Jana Uher

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Original Article

Data generation methods across the empirical sciences: Differences in the study phenomena's accessibility and the processes of data encoding

Jana Uher *[a,b]

[a] *University of Greenwich, United Kingdom*
[b] *London School of Economics, United Kingdom*

* Correspondence:
University of Greenwich
Old Royal Naval College, Park Row
London SE10 9LS, United Kingdom
Telephone: +44(0)20-8331 9654
E-mail: mail@janauher.com

Abstract

Data generation methods differ across the empirical sciences. Today's physicists and engineers primarily generate data with automated technologies. Behavioural, psychological and social scientists explore phenomena that are not technically accessible (e.g., attitudes, social beliefs) or only in limited ways (e.g., behaviours) and therefore generate data primarily with persons. But human abilities are involved in any data generation, even when technologies are used and developed. This article explores concepts and methods of data generation of different sciences from transdisciplinary and philosophy-of-science perspectives. It highlights that empirical data can reveal information about the phenomena under study only if relevant properties of these phenomena have been encoded systematically in the data. Metatheoretical concepts and methodological principles are elaborated that open up new perspectives on methods of data generation across the empirical sciences, highlighting commonalities and differences in two pivotal points: 1) in the accessibility that various kinds of phenomena have for the persons generating the data and for the researchers, and 2), as a consequence thereof, in the processes involved in the encoding of information from these phenomena in the signs (symbols) used as data. These concepts and principles cut across establish method categorisations (e.g., human-generated versus instrument-generated data; quantitative versus qualitative methods), highlighting fundamental issues equally important in all sciences as well as essential differences. They also provide novel lines of argumentation that substantiate psychologists' and social scientists' increasing criticism of their own disciplines' focus on standardised assessment methods and establish connections to concepts of data generation developed in metrology.

Key words:
assessment method, data generation, experience sampling, human-based measurement, introspection, measurement with persons, metrology, observation, qualitative methods – quantitative methods.

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1. Concepts about methods of data generation in the empirical sciences

Data are basic to all empirical sciences. A plurality of methods exists from which researchers must select those that are appropriate for their particular objects of research. Most methodological and methodical research is concerned with approaches and ways to analyse data (e.g., methods of statistical data analysis). But little discussion is devoted to the ways in which data are generated in the first place. *Methodologies and methods of data generation* are the focus of this article.

Common terms are misleading. *Data*, plural of *datum* (Latin for "the given"), originally referred to what is given by the senses. But in our sensory perceptions, 'data' are not given to us ready to be 'collected' as we can pick fruit from the tree. Our perceptions are shaped by experiences and inextricably interwoven with our conception of the world (Berger, 1972; Chalmers, 2013). Even a fruit can be recognised as such only after we have acquired, early in life, sensory representations enabling us to perceive it as a steady object as well as concepts defining it as edible and thus valuable for us (Gibson, 1979). Thus, data cannot be simply collected. It is the scientists who decide what they consider an object of research, how they conceive it and which elements they deem relevant for study—and thus also what constitutes data in their field (Althusser & Balibar, 1970; Weber, 1949).

1.1 Data generated WITH persons and data generated ON persons

In the physical sciences and engineering, data are primarily generated with technologies. But in the behavioural[1], psychological and social sciences, data are largely *generated by human individuals—by persons*. This is because these fields study phenomena occurring *in individuals* that cannot be captured technically (e.g., attitudes, social beliefs) or only in very limited ways (e.g., behaviours). For example, in assessment methods, persons are asked to indicate their subjective judgements of an individual or object (e.g., personality, attitudes) in questionnaire scales, thereby producing rating data. In interview methods, persons transcribe the verbal and non-verbal expressions of individuals (e.g., statements, pauses, utterances, gestures), thereby producing textual data (e.g., about social beliefs, political opinions). In observational methods, persons target their perception to specific behaviours of individuals and encode their occurrences, thereby producing observational data. But how do people accomplish these important tasks? While observers are trained to generate data in specific ways, most raters are lay people. What conditions must be met to enable persons to generate data?

The different data generation methods and the different study phenomena explored in different sciences entail numerous conceptual and methodological challenges. To explore these challenges, various concepts have been established. In metrology (the science of measurement; BIPM, 2006), concepts of *data generated ON persons* denote research where humans are the objects of investigation (Pendrill, 2014). They are differentiated from concepts of *data generated WITH person* where humans are involved with their senses in the data generation process, such as concepts of 'persons as data generation systems' (Berglund, Rossi, Townsend, & Pendrill, 2012), 'human-based measurement' and 'humans as measurement instrument' (Pendrill, 2014). These concepts highlight important differences in the ways in which data are generated in different disciplines. But they may not apply to all kinds of data generation and the differentiations towards which they are targeted can also be viewed in different ways, highlighting further aspects still not well considered.

[1] Behavioural sciences here refer to the fields of behavioural biology, behavioural ecology, ethology, human biology and related fields, but not to behavioural economics.

Specifically, in the self-assessments widely used in psychological and social sciences (e.g., judgements of own personality and own beliefs), the person generating the data and the person under study is one and the same individual (Pendrill, 2014). Thus, methodological issues emerging in 'data generated *with* persons' and in 'data generated *on* persons' cannot be disentangled. Other concepts are needed to explore the peculiarities and challenges involved.

Moreover, not all data generation is aimed at generating measurements for quantitative analyses, such as methods producing data for qualitative investigations (e.g., discourse analyses, hermeneutic analyses; see Flick 2014). And not all data meet the criteria of measurement. Measurement is a specific process to assign numerical values to observations in well-defined and traceable ways (Mari, 2003; Mari, Maul, Irribarra, & Wilson, 2016). This does not apply to assessment methods where the specific aspects of the phenomena under study that raters may have implicitly considered in their judgments and the ways in which raters have encoded their overall judgements in the quantifying categories remain unknown (Uher, Addessi, & Visalberghi, 2013; Uher & Visalberghi, 2016).

1.2 Jingle jangle fallacies across sciences: Are 'measurement instruments' persons or scales?

Metrologists' differentiation of methods in which persons are 'operators' of technical instruments from methods involving 'humans as measurement instruments' are aimed at highlighting important limitations and challenges that the direct involvement of human senses in the generation of data entails, such as for establishing metrological traceability (Fisher, 2009). Metrological traceability requires measurement results to be related to a reference through a documented unbroken chain of calibrations where the reference is a measurement standard or the definition of a measurement unit through its practical realisation (JCGM, 2012). But so far, these limitations are hardly considered in the psychological and social science fields of research in which such methods are primarily used (Uher, Werner, & Gosselt, 2013). One reason may be that psychologists and social scientist commonly consider as 'measurement instruments' not the persons who generate the ratings but the questionnaires consisting of sets of statements (items) and multi-stage answer categories worded in everyday language (e.g., rating scales; see e.g., Cripps 2017). As a consequence, all efforts of psychometricians to improve 'measurement' and 'measurement instruments' are directed at the questionnaire scales (e.g., psychometric properties like item response function, reliability and validity) and not also at their users as this is the case in observational research where observers are trained to use an observation and encoding scheme in specific and systematic ways to generate data (Uher & Visalberghi, 2016). This cross-disciplinary *jingle fallacy* (the same term denoting different concepts; Thorndike 1903) about what constitutes a 'measurement instrument' is highly confusing and may prevent psychological and social scientists from understanding metrologists' concepts and concerns.

