synaesthesia is a sensory or conceptual phenomenon is a result of –
(1) methodological "nativist" confusion of analytical perspectives (ontogeny vs ongoing induction);
(2) conventional understanding of these levels of psychophysiological processing (maturation of "modules" rather than development through histories of experience);
(3) modeling them as linear and localised rather than massive and widely distributed neural activity;
(4) attributing more cognitively involved processes entirely to the neocortical activity;
(5) overlooking the phenomenological differences between veridical sensory properties and synaesthetic concurrents;
(6) underestimating the attentional dynamicism in synaesthesia, and
(7) indiscriminately treating the unique aspects of categorical cognition in synaesthesia.

Degree of phenotypic expressivity of synaesthesia is defined as the extent to which phenotypic expression of the condition of synaesthesia differs from individual to individual. Accordingly, synaesthetes with the same genotype can be considered to have measurably different degrees of their synaesthetic phenotype. In this regard, *Synaesthesia Quotient* can be defined as an index of the quantitatively conceived degree of overall expressivity of synaesthesia in an individual case. Currently, SynQ is an operational construct substantiated by the data presented in scientific literature. The index is being constructed as capable of being identified along the reciprocally reinforcing lines of experiential (phenomenological), psychophysical (behavioural), neurophysiological and genetic studies. A Synaesthesia Quotient of an individual case is supposed to be expressed as both a numerical indicator that will define its absolute position according to a *norm-referenced score interpretation* and/or a verbal ratio-scale descriptor with a view of placing each case on the spectrum between the low (through average) and high-level extrema of synaesthetic manifestation.

Summing up, as some aspects of synaesthesia including the degree of its expressivity can be regarded as *theory-guided constructs*, it has been attempted to specify the content domains of the latter. Capitalising on empirical evidence from synaesthesia research literature as well as extrapolating the relevant supplementary data from external neuroscientific studies, ten domains have been derived within which possible overall rating values (scoring scheme tendencies for SynQ) have been determined. The identified content domains of the magnitude of synaesthesia expressivity include: multiplicity (number of possessed types within an individual case), aspectuality (functional difference among inducer systems), sensory versatility of concurrents, attrition (decremental proneness), extent of perceptual presence or veridicality of concurrents, cognitive involvement (selective complexity) of inducers, descriminative power of the sensory modality of induction (protopathic or epicritic sensations as a basis of inducers), attention-dependence of induction, controllability of concurrents, and stimulus-dependence of induction.
Thus, a person *with a higher Synaesthesia Quotient* will be (1) a multiple and (2) poly-aspectual rather than a single-type synaesthete. (3) Their concurrents are inclined to exhibit more sensorial characteristics, and (4) their synaesthetic experience is more consistent over time and less likely to dissipate with age or for other non-morbid reasons. A high SynQ case is (5) a projector type rather than associator with (6) inducers, more likely, constituting an all-modality, more comprehensive rather than selective, category-embedded type of synaesthesia. They will have a trend of (7) having protopathic rather than epicritic sensory modalities embedding the inducers which will trigger synaesthesia (8) relatively more independently of top-down modulation (attention, awareness, thinking, etc.). A greater magnitude of synaesthesia expressivity will manifest itself as (9) less controllable experience of concurrents (thus, being more structure-based and less function-dependent) and (10) less reliant on the presence of physical stimuli (being capable of self-triggering by merely mentally evoking the inducer) (SIDOROFF-DORSO, 2013).

METHODOLOGY FOR SYNAESTHESIA QUOTIENT: MERGING FIRST-PERSON AND THIRD-PERSON DATA

If considered from the perspective of a cognitive scientific endeavour, quantification of (psycho)phenotypic expressivity of synaesthesia

depends on resolution of at least three mutually entangled issues:
(a) Construct validity as generalised scope and homogeneity of the construct (phenotypic expression of synaesthesia) across its versatile specific manifestations or varieties;
(b) Identification of its proper content domains (common neurocognitive features);
(c) Operationalisation of the degree of expressivity of synaesthesia in individual cases.

In this regard, psychometric methods when applied to synaesthesiae will face very special practical challenges related to the issues that have not been yet cleared up in synaesthesia research itself. For instance, the properties of synaesthesia relevant for psychometric methods will characterise it as objectively unobservable, indirectly representative, causally mediated, incomparably qualitatively versatile across type-manifestations and behaviourally neutral (see below for other propensities and definition). For these epistemological complications, well-established psychometric methods might prove to be rather limited, if viable at all, for initiating the development of a well-structured measurement tool of synaesthesia. Indeed, when embarking on the project of measurement development one needs first to answer the questions –
Is synaesthesia a psychological attribute? Personality-related, perceptual, sensory or cognitive?
In what sense synaesthesia is measurable?
In what way is its manifestation additive? etc.
These questions are not trivial and answering them will reveal that much theoretical adjustment and even a special approach to data-analysis are required both from the established framework of synaesthesia research and current psychometric models of measurement construction.
The acknowledged methods of psychometric index construction for a certain individual difference presupposes working out some unique solutions at each stage of measure development. For a phenomenon such as synaesthesia that mingles categorial inducers and supervenient perceptual experience, the strategies can be exceedingly protracted and time-consuming. IQ and other aptitude inventories that are limitlessly re-interpretable both in terms of test situations and construct validity, can be designed only on the basis of interindividual differences. For this reason, what they measure as such is ultimately, introspectively unreachable by respondents or testees, and statistical explanations of the g-factor, for instance, do not include causal mechanisms *within* individuals. Unlike those measures, a synaesthesia index can be inferred, on balance, both as inter-individual and intra-individual variables (differing against the related veridical perception or jointly revealing some common factors, see SIDOROFF-DORSO, 2012).
Moreover, in contrast to aptitude and personality tests, the target variable of the SynQ-i can be considered as *latent* only from the perspective of hard-line empiricists (of the neo-bahaviourist, eliminativist or rigid functionalist stances; cf. GRAY *et al.*, 2002; MACPHERSON, 2007). With minimal instruction and training, these variables become knowable and can be made explicit at the individual level through introspective techniques. To specify, at the individual level the degree of phenotypical expression of synaesthesia can be interpreted as objectively latent but it can become *subjectively manifest for an informed synaesthetic introspector* who can share this type of data with the investigator (or these two can be the same person).
In this sense, having these data on hand and if some proviso is accepted and a certain method of structuring subjective experience is followed, psychometricians find themselves in an easier position when dealing with the phenomenon of developmental synaesthesia. Much in the same vein as research into neuronal correlations of pain and emotional feelings that, like synaesthesia, have involuntary, automatic and endogenous aspects to their genesis and evocations, synaesthesia research can be methodologically enhanced through developing its own variant of efficaciously combining first-person and third-person perspectives.

Techniques to reconcile subjective and objective means of researching synaesthesia were first implemented by S. BARON-COHEN and J. HARRISON by obtaining fMRI and rCBF data in combination with synaesthetes' personal experience (BARON-COHEN, HARRISON, 1995), which provided some validity evidence for synaesthetes' self-reports. Contemplating the clinician's ambiguous position in accumulating diagnostic data via introspective interviews and objective measurements, R. CYTOWIC proposed the idea of *nondismissive disregard* that is based on preventing the two flaws in clinical cases: (a) subjects may interpret their experience rather than report them; (b) investigators' assumptions are often theory-laden and both experimenters and subjects can cross-fertilise preconceptions for shortcuts to explanation (CYTOWIC, 2003). With regard to such a challenging condition as synaesthesia, whereby *symptoms* and *signs* are so idiosyncratic and, thus, elusive and intermingled, the theoretical framework that keeps sight of both sides of the story was developed further in another line of research into what was called a "synergistic approach". Having analysed the relationship between the outcomes of experimental research into synaesthesia and synaesthetes' self-reports, the scientists concluded that synaesthesia studies that are interpreted in alignment with subjective reports synergistically advance our knowledge about synaesthesia. Consequently, it was suggest that the field of synaesthesia research requires a clearly articulated combination of well-designed experimental studies and synaesthetes' subjective descriptions (SMILEK, DIXON, 2002).
Therefore, the choice of a neurophenomenological perspective to complement the psychometric methods

was prompted by a need for well-established tools of structuring the subjectivities of developmental synaesthesia within the tacitly acknowledged approach to researching the phenomenon. Neurophenomenology with its cornerstone mission to integrate research in the various fields that study experience, derive its no less powerful techniques from cognitive science, neuroscience, and philosophical phenomenology in an attempt to piece together a dynamic and inclusive picture. Neurophenomenological methods are designed to implement such integration on a vigorously structured basis with first-person experiential accounts being juxtaposed against empirical neuroscientific measurements and experiment-generated data (VARELA, 1996; LUTZ *et al*., 2002; PRICE, AYDEDE, 2005; BOCKELMAN *et al*., 2013).

Meanwhile any quantification of synaesthesia necessary for progress in its scientific understanding is compounded by the fact that, in the majority of cases, *none of the directly experienced propensities* of the phenomenon, i.e., neither of its inducers/concurrents nor their correspondences seems to be of gradable nature. These propensities taken unstructured are not *prothetic* in Stevens' terms (STEVENS, GALANTER, 1957), which renders them their characteristic arbitrariness. Prothetic aspects of stimuli are described as changeable quantitatively (e.g., loudness, brightness, intensity, etc.) while *metathetic aspects* are thought to vary in terms of quality (e.g., colour, flavour and pitch). Prothetic sensations are best assessed with ratio scales whereas metathetic sensations are best judged with category scales; and, hereupon, direct magnitude estimation (DME) is not possible for psychophysical measurement of the latter. Importantly, to distinguish prothetic from metathetic, it was suggested that perceptual ratings from a category-related scale should be regressed onto ratings derived from a ratio scale (STEVENS, 1975).