Further complicating is the fact that human abilities are always involved in data generation in all *empirical*—thus per definition *experience-based*—sciences, including physics and applications in engineering. This is because every concrete experience has two aspects, the content given and our apprehension of it—that is, the objects of experience themselves and the subject experiencing them (Wundt, 1896). Wilhelm Wundt, the founder of psychology, highlighted that this differentiation underlies two fundamental perspectives in which experience is treated in science. Natural sciences consider the objects of experience in their properties as conceived independently of the subject. Psychology explores the entire content of experience in its relation to the subject and the properties that the subject directly attributes to the content. Thus, the natural-science perspective is possible only by subtracting from the concrete experience the subjective aspect always contained in it and may therefore be designated the

perspective of *mediate experience*. By contrast, psychology does not (and cannot) subtract the subjective from experience because experiencing subjects and their apprehensions of the content given are this discipline's objects of research. Therefore, psychology's perspective is that of *immediate experience*. Psychological scientists seek to make abstractions and generalisations from many subjects' experiences and those psychologists studying the biological foundations of psychical phenomena can do so only by exploring psychical phenomena as well (Wundt, 1896).

The advanced measurement technologies available today have been developed to minimise the involvement of human abilities and their inherent subjectivity. But this should not hide the fact that they have once been developed by humans and on the basis of their human perceptual and cognitive abilities (see, e.g., the history of the development of thermometers; Chang 2004). And still today, it is humans who are using technologies to generate data and humans who make sense of the data thus-created. Determinating temperature with a thermometer requires human skills to perceive the extension of the scale or the signs displayed on screen and the ability and knowledge to interpret this correctly (e.g., differences between Fahrenheit and Celsius scales). Therefore, a clear-cut separation of methods on the basis of their involvement of human senses, as implied by concepts of humans as 'measurement instruments' versus humans as 'operators of measurement instruments', is not possible.

These issues may have contributed to the fact that metrologists' important concerns about the limitations and challenges of 'human-based data generation' (Berglund et al., 2012; Pendrill, 2014; Pendrill & Petersson, 2016) have hardly been noted by psychological and social scientists. And this although metrologists' views can meaningfully complement and expand on the psychologists' and social scientists' increasing criticism of their own methodological practices that, so far, mostly concern the generation and analysis of quantitative data in their fields (e.g., Bruschi 2017; Buntins et al. 2016; Hammersley 2013; Morris et al. 2017; Tafreshi et al. 2016; Valsiner 2017). A prominent controversy is the debate about *so-called quantitative and qualitative methods*, which revolves around the question of whether or not behavioural, psychological and social phenomena can be meaningfully explored by means of quantification, what access researchers can generally gain to these phenomena and how findings can be interpreted (e.g., Bruschi 2017; Michell 2010; Sale et al. 2002; Toomela 2011).

A frequent argument in the so-called qualitative-quantitative debate is that methods must be matched to the phenomena under study, thus be appropriate. But—in all epistemologies considered—this old dictum is as true as it remains vague. In what ways should methods be matched? What specific abilities must a method have to be appropriate? And what should it enable researchers to do? Psychologists and social scientist are surprisingly vague about these fundamental questions.

1.3 Aim of this article

This article adopts transdisciplinary and philosophy-of-science perspectives to explore concepts and methods of data generation across disciplines and to contribute to existing pertinent efforts (see Mari 2003). It presents a novel conceptual approach developed from these perspectives to carve out commonalities and differences in the ways in which data are generated in different sciences (e.g., physical sciences, behavioural, psychological and social sciences). This approach starts out by the fact that empirical data can reveal information about the phenomena under study *only if* relevant properties of these phenomena have been encoded systematically in the signs used as data. Consequently, this encoding and the ways in which it is accomplished in different methods are the pivotal points of data generation. The article therefore takes a step back from the common considerations of data properties (e.g., ordinal or metric

scales), data structures (e.g., norm-distribution), analytical methods (e.g., Rasch modelling) and theoretical inferences that can or cannot be drawn from the data (e.g., properties of the mind). Instead, it focuses on the conditions that persons (e.g., observers, raters, transcribers, technical instrument developers and users) encounter in the moments in which they generate data—thus, on stages in the research process *before* any mathematics or statistics are applied. That is, unlike most methodological research, this article explores not properties of data once they were generated. Instead, it explores *1) properties of the phenomena under study* that the persons generating data can perceive and *2)* the *processes* involved in their *encoding* in the signs used as data, thus on the *processes by which data are generated in the first place*.

A focus is on research on individuals where 'data *on* persons' are generated using a plurality of methods, some of which involve humans directly (metrologists' concept of 'data generated *with* persons' who act as 'data generating systems') and others only indirectly (metrologists' concepts of persons as 'operators' of technical methods; see Section 1.2). The philosophy-of-science perspective adopted in this article opens up a more abstract level of consideration than commonly applied. This contributes a novel perspective that goes beyond behavioural, social and psychological scientists' common arguments about so-called quantitative versus qualitative methods, and that also opens up new perspectives on metrologists' concepts about the involvement of persons in the data generation methods of different disciplines. It presents concepts that cut across these established categorisations, highlighting fundamental issues that are equally important for all methods in all sciences as well as essential differences.

The subsequent Section 2 briefly introduces the Transdisciplinary Philosophy-of-Science Paradigm for Research on Individuals applied in this article and outlines its philosophical and metatheoretical frameworks that provide concepts for differentiating phenomena on the basis of their perceptibility by humans. In Section 3, these concepts are used to specify basic conditions that must be met to enable the persons generating data to perceive the phenomena under study, which therefore define basic classes of methods. Section 4 metatheoretically explores the encoding processes involved in the generation of 'data', specifying basic methodological principles underlying them. The final Section 5 demonstrates applications of these principles to methods concerned with the measurement of human psychical abilities, focussing on the so-called qualitative-quantitative debate, on psychophysics and on psychometrics, revealing new insights and methodological mismatches not well considered.

2. Transdisciplinary and philosophy-of-science perspectives on data generation

Data cannot simply be 'collected'—data are generated for a purpose. This requires decisions about what elements of the perceptible to demarcate, how to categorise these elements and how to encode them in the signs used as 'data'. Raising an arm may be demarcated as an event of interest that could be categorised as a movement in itself considering the particular muscles involved (e.g., in physical therapy research). Considering the context in which it occurs, raising an arm could be categorised as greeting, threatening others or cleaning windows (e.g., in behavioural, psychological and social research). Observers may encode occurrences of this event in terms of every single arm movement back and forth or of series of consecutive movements demarcated from one another by breaks of non-movement; in terms of their duration, speed and radius as well as of the particular parts of the arm involved. Raters may be asked to assess this event in terms of how active, friendly, aggressive or industrious the person is. All this must be decided—if not explicitly by the scientists, then at least implicitly by the persons who generate the data about this event. These decisions have far reaching consequences; they determine what data are produced.

The specific conditions encountered by the persons who are making these decisions can be explored by applying a paradigm that adopts a philosophy-of-science perspective on research on individuals, the *Transdisciplinary Philosophy-of-Science Paradigm for Research on Individuals (TPS-Paradigm;* Uher, 2013, 2015a). It comprises interrelated philosophical, metatheoretical and methodological frameworks that coherently build upon each other; therefore, this system is called a paradigm. In these frameworks, philosophical assumptions, concepts, approaches and methods from various disciplines (e.g., psychology, biology, social sciences, physical sciences, metrology) are systematically integrated, refined and complemented by novel ones, thereby creating unitary frameworks that transcend disciplinary boundaries. Its philosophy-of-science label indicates the aim to make explicit the basic assumptions, metatheories and methodologies underlying given scientific systems to help scientists scrutinise and further develop the theories, models and practices established in their fields.

2.1 Philosophical framework

The TPS-Paradigm's philosophical framework specifies presuppositions that are made about the nature and properties of individuals and the fundamental notions by which knowledge about them can be gained. First, it builds on *complexity theories* to consider that individuals are living organisms that can be conceived as nested systems that function as organised wholes at different levels of organisation, from cells over single individuals up to societies. From dynamic multilevel transactions, new properties emerge at each level that could not be predicted from knowledge simply of the constituents and that create complex patterns of causation not ascertainable by deterministic and reductionistic concepts and methods (Capra, 1997; Morin, 2008).

Second, it builds on the *principle of epistemological complementarity* originally introduced to quantum physics as a resolution to the wave-particle dilemma in research on the nature of light (Bohr, 1937). This principle highlights that application of different methods can reveal information about properties of an object of research that are maximally incompatible but both essential for an exhaustive understanding of it, and that may therefore be regarded as *complementary* to one another. This implies that investigations of an object of research should not be limited to just one method but without making methodological compromises. Rather, methods should be adapted to the properties of the phenomena under study. In the TPS-Paradigm, this epistemological principle is applied in several ways, such as to the body-mind problem as already suggested by Bohr (1937) and others (Fahrenberg 2013), and to develop a solution for the nomothetic-idiographic controversy intensely debated in individual differences and personality research (Uher, 2015c, 2018).

Third, the TPS Paradigm considers that *all research is done by humans* and thus limited by human perceptual and conceptual abilities (Uher, 2013; J. Valsiner, 2012). This does not imply denial of a reality that exists independently of human abilities and in which humans have evolved as a species over millions of years (Uher, 2015a). It merely emphasizes that the sole access we can gain to this reality is enabled by our human abilities, which, consequently, limit our possibilities for getting to know about, exploring and understanding this reality. This affects all sciences, including physics (see, e.g., the long struggles in the history of the development of thermometers; Chang 2004). But research on individuals is affected in particular ways because all scientists are individuals themselves who are embedded in particular sociocultural and language systems that inevitably influence their perceptions and conceptions of the world and especially of other humans around them. Therefore, scientists exploring individuals cannot be independent of their objects of research, which entails particular methodological intricacies. The

TPS Paradigm also highlights that research on individuals primarily relies on data generated by persons who perceive and interpret the phenomena under study. Therefore, a *phenomenon*[2] is defined as anything that humans can perceive or can (e.g., technically) make perceptible or that humans can conceive. Occurrence of a phenomenon is called an *element* or (for transient phenomena) an *event*.

These philosophical presuppositions form the basis of the meta-theoretical framework.

2.2 Meta-theoretical framework

2.2.1 Three meta-theoretical properties

In the TPS Paradigm, three abstract properties are considered that can be conceived in different forms for every phenomenon explored in individuals and that determine their accessibility by humans. Given the paradigm's focus on research on individuals, these properties are conceived with regard to human everyday life experiences, thus in terms of spatial dimensions scaled to the human body and temporal dimensions of the international time standards used in daily life rather than, for example, in the micro-dimensions of Nano-seconds and or the macro-dimensions of outer space. These properties are a phenomenon's *1) location in relation to the intact bodily entity of the individual under study* (e.g., internal, external), its *2) temporal extension* (e.g., transient, longer-lasting) and *3) spatial extension* conceived as (material and immaterial) physical (i.e., spatially extended) versus "non-physical"[3] (i.e., without spatial properties; Uher, 2015d). The first two constitute continuous dimensions, whereas the third denotes properties that are mutually exclusive and complementary to each other. This relates to the body-mind problem, called the *psyche-physicality problem* in the TPS Paradigm, in which it takes the metaphysically neutral stance of epistemological complementarity, thus without making assumptions on their relative interconnectedness of either dualism or monism (Fahrenberg, 1979, 2013; Wundt, 1894).

These properties are termed meta-theoretical because they are conceived on a level of abstraction commonly not considered explicitly in everyday life and most research, and only time and space constitute ontological categories. Because these properties generally determine a phenomenon's accessibility to human perception, they also determine accessibility of further properties that can be perceived in phenomena (e.g., colour) or inferred about them (e.g., causal mechanisms) and that more commonly are the focus of research.

2.2.2 Various kinds of phenomena

The three abstract properties can be used to meta-theoretically differentiate and define *various kinds of phenomena* studied in individuals. These *kinds* are conceived on a high level of abstraction; they represent theoretical but not necessarily ontological categories. Their differentiation, as it is based on perceptibility by humans, is only conceptual; the phenomena themselves cannot be separated from one another in any living individual (e.g., morphology and physiology). Four kinds of phenomena, morphology, physiology, behaviour and the psyche, are conceived as *basic* because they are inseparable from the intact individual's bodily entity (Uher, 2015d).

Morphology comprises living organisms' bodily structures and their constituting parts; morphological phenomena can be located external and internal (e.g., hair, bones) and are temporally extended and material physical. *Physiology* denotes the physical and chemical

[2] This notion differs from various philosophical definitions (e.g., Kant's 2000).
[3] The term "non-physical" is put in quotation marks because it denotes properties that are not simply contrasted against the physical but that are epistemologically complementary instead.

functioning of morphological phenomena (e.g., heart beats, neurotransmitter activity); they occur (mostly) internal, are (often) transient and immaterial physical.

Behaviours are defined as "living organisms' external changes or activities that are functionally mediated by other external phenomena in the present moment" (Uher 2016a, p. 490). Thus, behaviours are conceived as entirely external, transient and (mostly) immaterial physical (e.g., movements, vocalisations, radiation). An important distinction is made between behaviours and the psyche. This differentiation of often made only implicitly in psychology as reflected in the vague notions of 'outer' versus 'inner' behaviours (Furr, 2009). This obscures vital differences between kinds of phenomena that differ in perceptibility by humans and therefore require different methods of investigation.

Psyche is defined in the TPS Paradigm as the "entirety of the phenomena of the immediate experiential reality both conscious and non-conscious of living organisms" (Uher, 2016b, p. 303; with immediate indicating absence of phenomena mediating their perception; see Section 1.2; Wundt, 1894). Psychical[4] phenomena are conceived as located entirely internal to individuals' bodies (yet without adopting ideas of internalism[5]). Ongoing psychical events, called experienc*ings*, are transient (e.g., thoughts, emotions, motivations). They can be differentiated from temporally more extended psychical phenomena broadly conceived as *memorised psychical resultants* (experienc*es*; e.g., sensory and mental representations, knowledge, mood tendencies, mental capacities, with memorisation here referring to any retention process) that, however, are accessible only in individual's experiencings, in the here and now. This reflects that memorised knowledge does not exist like bones in a body that could simply be 'retrieved' ad libitum and (particular circumstances provided) be excavated even millions of years later. Instead, it is reconstructed in each moment anew in the context of the given situation, whereby it is adapted and changed (Schacter & Addis, 2007). The immaterial properties of the psyche are conceived as "non-physical" because they lack spatial properties and systematic relations to physical phenomena to which they are bound (e.g., brain morphology and physiology), reflecting complementary body-mind relationships (see Section 1.2.1; Fahrenberg, 1979, 2013).