As an aside, the adopted approach does not modify the general assumptions of current synaesthesia research, according to which the condition is considered to be manifestation of a certain neurophysiological substrate that is pre-determined genetically to some extent and manifests itself through subjective experience on a causally relational basis. However, such an understanding overlooks some facts including the modifying influence of the environment and learning and, therefore, results in "paradoxes of nativism" such as "inborn music", "brain-wired letters", etc.; or difference between the varieties of the condition in parents and children, between siblings or even twins.

To overcome these pertinent issues, I proposed to alter the perspective from experiential (content-oriented) to ontogenetic (development-oriented). Consequently, the important issue of homogeneity and scope is addressed by adopting a view that developmental synaesthesia can be subject to both heritability and malleability. Synaesthesia types (varieties of developmental synaesthesia), therefore, can have both unique and common genetic determinants with particular varieties being phenotypic variance instantiated through learning and experience in the form of qualitatively different subjectivities (what I called *ontogenetic equivalence* for the same genotype).

Therefore, a major task to accomplish at the initial stages of constructing the SynQ-i was to develop a neurophenomenological framework that can methodologically reduce the experiential, mostly metathetic features of the synaesthetic experience in the respondent's case to structured, further irreducible and, thus, potentially measurable dimensions. For example, in Items #4 (Have your synaesthetic reactions changed over lifetime?) and #7 (Which sensory modality or several modalities do your synaesthetic triggers belong to?), it is achieved through extrapolating the metathetic features into the ontogenetic perspective and, thereby, tracing down their statistically probable developmental histories.

Regarding the issue of integrating the subjective experiential descriptions into the method of deducing constraints for Synaesthesia Quotient measurement, it should be highlighted that in research into developmental synaesthesia (as well as in any line of experimental psychology, neuroscience or psychometrics; HORST, 2005), phenomenological references have always played a crucial and indispensible role. Well beyond its domain, the established practices of scientific investigation of the phenomenon are necessarily and essentially committed to phenomenological properties as a fundamental part of their methodology. Providing the constraints within which a realistic model of synaesthetic mechanisms can be elaborated, almost all the available reports of empirical evidence by necessity represent the condition in the form of subjective descriptions that emerge in scientific reports in unmediated phenomenological language. Importantly, these descriptions broadly function not as theoretical posits but as the *data* that further inform the demarcation between manifest-varieties of synaesthesia in statistics, substantiate and parameterise the design of experiment paradigms, and ultimately provide constraints for further theoretical and practical advancements in synaesthesia investigation.

To break out of the unproductive circle of the yet-undefined phenomenon whose definition is contingent on generalisation of yet-undefined individual differences (that in turn can specifically be determined only on the basis of a proper definition of the yet-undefined phenomenon), one should venture what seems at first approximation as three steps though each can be reiterated or accomplished alongside the other at a later, more advanced stage (for detail, see SIDOROFF-DORSO, 2012).

(1) Broad psychologically generalised, maximally "content-free", propensities of synaesthesia, not face-value descriptions;

(2) Establish possible correlations among them to find out whether they are determined by same and/or common factors;

(3) Common factors being refined on the basis of newly found or interpreted genetic, neuronal, behavioural and psychophysical constraints, etc.

Several methods of phenomenological analysis are regularly employed throughout cognitive sciences (cf. GIORGI, 1971; WERTZ, 1983; POLKINGHORNE, 1989; VARELA, 1996; LUTZ *et al*., 2002; PRICE, AYDEDE, 2005; BOCKELMAN *et al*., 2013). Generally, it consists of three stages. At first, naive subjective descriptions are gathered and individual constituents are derived in each description ("individual structure"). The descriptions can be part of completed preliminary questionnaires, scientific literature sources, interview protocols, etc. Each derived constituent is similarly deduced from cross-individual samples. A major task at these two partly overlapping stages is to arrive at a certain further irreducible system of functionally interrelated invariants that sufficiently represents a phenomenon or experience both at the level of individuals and at the group level ("general structure"). In so doing, a researcher acquires what can be called a "phenomenological cluster" of the experience under study. Phenomenological clusters are, thus, the subjectivity-based constraints that are explicitly articulated in as unambiguous and scientifically rigorous terms as possible. The phenomenological clusters/phenomenological model should also formulate the necessary and sufficient conditions, elemental constituents, and overall structural interrelationships that comprise the phenomenon in all its instantiations. It is to include relevant parametric characteristics so as to render them applicable for an experimental setting. At this stage, the parameters and interrelationships are experimentally treated as variables. If necessary, corrections are introduced to the phenomenological model. A similar procedure was implemented for synaesthetes' self-reports solicited through survey forms, unstructured interviews, individual descriptions, etc. The "neuro"-stage was supplemented by comparative analysis of laboratory research data both synaesthesia-related and independent but relevant for the deduced constituents. This converged into a neurophenomenological model of developmental synaesthesia (see the definition above; and SIDOROFF-DORSO, 2013).