Three further kinds of phenomena are conceived as *composite*, semiotic representations (e.g., language), artificial outer-appearance modifications (e.g., clothes) and contexts (e.g., situations; Uher, 2015a,d). They comprise phenomena of different kind (distinguished by the three meta-theoretical properties) that are tightly interrelated with one another, forming a functional whole from which new properties emerge not present in their constituents. Therefore, these new properties can be explored only if the constituents are studied in their functional interdependence. A peculiarity is that these composites lack physical boundaries demarcating

[4] The phenomena of the psyche are of very special kind because they are the tools by which any science is made. A science exploring the psyche must therefore differentiate between its objects of research and its tools for exploring them. Therefore, the phenomena of the psyche themselves are referred to as psychical, whereas the term psychological refers to the ideas and body of knowledge (Greek -λογία, -logia) about psychical phenomena (a differentiation common in many languages but not in the English).

[5] The conception of psychical phenomena as entirely internal essentially differs from ideas posited in the externalism-internalism debate in the philosophy of mind about how individuals can get to know about the world if their psyches are entirely internal to their bodies as assumed in internalism. Externalism contends that psychical phenomena are affected by external phenomena and therefore cannot be only internal (Rowlands, 2003). In the TPS Paradigm, unlike internalism, no idealistic assumptions are made about experience-independent (a-priori) knowledge (as posited by Kant 1998; for a critical discussion, see Russell 2014). Instead, the meta-theoretical framework specifies connections between an individual's psyche and its external surroundings that enable the individual to get to know about, to adapt to and to intentionally act in its surroundings (Uher, 2013, 2016a). Consequently, ideas of an 'extended mind' (Clark & Chalmers, 1998) are rejected.

them (e.g., cell membranes); instead, the phenomena involved are often located apart and also separate from the individual's body. Semiotic representations exemplify this.

Semiotic representations (e.g., spoken, written language) are composites comprising psychical and thus internal "non-physical" phenomena (e.g., meanings, mental representations) that are tightly interrelated with physical phenomena external to individuals' bodies (e.g., vocal sounds, ink on paper). These external phenomena are used to represent in publicly accessible ways the meanings and referents to which they refer, forming a functional whole from which new properties emerge. This interrelation is so deeply embedded in our everyday thinking that its composite nature does not become readily apparent and may sometimes create the illusion meanings are contained in the spoken and written words themselves. The word "two" can be composed of visible patterns shaped like "TWO" or "*DEUX*" (French for two) written here on the page or the vocalisations [tuː] or [dø] that correspond to their respective pronunciations. In their composite, these external physical elements carry meaning that is not inherent to them in themselves, but that individuals only as*sign* to them (see, as an example, culture-specific variations in the mapping of numbers onto space; (Dehaene, Izard, Spelke, & Pica, 2008; Pendrill & Fisher, 2015). When as*sign*ments are socially shared among individuals, the physical elements involved in this composite become *signs* (here the term sign includes the notion of symbol). Assignments of meaning are generally arbitrary and therefore vary. Nobody can straightforwardly recognise the meaning of "deux" just from the word itself without knowing the meaning that French speakers assign to it.

This has important implications for research methodology because *data are signs* (symbols)—physical representations to which particular individuals (e.g., researchers, observers, raters) assign particular meanings and referents. Whether "TWO" or the numeral "2" represent the number 2, thus a quantity, or just a judgement category denoting "disagree" or "rarely", as in many assessment methods, is not inherent to the physical sign "2" itself. This illustrates the fact that data cannot be simply 'collected' but are generated by humans who decide about what particular signs (symbols) are meant to represent for a given purpose.

2.3 Methodological framework

These and further metatheoretical concepts form the basis of the TPS Paradigm's methodological framework. It comprises approaches for taxonomising individual differences in the various kinds of phenomena studied in individuals (Uher, 2008a, 2008b, 2015e, 2018), for comparing individual differences across situations, groups, cultures and species (Uher, 2011, 2013, 2015b), and for carving out fundamental methodological differences between observation methods and assessment methods, empirically demonstrated in multi-method studies (e.g., Uher et al. 2013b; Uher and Visalberghi 2016).

In the following, the above-outlined concepts are applied to explore the conditions that persons generating data in different fields encounter given their study phenomena's peculiarities. From these conditions, basic methodological principles are derived that determine the ways in which these persons can perceive relevant properties of the study phenomena (Section 3) and can encode their perceived occurrences systematically in the signs used as 'data' (Section 4).

3. The study phenomena's accessibility determines the class of methods required for data generation

When data on individuals are generated by persons, the methods of data generation used must enable these persons to perceive the study phenomena; this is the first pivotal point of data generation. The three meta-theoretical properties determine a phenomenon's

perceptibility under everyday life conditions and, as a consequence thereof, they also determine the methods required to make it accessible under research conditions (e.g., controlled settings, invasive methods, technical instruments). Hence, the three properties are useful to derive basic methodological principles (Uher, 2015e). These principles define *classes of methods* that are more basic than those commonly considered and therefore cut across established method classifications (e.g., qualitative and quantitative methods, 'humans as measurement instruments' versus as 'operators' of such instruments), providing new insights into commonalities and differences (see Table 1).

3.1 Phenomena located external versus internal to individuals' bodies: Observational methods versus invasive and technical methods

Phenomena located external to individuals' bodies (e.g., outer morphology, behaviour, physical [i.e., acoustic] parts of spoken language), are publicly accessible and can therefore be directly perceived by the persons generating the data. *Observational methods* involve the targeted, and thus trained, perception of the study phenomena without any mechanism standing between the observer and the observed (see Faßnacht 1982). Binoculars facilitate observation over longer distances; but they do not make accessible anything that could not be perceived without any technical support at close distance.

Internal physical phenomena (e.g., brain, bones, blood circuit) cannot be perceived by persons under everyday conditions; but they can be made perceptible under research conditions using *invasive or technical methods*. Open surgeries harm individuals' bodily integrity so that investigators can directly perceive inner body parts (e.g., bones). Imaging techniques, such as x-ray, ultrasound or MRI, can make inner body parts indirectly perceptible; but unlike binoculars, these technologies make accessible internalities that are otherwise not perceptible without destroying the bodily integrity of the individuals under study.

3.2 Transcient phenomena: Nunc-ipsum methods

Temporally extended phenomena do not change quickly (e.g., an individual's body height or the physical elements of the words printed in a lexicon); this facilitates their perception by persons generating data so that they can take their time and can perceive the same elements also repeatedly. By contrast, to generate data about transient phenomena (e.g., individuals' gestures, verbal comments or heart races), persons must focus their perception on these phenomena in the brief moments of their occurrence. This requires methods enabling the *real-time recording of transient events*, called *nunc-ipsum methods* in the TPS Paradigm (from the Latin *nunc ipsum* for at this very instant; Uher, 2015d).

This class comprises heterogeneous methods that are each targeted at a specific kind of phenomenon. In observations, the persons generating data record the behavioural acts they have perceived (e.g., a jump, start and end of an activity) *while or immediately after these acts have occurred*. Investigators can perceive and record an individual's heart beats only while these occur; a retrospective recording is not possible. Real-time recording of transient physical phenomena can be supported by technologies, such as electronic heart rate monitors, audio-visual recording such as videotaping behaviours (Uher, Addessi, et al., 2013), life-logging and reality-mining of individuals' physical activities in real-live contexts (Eagle & Pentland, 2006), as well as ambulatory monitoring of physiological and behavioural phenomena (Fahrenberg, Myrtek, Pawlik, & Perrez, 2007; Matthias R. Mehl & Conner, 2012).

Table 1 Three metatheoretical properties determining accessibility by humans and the classes of methods derived from them

Metatheoretical property	Methodological implications
Location in relation to the intact individual's body	
Internal	**Invasive methods** = Procedures harming the individual's physical integrity (e.g., surgery, blood samples) **Technical methods** = Physical procedures making perceptible inner physical phenomena without harming the individual's bodily integrity (e.g., f-MRI, x-ray) Intro*questive* methods (see below)
External	**Observational methods** = Procedures enabling the recording of phenomena without any mechanism standing between observer and observed (e.g., ethological observation)
Temporal extension	
Transient	**Nunc-ipsum**[6] **methods** = Procedures enabling the real-time recording of transient phenomena (e.g., behavioural observation, experience sampling)
Temporally more extended	No special methods needed because temporal extension facilitates perception
Spatial extension	
Physical (both material and immaterial)	**Physical methods** = Procedures relying on the spatial extension of materials that are systematically related to the physical phenomena under study, directly perceptible and easier to demarcate and categorise than the study phenomena (e.g., length of a spring scale to measure weight). **Extro*questive* methods** = Procedures for studying phenomena that individuals can perceive as from outside of themselves (e.g., behavioural observation) and that are (or can be made) perceptible by multiple individuals (e.g., invasive methods)
"Non-physical" (i.e., without spatial properties)	**Intro*questive* methods** = Procedures for studying phenomena perceivable only from within the individual itself and that *cannot* be made perceptible by multiple individuals under all possible conditions (e.g., inner self-observation, self-report) • **Nunc-ipsum introquestion** = Self-reports about experiencings while they occur (e.g., thinking aloud method) • **Retro-introquestion** = A-posteriori self-reports of specific experiencings had in specific moments (e.g., interviews about own first-person videos) • **Long-term memory-based introquestion** = Self-reports about memorised psychical resultants (e.g., personality judgements).

[6] From the Latin *nunc ipsum* for at this instant.

3.3 Physical versus psychical ("non-physical") phenomena: Physical methods, and extroQUESTIVE versus introQUESTIVE methods

Physical phenomena (e.g., morphology, physiology and behaviour) constitute or become manifest in bodily matter. Their spatial extension facilitates their perception by persons generating data and enables the application of physical methods. *Physical methods* rely on the spatial extension of materials that show systematic relations to the physical phenomena under study, that persons can directly perceive and in which they can demarcate and categorise units more easily than in the actual phenomena under study. The length of mercury in glass tubes, for example, is systematically (though not linearly) related to temperature (see Chang 2004); the extension of this material can be directly perceived and facilitates the intersubjective categorisation of units to determine degrees of temperature.

But the immaterial phenomena of the psyche lack spatial properties. Unlike, immaterial physical phenomena (e.g., heat, sound waves), thoughts and emotions cannot be measured in terms of their weight or length on spatial scales. Psychical phenomena are obviously bound and related to physical phenomena (e.g., brain morphology and physiology), but systematic relations that could enable indirect explorations have not yet been found (Fahrenberg, 2013). These "non-physical" properties make psychical phenomena inaccessible by physical methods. Neuroscientific technologies, such as fMRI and EEG, can capture blood flow and electric neuronal activity in the brain but cannot make perceptible individuals' thoughts and feelings; this reflects the complementarity of the psyche-physicality relations.

To distinguish methods that enable the investigation of psychical phenomena from those that cannot, the concepts of extro*questive* and intro*questive* methods (from the Latin *quaerere* for to seek, enquire) are introduced (Uher, 2015d). All procedures enabling the study of phenomena that *are or can (technically) be made perceptible by others* are *extroquestive methods*. This enables multiple individuals (e.g., scientists) to observe one and the same element, which facilitates the ability to arrive at an intersubjective consensus on how to demarcate and categorise elements (e.g., different kinds of neurons) and on how to encode them in the signs used as 'data', thus making the process of data generation *public*. Shared perception is important for establishing independence from individual investigators, which constitutes one of various types of *objectivity* in science (Daston & Galison, 2007; Gigerenzer, 1987).

Establishing shared perception is possible for all physical phenomena both internal (e.g., brain morphology, physiology) and external to individuals' bodies (e.g., behaviour, facial expressions and verbalisations of emotions, mercury in glass tubes). But this is not possible for psychical phenomena (e.g., emotions in themselves), which are perceivable only by each individual itself. Imperceptibility by others is a unique property of psychical phenomena (Uher, 2015a); it is therefore the crucial criterion to distinguish methods that enable investigation of psychical phenomena from those that do not. All procedures for studying phenomena that can be perceived *only from within the individual itself but by nobody else in principle under all possible conditions* are *introquestive methods*.

Importantly, the study phenomena's internal location alone does not define a method as introquestive. For example, physicians apply ultrasonic or endoscopic technologies to make internal properties of individuals' bodies (e.g., tissue structures) visible on screens that also the studied individuals themselves can perceive as from outside of their bodies, thus extroquestively. But the sensations that ultrasound and endoscopic investigations may cause (e.g. pressure, pains) can be perceived only by and from within the individual under study and by nobody else, thus only introquestively. Similarly, dentists can see a tooth damage and can use

invasive and technical methods to also make visible structures hidden in patients' teeth and jaw bones (e.g., on x-ray); but no dentist can perceive the patients' tooth pain.

This criterion-based definition and distinction of intro*question* from extro*question* essentially differs from concepts of intro*spection* and extros*pection*, which are commonly distinguished from one another on the basis of the *individual under study*, whereby introspection denotes individuals' "inward perspectives" on their own experiencings and extrospection individuals' "outward perspectives" onto their "outer world" (Butler, 2013; Schwitzgebel, 2016). But in individuals' immediate experiential reality, "inward" and "outward" perspectives are not given as separate channels of information. Perceptions are complex unities that emerge from the composite of all information available at any given moment (Wundt, 1896). Therefore, extro*spection* and intro*spection* cannot be clearly differentiated as separate methods (Uher, 2016a).

This challenge arises because all explorations involve human perception (see Section 1.2). Distinctions are possible only by defining what is being perceived and by whom. Accordingly, the concepts of extro*question* and intro*question* are defined and distinguished from another by *1) the particular phenomena under study* (e.g., neurons, thoughts), considering that various other phenomena may be present and perceivable as well, and *2) the particular persons who perceive the phenomena under study* and who generate the data of them on the basis of these perceptions (e.g., observers, individuals under study). This opens up a further conceptual dimension that lies across metrologists' concepts of 'data on persons' generated 'with persons' (see Section 1) and that highlights challenges and essential differences that investigations of the various kinds of phenomena studied in individuals entail.