Taking into consideration a crucial part that synaesthetes' self-reports play in informing preparation and implementation of experimental studies, the condition itself and its epistemic status in neurosciences entails a particularly articulated manner of investigation. Indeed, being almost neutral in behavioural terms, synaesthesia basically lends itself to analysing, researching and classifying solely via self-report. It has not once been suggested that progress in understanding the phenomenon should require a more thorough integration of empirical methods and first-person descriptions (cf. SMILEK, DIXON, 2002). Such a "synergistic approach" should be reflected in an appropriately selected mode and type of the constructed inventory. For this reason, for the Synaesthesia Quotient Inventory the self-rating format is proposed in this paper as a method of data gathering and scaling. As a technique, besides the benefit of directly measuring the phenomenology of the respondent, self-rating has proved to present opportunities for rigorous standardisation, reliable comparison across various samples of interest, and a normative comparison that is facilitated by its efficient data gathering (MOREY, 2003). To compensate for the shortcomings of subjective evaluation, a supplementary appendage with an objectively verified estimate, if such is obtainable, will accompany each item.

Summing up our methodological perspective, our approach is threefold. First, regarding the fact that some characteristics of degrees of manifestation of synaesthesia with very few exceptions (e.g., *multiple* and *strong* types) have been implicated practically though in a non-conventional manner, these implicit magnitude estimations have been analysed in the context of results from synaesthesia-based and external neuroscientific studies of the relevant traits. Second, on the basis of some data drawn from the synaesthesia research literature, additional aspects of synaesthesia have been demonstrated to be similarly significant for invariantly characterising the condition and, at the same time, to be quantitatively different from case to case. Explication of both groups of characteristics has led to elucidating the array of domains of the target construct of phenotypic expressivity of synaesthesia. Finally, following the same principle of data extrapolation and consolidation, the revealed characteristics have been assigned rating scale values or, more precisely, relative "direction of growth" within the identified content domains. All in all, I have expounded the delineated aspects as *measurable manifestations* capable of reflecting *a degree* of synaesthesia expressivity in each individual case. Generally, a greater magnitude of expressivity is shown to manifest itself across the identified domains as earlier appearance, stronger veridicality, a greater number of types and lower selectivity of induction. At a later stage (see the description below) the revealed structure of the content of the construct of synaesthesia expressivity was item-by-item juxtaposed with the biological constraints in related neurophysiological studies (for detail see SIDOROFF-DORSO, 2013).

SYNQ-I'S CONSTRUCT VALIDITY: NOMOTHETIC SPAN AND CONSTRUCT REPRESENTATION

Another issue intricately related to the method of developing SynQ-i is its *construct validity*. In experiment settings and reports, definitions of developmental synaesthesia are phrased parsimoniously in an attempt to relate the examined

variety to all the known types of the condition. However, such definitions are basically face-value assumptions generalised upon the experimenter's intuition and implicit epistemic judgement. Few or almost no systematic explications have been provided to align the idiosyncrasies of each recorded (reportable) manifest-type of synaesthesia in order to substantially present all the varieties as a homogeneous phenomenon. For this particular purpose the field of synaesthesia research needs a very special construct validation theory that would capitalise on all the available statistical data and empirical evidence combined with our ever-progressing understanding of the ontological status of synaesthesia *per se* and among other cognitive phenomena. The question that such a theory will deal with is not trivial:

What is synaesthesia? Or How can we know that all the observable (reportable) phenomena fall into the same epistemic category "synaesthesia"?

What are our criteria to select, generalise and measure the various manifest-types as (a degree of expressivity of) the same phenomenon?

The issue of (construct) validity is a special concern in synaesthesia research though it is not always expressed explicitly and dealt with in a vigorous manner. Indeed, in multiple descriptions of the phenomenon duly provided in introductory sections and chapters of the majority of publications one can find what seems to be shorthand definitions based solely on face validity. For this reason, over the last decade, otherwise exceptionally meticulous studies have warranted the umbrella term synaesthesia to stretch upon the phenomena of personification, ticker-tape projections and empathy-related somatosensory perceptions. On the other hand, over-analytical stances tend to disjoin the phenomenon of synaesthesia into different varieties (ideaesthesia, sociosthesia, propriocepthesia and suchlike), again, as I demonstrated elsewhere (SIDOROFF-DORSO, 2012), mostly *prima facie*.

The fact of the matter – and the proof for that is that such a theory has not been yet advanced though the accumulated data could have been an excellent springboard for it – is that there is an "epistemic gap" between various face-value definitions of synaesthesia (at least in its developmental form) that are unstructured and unconventionalised and operationalisations of particular manifest-types for individual experimental paradigms. This theoretical discrepancy is tolerable if the experimenter (or test designer) does not switch the plains from specific to general or from type to type by extrapolating their conclusions upon other varieties or synaesthesia in general without proper provisos. But developing a measure of phenotypic expressivity of developmental synaesthesia is apparently more demanding along these lines.