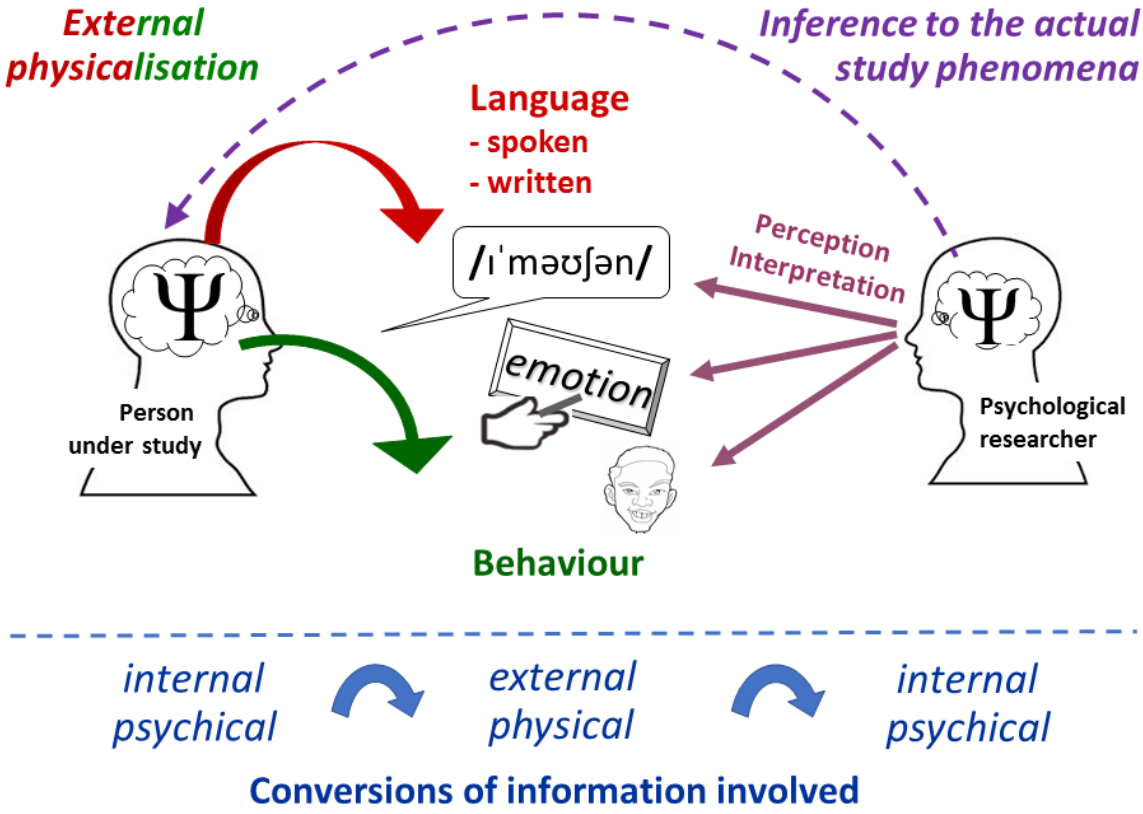
3.3.1 Others' psychical phenomena: Indirect exploration through externalisations

The introquestive accessibility of psychical phenomena entails that their scientific exploration is possible *only indirectly through inferences from individuals' externalisations*. The term '*external*sations' indicates that it denotes phenomena located external to the studied individuals' bodies that are therefore perceptible by others, such as by persons generating data. This reflects the explicit conceptual differentiation of psychical phenomena (e.g., emotions in themselves) from other kinds of phenomena with which they may but need not co-occur, such as their (possible) expression in behaviour (e.g., facial expression of emotion) or language (e.g., verbalisation of emotions; see Figure 1; Section 2.2.2; Uher, 2016a). But importantly, these external physical phenomena are not one-to-one reflections of individuals' psychical phenomena because externalisations can be controlled and modified and may also be misinterpreted by others. Therefore, inferences to others' psychical phenomena are inherently fallible (Schwitzgebel, 2016; Uher, 2013). Moreover, not all important psychical phenomena can be consciously perceived (Freud, 1915) and be verbalised easily (Kant, 2000; Kelly, 1963).

Consequently, exploring psychical phenomena imperatively involves also the study of behaviour and semiotic representations (e.g., language, (Bühler, 1999; Jaan Valsiner, 1998), which requires the purposeful combination of introquestion and extroquestion as complementary methods (see the principle of complementarity; Section 2.1). Introquestive methods are needed to help individuals become aware of and conceive the psychical phenomena under study, such as through inner self-observation. The introquesting individual must then externalise the outcomes of its introquestion to make them accessible to others, such as through self-report. These externalisations can only be made by the individual under study. Therefore, introquestion denotes not only trained or guided inner self-observation as this is common for introspection (e.g., Butler, 2013) but broadly denotes *all* methods relying on inner self-observation and self-report.

To explore and categorise these externalisations, because they are external and thus perceptible by multiple individuals, extroquestive methods must be applied, such as behavioural observation (e.g., using computerised and videographic techniques) or recording of language in audio or text (e.g., in interviews). Thus, data about an individual's externalisations can be generated not only by the individual itself (apart from externalisations that it cannot perceive like some facial expressions) but also by others (e.g., observers). Inferring from an individual's externalisations the actual psychical phenomena under study, in turn (see Figure 1), requires *hermeneutic-interpretive methods* to establish an intersubjective consensus on the specific inferences made (Fahrenberg, 2002; Wong, 2009) and in which researchers must also critically reflect on their own interpretations (Uwe. Flick, 2008).

Figure 1 Individuals' psychical phenomena can be explored only indirectly through individuals' *external*isations



3.3.2 The role of time: Nunc-ipsum introquestion, retro-introquestion and long-term memory-based introquestion capture different kinds of psychical phenomena

The special temporal properties of psychical phenomena allow the distinction of various kinds of introquestion. The transient properties of individuals' ongoing experiencings actually require real-time explorations, thus methods of *nunc-ipsum introquestion.* In thinking aloud

methods, for example, individuals are asked to verbalise their thoughts *while* they are having them. But attention and externalisation inevitably alter the course of experiencings (Kant, 2016). This entails particular intricacies and hinders nunc-ipsum explorations of more complex experiencings, thus allowing explorations of only brief experiencings, such as sensory perceptions as studied in psychophysics (see Section 5.2; Wundt, 1904).

In *retro-introquestive methods*, individuals are therefore given a task and are asked, after its completion, to reconstruct and externalise the experiencings that occurred while executing it, thus *ex post facto* and without disturbing them—but necessarily at the expense of those already forgotten or that cannot be easily verbalised (Valsiner, 2017). First-person videos in which individuals' activities are captured with miniature cameras worn at eye level can provide detailed contextual cues that facilitate access to episodic memory. Individuals' accuracy in recalling their activities and the situations encountered, as verifiable by the videotaped evidence, supports assumptions that their reconstructions of the experiencings they had in the particular moments captured on film may also be substantially accurate, especially when they do not follow common schemata (Lahlou, 2011).

But with increasing time lags between the experiencings under study and their introquestive reconstruction, individuals' memories of specific events fade and are changed through subsequent experiencings, their processing and memorisation. Further changes are introduced through individuals' active imagination and mental simulation of experiencings and their projection into the future (Hassabis & Maguire, 2007; Schacter & Addis, 2007). With increasing time lags, individuals will therefore more likely reconstruct experiencings that they *believe* they had or ought to have had rather than the particular ones that they *actually* had at a given moment. To reduce fallacies of memory (Schacter, 1999), application in *closest possible temporal proximity* to the particular experiencings studied therefore is an essential criterion for retro-introquestive methods.

Self-reports are constructed in the moment of inquiry, thus in individuals' experiencings. But the *self-reported content* in itself need not refer to specific experiencings an individual has had in particular moments. Self-reports can also reflect individuals' overall considerations of the experiencings they commonly have, thus the ideas, self-knowledge and personal narratives that individuals have developed *about* their experiencings (e.g., narrative identities, McAdams 2001, or personal projects, Little 2014; see Uher 2016b). These memorised psychical resultants, because they are temporally extended, can be captured with methods of *long-term memory-based introquestion*. In these methods, the persons who generate data reconstruct *from their memories* information, beliefs and ideas that they have about somebody or something. Personality questionnaires, for example, ask individuals to judge their "habitual" thoughts and feelings. Importantly, these questionnaires capture not the particular thoughts and feelings in themselves that individuals may have had in particular moments, but the generalised ideas and beliefs that individuals have developed *about* many pertinent experiencings they have had in the past. Hence, a key indicator of long-term memory-based introquestion is that persons can generate such self-reports *on demand* and *in any given situation* including situations that are completely unrelated to the kinds of experiencings enquired (e.g., when asked to complete an online survey about fear of speaking in public) and in which the target individuals may not even be present (e.g., online assessments of others).

4. Encoding the perceived properties into the signs used as 'data': Processes involved and basic conversion principles

To generate scientific data, persons must encode the perceived occurrences of relevant properties of the study phenomena systematically and according to explicitly defined assignment

rules into the signs used as 'data'. This encoding (also coding) and its implementation in a given method is the second pivotal point of data generation.

In *encoding schemes*, researchers specify the particular agreements that are made in a study about which particular pieces of information about the phenomena under study, as perceived and conceived by human individuals (e.g., researchers, observers), can be demarcated and categorised in what ways and how the thus-defined elements or events shall be represented by what particular signs used as data (e.g., behavioural variables, numerals). These issues of operational definition and assignment are well known and frequently discussed. But what specifically must the data-generating persons accomplish during this encoding process? The metatheoretical concepts above allow to explore these processes on more abstract levels of consideration to open up new perspective not yet seen that way.

4.1 The phenomena's frames of reference and conversions of information between phenomena of different kind

The distinct constellations of metatheoretical properties, because they determine accessibility by humans, establish for each given kind of phenomenon its own *frame of reference* that is applicable to other kinds of phenomena only to some degree or not at all. Therefore, these frames of reference determine the *ways in which information from one kind of phenomenon can be represented in another one*; this is called *conversion* in the TPS-Paradigm (Uher, 2015d)

Conversions of information happen all the time individuals are communicating. To transmit information from their *internal psychical* systems (e.g., thoughts, ideas) to their outer world, individuals must represent this information in *external physical* phenomena that others can directly perceive (e.g., verbal and nonverbal behaviours, visual patterns on paper); this is called *external physicalisation* in the TPS Paradigm. Others can use these perceivable external physical phenomena (commonly termed signals in communication research) to infer the ideas and meanings that they believe the sender may have intended to convey, thereby representing this information in their own psychical systems, thus in *internal psychical* phenomena (see Figure 1). Hence, communication involves back and forth conversions of information between internal-psychical and external-physical phenomena (Uher 2016a; Uher 2015a). Problems occurring in communication processes are distortion and loss of information (see Ellis and Beattie 1986).

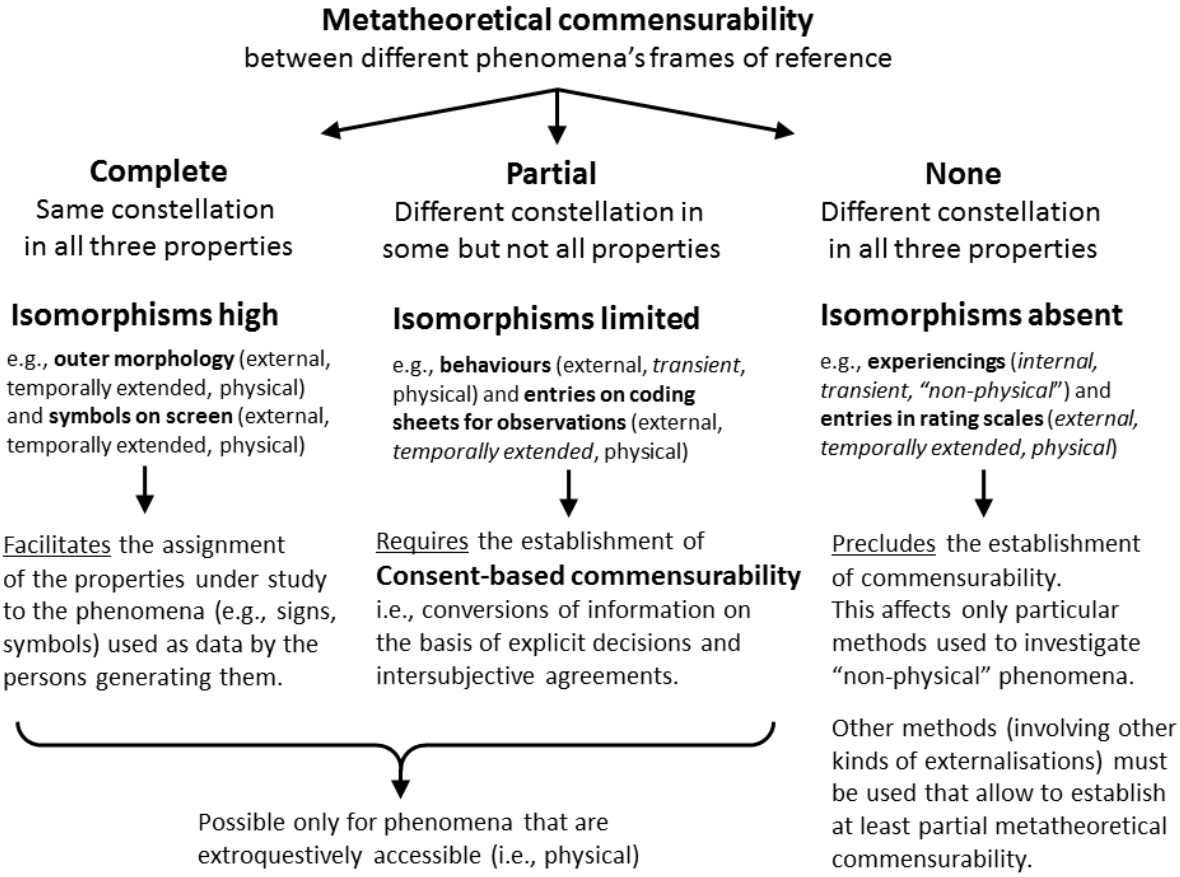
Data generation involves the conversion of information about the phenomena under study (e.g., physical objects, individual behaviours) into information encoded in the phenomena used as 'data'. Data are semiotic representations (signs, symbols), that is, external physical representations (e.g., variable names and numerals printed on paper or screen) to which particular individuals (e.g., researchers, observers, raters) assign particular meanings (e.g., meanings of numbers) and particular referents (e.g., perceived properties of the phenomena under study; see Section v). What distortions or losses of information may occur in this encoding process?

4.2 Metatheoretical commensurability and three basic conversion principles

The demands that conversions of information impose on the persons generating the data and the challenges involved can be explored on the basis of the three metatheoretical properties and of properties ascribed to the signs (symbols) that are used as data (e.g., mathematical properties of numerals). Specifically, if two kinds of phenomena share the same constellation of forms with regard to the three metatheoretical properties, then isomorphisms between them can be high and their frames of reference can be considered as *completely metatheoretically*

commensurable (from the Latin *commensurabilis* for having a common measure). Complete metatheoretical commensurability facilitates conversions of information between phenomena of different kind, such as between the phenomena under study (e.g., physical objects, individuals' morphology) and the physical phenomena used as signs for data generation (e.g., lexical variables, numerals written on paper). Thus, complete metatheoretical commensurability facilitates the assignment task that persons generating data have to accomplish. It also facilitates the development of physical methods (see Section 3.3), including technologies enabling automated conversions of information (e.g., technical measurement instruments; see Figure 2).