As is the case with other constructs in extensively used measurement tools (such as IQ or EQ tests), one of the key issues to be addressed at the initial stage of scale construction will be the scope or generality of the target construct (cf. DOWNING, HALADYNA, 2006; DEVELLIS, 2003; IRVINE, KYLLONEN, 2002). Regarding the issue of homogeneity or heterogeneity of the phenomenon of synaesthesia and, therefore, inclusion/exclusion of some of its particular types, advancing *sufficient* criteria for both, equally, isolating and joining the types can be paradoxically daunting. In subjective descriptions it might sometimes be very difficult to draw a definitive line across types and, more importantly, within (taken to be) the same type of synaesthesia. Indeed, psychoactive substances, for instance, can expand someone's developmental synaesthesia onto other (categories of) inducers (BRANG, RAMACHANDRAN, 2008). The same has been demonstrated to be a result of short-term training (MROCZKO *et al.*, 2009; SIDOROFF-DORSO, 2010). Additionally, heightened arousal can sometimes make music and sound-based types less distinct, while long-term moods can expand emotion-triggering types into "auric" varieties ("seeing" people's countenance or visage in colour), etc. On the other hand, comparative data derived from the genetic and behavioural studies demonstrate that synaesthesia can be inherited as different types or some synaesthetes can develop or lose this or that type of experience (e.g., BARON-COHEN *et al.*, 1996; BAILEY, JOHNSON, 1997; CYTOWIC, 2002; WARD, SIMNER, 2005; SIMNER *et al.*, 2006; BARNETT *et al.*, 2008; SIMNER, 2012).

It has also been demonstrated that clusterisation of synaesthetic manifestations informed by factor analysis (NOVICH *et al.*, 2011) is not necessarily genetics-driven and is highly likely to be mediated through environmental influences (SIDOROFF-DORSO, 2012). These facts might suggest some resolution or at least alleviation of the dilemma of homogenous/heterogeneous characterisation of synaesthesia as an objectively identifiable aspect. The decision whether this or that reportable phenomenon should be characterised as a type of synaesthesia should be based on correlative consistencies among the basic properties revealed through experiential phenomenological analysis and juxtaposed (also on certain positive correlation) with available or potentially available biological data.

It is due to emphasise that the construct that the Synaesthesia Quotient inventory is designed to measure is the (psycho)phenotypic expressivity of developmental synaesthesia. The bracketed appendage psycho primarily highlights the cognitive aspects of synaesthetic experience that the underlying methodology was implemented to analytically disentangle and the pragmatic perspective that the theoretical foundation of the inventory acquires. In general, *expressivity* is a notion that implies the extent to which a genotype exhibits its phenotypic expression at the level of an individual. Individuals with the same genotype can show substantial differences in many aspects of their related phenotypes. A particular inherited trait is expressed to a different degree among individuals with the same genotype, which is described as variable expressivity. For example, individuals with the same

allele for a gene responsible for a quantitative trait like body height can have large variance. At large, the degree to which a genotype is phenotypically expressed in individuals is measurable (e.g., GRIFFITHS *et al*., 2000; CUMMINGS, 2010). For the purposes of this paper, phenotypic expressivity of synaesthesia is defined as the degree to which phenotypic expression of the condition of synaesthesia differs from individual to individual. Accordingly, synaesthetes with the same genotype can be considered to have measurably different degrees of the synaesthetic (psych)phenotype.

A large bulk of statistic evidence demonstrates (e.g., BARON-COHEN *et al*., 1996; SMILEK *et al*., 2002; BARNETT *et al*., 2008; WARD, SIMNER, 2005) that, though being inherited and with some varieties clustering with more than statistic probability, it is not the specific types of synaesthesia that appear to be passed on from generation to generation, which can be mutable and deferring to a varying extent between twins, siblings, and parent and child but (a) certain underlying factor(s). Whether or not such a malleability is an instantiation of epigenetic mechanisms that embody "cognitive imprints" of an individual's ontogenetic development as synaesthesia varieties is a separate question. Regarding construct validity of synaesthesia-based paradigms and measures these facts about inheritance of type-related variable correlations provides biological testimony to a certain degree of homogeneity of the condition.

Therefore, as was elaborated elsewhere (SIDOROFF-DORSO, 2013), the same manner as the human cognitive capacity of memory could never be properly explored if not theorised as "content-free", so is the progress in synaesthesia research currently being hampered by similar content-bound particularisation spurred by prima facie judgement that can be characterised here as dysfunctional over-analysis.

As was discussed above, construct representation of any theoretic formulation of definition of developmental synaesthesia is to be based on a different type of particularisation – the one aimed at figuring out irreducible characteristics inferred from inter- and intra-individual experiential phenomenological analysis on systematic juxtaposition with empirically available biological constraints (structural or functional reciprocal constraints). Like neuronal signature/correlations and genetic markers of synaesthesia, these substantive item-generation prerequisites provided by cognitive scientific enterprise should also be expressed in rigorous psychological terms with minimal data loss. Therefore, the precision with which synaesthetic experiential processes are inferred (through phenomenological analysis) and causally related to each other (through factor analysis), and its detailed substantiation of the items both contribute to the construct representation of the SynQ-i. In other words, the validity of the proposed model is partly and for some propensities of the construct indirectly established by empirical and/or statistical data (projector vs associator, concurrents' involuntariness, etc.), which provides evidence of the construct representation component of the measure (cf. STRAUSS, SMITH, 2009).

Similarly, in the domain of individual differences, the nomothetic span (with synaesthesia expressivity as an inductive summary) of the SynQ-i is preliminarily established by the pattern of significant relations among synaesthesia-related measures that served as sources of reference for its construction (i.e., convergent validity). On the other hand, as identifying the presence/absence or establishing genuineness of synaesthesia in each particular case is beyond the SynQ-i's main objective and yet no other model to measure phenotypic expressivity of synaesthesia was proposed, further theoretical advancement and expansion of knowledge base are needed to deduce the sufficient criteria for establishing the discriminant validity of the SynQ-i.

In psychometrics, validity of a measurement is broadly defined as "an overall evaluative judgment of the degree to which [many sources of] evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions on the basis of test scores…" (MESSICK, 1995, p. 741). Therefore, more advancement in revealing intrinsic constituent propensities of synaesthetic experience and their extrinsic correlation with neuronal properties and genetic markers (as well as the other way around) will result in more articulate and multivariate criteria for the construct validity of the SynQ-i.

At this point it should be clear that as in the case of development and validation of any measurement, validation of the SynQ-i is actually a process with a transient outcome. With every use of the SynQ-i, there will be, at the same time, a test of the validity of the inventory and a test of the generative theory underlying the construct. Each use will provide additional information supporting or undermining the theory, methodological procedures or/and validation claims. Therefore, with each new application, the validity evidence should develop further towards its ultimate (ideal) epistemic destination–a model of experiential propensity-to-brain property-to-gene correspondences within a certain framework of monistic physicalism.

SYNQ-I: RESOLVING COMPREHENSIBILITY, ORGANISATIONAL AND ADMINISTRATION ISSUES

During some trial sessions of administering the preliminary version of the SynQ-i, several shortcomings arose along the lines of language comprehension, completion and administration on the part of respondents and assisting interviewer (if it was an assisted administration session). What follows is a set of explanations and suggestions for refinements in the next version of the SynQ-i. (The new version along all the previous ones can be found at www.synaesthesia.ru/synq).

When completing a form of the Synaesthesia Quotient inventory either on their own or through the examiner's facilitation, some respondents tend to characterise some word clusters or separate words (respondents call them "these scientificterms") in the items of the measure as incomprehensible. Upon further scrutiny, this impediment is usually attributed to a certain level of difficulty due to "excessive scientific load" of the language itself or "lack of background knowledge." Any written explanations in the form of footnotes or extended descriptions within the text of the items themselves would enlarge the questionnaire copy out of proportion and transform its completion into a synaesthesia 101 tutorial. Instead, as a result of follow-up discussion and unstructured group and one-to-one interviews, the solution that was found best was to put together a certain introductory passage (a brochure) that will describe cohesively and in non-technical terms all the basic facts about synaesthesia and its manifest-types. This briefing passages will be supplied with necessary illustrations and multiple examples. On the other hand, the terminological vernacular of the very text of the questionnaire also should be reduced to a minimum. To keep within the paradigm of the assumption-free respondent/interviewer framework, no scientific explanations will be provided or links revealed. This briefing blurb that will inform the perspective respondent on the targeted intricacies of synaesthetic experience will also function as elementary phenomenological training.

As was reiteratively emphasised both in my publication that laid out the theoretical foundation of the SynQ-i (SIDOROFF-DORSO, 2013), specified up-front in the definition provided there and multiple references to sources on the specific form of synaesthesia, the SynQ-i measure is reserved exclusively for cases of developmental synaesthesia. Whether the SynQ-i questionnaire is to encompass all forms of synaesthesia (jointly or separately), then the variances between developmental, adventitious, drug-induced, and ASC forms will need to be constantly kept in mind so that one does not slip into talking solely in terms of developmental synaesthesia. The SynQ-i can also be used as an impetus for building additional, similar measurements and/or assessment paradigms for adventitious and other forms of synaesthesia. (I fully credit SEAN DAY for this particular remark and suggestion).

A certain corrigendum is due regarding the explanation of non-equivalence in transition from point to point in the scoring value system. As was explained in (SIDOROFF-DORSO, 2013): *"Putatively, the weighting formula is expected to reflect the significance of individual items on a relative basis within the summative index. Therefore, the assigned value of the scoring and the spread space between each option does not hold any intrinsic meaning (quasi-logarithmic scaling); i.e., a transition from point one to point two might not be equivalent to that from four to five."* What was implied is that until each item and its response options are loaded on the factor(s) underlying the measured construct on a quantifiable basis and its distribution across all the items is identified measurably, the scoring system and spread between the options are both arbitrary or, better, relative. Anyway, attempts have been made to compensate for this by distributing the manifestation degree of the corresponding (measured) propensity gradually between the response options within the item.

Starting from Item#5 in the base variant of the SynQ-i, if having a multiple or poly-aspectual variety of synaesthesia, the respondent is instructed to refer to any of their synaesthesiae and assume it as a "typical" or standard one when choosing the options. However, this one may be very difficult to do for someone with more than one type of synaesthesia the types of which are all equally prominent for different qualitative feel. As SEAN DAY pointed out in our personal correspondence "the different types of synesthesia may not all work the same." Moreover, even though the situation sensitivities are treated in other items, such a different within-subject manifestation of a particular synaesthesia (in a multiple or poly-aspectual case) should be represented in the scoring system. An optimal mechanism for it would be to calculate one's scoring separately for each synaesthesia type (on the items that target the propensities of inducer/concurrent sets) and, having received the mean value, add it to the remaining score.

The options in Item#5 describe the subjective experience of the continuum between an associator type and a projector one as being distributed from "persistent knowledge" to "sensory overlay" to "physically tangible sensation located over or emitted by the inducing stimulus." However, an intensity degree that can result in superimposing the veridical perception field and be experienced as a "solid" variation (DAY, 2013) of a projector variety was overlooked. Therefore, the next version of the inventory will include a "non-feel-through" option so as to suit the possible experiential property of the concurrent sets in all the modalities.

CONCLUSION

Regarding the issue of integrating the subjective experiential descriptions into the method of deducing constraints for Synaesthesia Quotient measurement, it should be highlighted that in research into developmental synaesthesia, well beyond its domain, the best established practices of scientific investigation of the phenomenon are essentially committed to phenomenological properties as a necessary part of their methodology. In a realistic model of synaesthetic mechanisms, these phenomenological descriptions broadly function not as theoretical posits but as the *data* that further inform the demarcation between manifest-varieties of synaesthesia in statistics, substantiate and parameterize the design of experimental paradigms,

and ultimately provide constraints for further theoretical and practical advancements in synaesthesia investigation.

According to some leading neuroscientists of synaesthesia (CYTOWIC, DIXON, SMILEK), phenomenological descriptions not only cannot be eliminated but, if taken in a scientifically rigorous and substantively structured manner, will add expertise and professional merit to a proposed instrument. Therefore, during the stage of item generation and item selection in constructing the Synaesthesia Quotient inventory, neurophenomenology was adopted as a major pragmatic inroad into the subjective domain of synaesthesia and some of its methods were re-adjusted to the neurocognitive specificities of the condition.

Such a reliance on mediated experiential data and integrated first-person methods, as I attempt to advocate it in this paper, does not undermine the reliability and validity of the SynQ-i. On the contrary, many of the reference sources and original objective data that are used as a foundational backdrop in the form of biological, experimental and statistical constraints in the development of the SynQ-i lend the measure their operational validity (i.e., enhancing its convergent validity). Indeed, with part of its construct-(psycho)phenotypic expressivity of developmental synaesthesia-already *empirically established* in the neurobiological domain, the *theory-guided* aspects of the Synaesthesia Quotient framework are limited to two dimensionalities: homogeneity of the phenomenon (embracing the observable varieties of synaesthesia) and hypothetical degree of it expressivity. While the former is based on reliable statistical evidence of joint or variable inheritance or/and explanation of environment-related variance as cognition-dependent clusters, the latter is delineated through correlation analysis (SIDOROFF-DORSO, 2012).

Therefore, according to the proposed framework, the seemingly distinct types of developmental synaesthesia can be analysed as a unitary phenomenon with some of their observable properties being indicators of the quantifiable degree of synaesthesia's (psycho)phenotypic expressivity. Understanding developmental synaesthesia as a functionally homogeneous formation with identifiable general type-neutral characteristics enables formulating its definition with its multiple manifestation varieties as *neurocognitive taxonomy*.

For the time being, the presented methodological delineations and practical refinements of different usability features do not yet make the Synaesthesia Quotient inventory complete. Whether the current number of items (10) and semantic precision of their wording accurately pinpoint and fully embrace the degree of expressivity of developmental synaesthesia or they should be expanded, more carefully selected and, eventually, reduced to a smaller number and loaded, for example, on the five overarching synaesthesia subfactors identified elsewhere (SIDOROFF-DORSO, 2012) is a matter of further psychometric specification and development. Admittedly, much more work is required on item selection, factor loadings and validity improvement.

However, resolving some epistemological quandaries and overcoming many practical deficiencies in the field, the Synaesthesia Quotient inventory can be used in its current form as an in-progress theory-guided instrument the development of which is founded on an empirically informed construct. The SynQ-i is a rigorously operationalised index that is designed to measure individual differences in phenotypic expressivity of developmental synaesthesia. In particular, the index is plausible for setting up type-neutral experiments whose outcomes will contribute to a more profound understanding of developmental synaesthesia by eliciting its specificities across varieties and forms, situating it in relation to other individual differences and, ultimately, elucidating its neuronal correlates with more analytical accuracy.

Anton V. Sidoroff-Dorso. Moscow State Pedagogical University, Department of Psychology, Department of Foreign Language Teaching Methodology. Research focus on neurocognitive aspects of synaesthesia, synaesthetic foundations in cognitive anthropology and linguistics; originator of the concept of *Synaesthesia Quotient*; co-author of *An Anthropology of Synaesthesia* project; founder and science monitor of Russian Synaesthesia Community – www.synaesthesia.ru

Exhibit 1. The Synaesthesia Quotient Inventory (SynQ-i).[2]

Synaesthesia is thought to be an inheritable phenomenon. The following questions are designed to find out how strongly synaesthesia manifests itself in your case. Your answers will help to identify your Synaesthesia Quotient (SynQ). Remember that the questionnaire is not to prove the authenticity of your synaesthesia. For that, you should take other tests.

Do not skip questions – answer all the questions as best as you can.
Read each item and mark the number of the option which comes closest to your synaesthetic experience.
Do not select more than one option per question.
If you have several types of synaesthesia about which you can answer differently, describe your most typical one.
Please pay close attention to whether the question targets the triggers (inducers) or the reactions (concurrents) in your synaesthesia.

We would appreciate your feedback and kindly ask you to send us your experiences and suggestions regarding the content or completion of this questionnaire to: anton.dorso@gmail.com

[2] The briefing intro and the "lab checked" boxes are omitted in this publication for lack of space and layout concerns.

1. How many types of synaesthesia do you have?
(1) One type. (2) Two types. (3) Three types. (4) Four types. (5) More than four types.

2. How different are the categories/sets that trigger the individual types of your synaesthesia?
(1) Almost similar. For example, letter and number graphemes or, alternatively, names of the months and days of the week.
(2) Rather similar. What they feel like or what they mean, like pain, emotions or, in a different case, coloured smell and taste.
(3) Somewhat different but still have something in common, like coloured music and phonemes, or letters and spelling of names.
(4) Very different. Because my stimuli belong to two different senses, e.g., music and graphemes, or taste and music.
(5) Drastically different. My stimuli belong to more than two different senses *and* concepts, e.g., names and smell, or numbers and pain.

3. How many sensory elements or qualities do your synaesthetic reactions have?
(1) They are plain and unblended. For example, sensations of pure colour or just taste.
(2) They have two properties in one sensory modality. For example, colour is localised.
(3) They have several properties in one modality. Say, colour, texture and location.
(4) They spread across two modalities. For example, vision *and* tactility.
(5) They spread across more than two modalities.

4. Have your synaesthetic reactions changed over lifetime?
(1) Yes, almost disappeared.
(2) Yes, they have become vague and/or frayed.
(3) Yes, some of my stimuli have stopped triggering synaesthesia or/and have become somewhat dimmer.
(4) Yes, depending on the situation or state I am in, they become less distinct or/and disappear.
(5) Nothing has changed or changes at all.

5. How do you experience your synaesthetic reactions?
(1) As persistent knowledge.
(2) As a sensorial presence in my mind.
(3) As an indefinitely located but almost physically tangible sensation/"sensory overlay."
(4) As a physically tangible sensation located over or emitted by the inducing stimulus.
(5) As a "solid" impenetrable sensation that tends to obstruct the inducing stimulus or/and (part of) my perception.

6. How inclusive/selective are your synaesthetic triggers?
(1) Very selective because my "triggers" are abstract (notions, names, symbols, etc.).
(2) They tend to be somewhat selective, not very often present (for example, music, pain, etc.).
(3) They are very frequent as I encounter them almost constantly (language, people, noise, etc.)
(4) They are rather broad and embrace almost the entire modality with some exceptions (for example, *almost* all sounds, tastes, or tactile sensations).
(5) They are very broad and embrace the entire modality with no exceptions (all what I hear, taste, or touch).

7. Which sensory modality or several modalities do your synaesthetic triggers belong to?
(1) They do not belong to any modality because it does not matter what way I perceive them.
(2) They are mostly related to vision and hearing.
(3) They are mostly related to emotion.
(4) They are mostly related to smell and/or taste.
(5) They are mostly related to pain, touch or/and inner feelings.

8. Do your synaesthetic reactions appear when you *do not* pay attention to their triggers?
(1) No, because I definitely need to recognise the trigger first for synaesthesia to appear.
(2) Hardly, but sometimes my reactions help me tell one trigger from another.
(3) Difficult to say because my reactions and what triggers them are indiscriminately fused.
(4) Yes, sometimes. I can experience my reactions without recognising what evoked them.
(5) Yes, they quite often spring out, even before I recognise their triggers.

9. To what extent can you control or change your synaesthetic reactions?
(1) Totally, because I can suppress them altogether.
(2) Considerably, though I can't suppress them, I can noticeably change their qualities: tints of their tastes or shades of their colours, etc.
(3) Partly. I can change their intensity, zoom them in and out, expand them, etc.
(4) A little. I can change them only slightly: dim them a bit down, fuse them with the surrounding, etc.
(5) In no way. My reactions are completely uncontrollable.

10. Are you able to evoke your synaesthesia by merely thinking about the corresponding triggers; that is, without directly sensing the triggers?
(1) No, I need to experience the external triggers for my synaesthesia to appear.
(2) It depends on the type of my synaesthesia, the situation and/or state that I am in.
(3) Yes, but it produces very weak reactions, almost like distant recollections.
(4) Yes, but in such cases my synaesthesia is *not* as pronounced as with immediate stimuli.
(5) Yes, and when I do so, my synaesthesia is as strong and vivid as when I actually experience the triggers externally.

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