Figure 2 Levels of metatheoretical commensurability and their methodological implications



If *different* frames of reference must be conceived, conversions of information may inevitably entail distortion or even loss of information, which is studied, amongst others, in concepts of measurement error and uncertainty. (For this reason, the term conversion is used rather than translation or transcription, which implies loss-free conversion of information between different media.) Significant distortion or loss of relevant information entails that the frame of reference of a particular semiotic system cannot be used to appropriately represent information from the phenomena under study, thus hindering their scientific exploration.

Differences in the phenomena's frames of references can occur with regard the three metatheoretical properties that determine a phenomenon's perceptibility by humans, which can be formalised in three *basic conversion principles* (Uher, 2015d). *Conversion Principle 1* states that differences in the phenomena's location internal or external to the studied individual's body may constrain conversions of information if, through these conversions, the phenomena under study are altered in themselves. This entails challenges, for example, for research on physiological phenomena (e.g., metabolic phenomena) but in particular for research on psychological phenomena (e.g., experiencings; see Section 3.3.1).

Conversion Principle 2 denotes that constraints for conversions of information may arise if the phenomena involved differ in their temporal extension, in particular, if one or even both of them feature events of variable temporal extension. This variability increases the demands imposed on the persons generating data because, without special provisions (as arranged, e.g., in races), the temporal extensions of different events cannot be perceived together at any given moment, thus hindering direct comparisons and requiring technical support for data generation. This entails challenges in particular for research on behavioural and psychical phenomena.

Conversion Principle 3 denotes that differences in the phenomena's physical properties may constrain conversions of information between them, in particular, if they feature elements of variable spatial extension because this complicates their categorisation and comparison by the persons generating the data. But unparalleled challenges emerge when spatial extension cannot be conceived at all as is the case for psychical phenomena that, moreover, are accessible only introquestively by each individual itself and by nobody else. This substantially complicates explorations of the conversions of information that individuals have applied when externalising information from their psychical systems.

The challenges specified in these three abstract principles often occur together, which increases the demands placed on the persons generating data. For example, behavioural events show pronounced and complex variations in both their temporal and their spatial extensions (Conversion Principles 2 and 3), making their categorisation in a given moment highly challenging for the persons generating data (e.g., how to categorise raising an arm, see Section 2; Uher & Visalberghi 2016).

But some of these challenges can be mitigated. This applies in particular to physical phenomena that, given their extroquestive accessibility, enable the development of physical methods that facilitate or can even replace direct perception by humans with automated conversions of information (e.g., technical measurement instruments; see Figure 2; Section 3.3). What does this involve?

4.3 Consent-based commensurability

When the frames of reference of different kinds of phenomena can be assumed to have only *partial metatheoretical commensurability* (i.e., differ in some but not all three properties), then commensurability must be established on the basis of decisions. These decisions must be made by the persons who convert information from their perceptions and conceptions of the phenomena under study into information encoded in the phenomena used as signs (e.g., symbols in check sheets or on computer screen).

When these decisions are made explicit and specified in intersubjective agreement, this is referred to as *consent-based commensurability* (see Figure 1). For example, when behavioural scientists develop and test the encoding schemes specifying the behavioural events to be observed, they establish intersubjective consent in the ways in which perceivable properties of these behaviours should be demarcated and categorised, and how their occurrences should be encoded in the signs used as data (e.g., behavioural variables,

numerals). This intersubjective consent is also essential for training observers to target their perceptions to the behavioural events specified and to use these encoding schemes in systematic and standardised ways, which is statistically tested in terms of inter-observer or inter-coder reliability. Intersubjective consent also underlies the conventions that scientists and engineers establish and use to develop technical devices that enable automated conversions of information from phenomena featuring events of variable spatio-temporal dimensions as well as the particular calibrations that are implemented in each single device (e.g., heart rate monitors, EEG, blood count analysers).

The abstract metatheoretical level on which the three conversion principles are formulated helps to specify the unparalleled challenges that arise for psychologists and social scientist from the unique properties of the phenomena of the psyche. These are *a)* the immaterial and "non-physical" properties of psychical phenomena and of social phenomena arising from them (Conversion Principle 3), *b)* the only transient access individuals have to these phenomena in their ongoing experiencings (Conversion Principle 2), *c)* the only indirect access scientists can have via individuals' externalisations (apart from self-explorations), and *d)* the fact that introquestion and externalisation inevitably alter and change the course of experiencings (Conversion Principle 1; see Sections 3.3.2 and 4.2). This unique constellation entails that, between the frames of reference that can be conceived for psychical phenomena and those conceivable for the phenomena used as data in some research methods, *no metatheoretical commensurability* can be assumed (i.e., they differ in *all* three metatheoretical properties). Metatheoretical commensurability between individuals' experiencings and their externalisations can be, at best, only partial (e.g., behaviours and verbal reports share the transience of experiencings but not their internality and "non-physicality"). This makes one-to-one externalisations of experiencings and, vice versa, one-to-one inferences from externalisations to individuals' experiencings impossible and requires methods enabling the establishment of at least consent-based commensurability (Figure 2).

5. Discussion and conclusions

The above-presented metatheoretical concepts and methodological principles open up new perspectives on the ways in which data are generated in the different sciences. They highlighted commonalities and differences in the two pivotal points of data generation: *1)* in the accessibility that various kinds of phenomena have for the persons generating the data and the researchers, and *2)*, as a consequence thereof, in the processes involved in the encoding of information from these phenomena in the signs (symbols) used as data. These concepts and principles cut across various previous concepts of data generation established in different fields. Their abstract level of consideration provides a common language for comparative explorations of the data generation methods used in different sciences, and in particular to specify the fundamental challenges involved in the exploration of psychical phenomena that scientists from all fields have highlighted in various ways.

This final section therefore discusses new insights that the metatheoretical concepts and methodological principles open up on various methods used for exploring psychical phenomena to pinpoint methodical insufficiencies not well considered. Discussions focus on the so-called 'qualitative-quantitative' methods debate in psychology and the social sciences, on introspective methods used in psychophysics, and on assessment methods used in psychometrics.

5.1 So-called 'qualitative versus quantitative methods': Differences in establishing consent-based commensurability and metatheoretical criteria of 'appropriateness'

In many so-called '*qualitative methods*', psychologists and social scientist explore individuals' externalisations (e.g., verbal reports in interviews, discussions in focus groups, written reports in textual analyses) in order to infer from these materials the actual phenomena under study (e.g., individuals' experiencings, social beliefs). As this is, necessarily, a subjective process, qualitative researchers commonly make their own interpretations of the externalisations studied and the inferences that they make from these externalisations explicit in order to establish an intersubjective consent about the interpretations and inferences they are making (e.g., inter-subject comprehensibility; Steinke 2004). Methods in which these intersubjective discussions also involve the studied individuals themselves (e.g., communicative validation; Flick 2008) constitute for these individuals a retro-introquestive exploration of the conversion decisions that they have made while externalising their experiencings. For all persons involved in this process (individuals studied and researchers), such methods constitute introquestive explorations of the decisions they are making to convert information contained in individuals' externalisations (external, physical) into the meanings (internal, physical) that the given externalisations (e.g., sentences transcribed) have for them (see Figure 1). Thus, in qualitative methods, psychologists and social scientists try to make explicit as good as possible the conversion decisions that are being made in these investigations—within the limits inevitably entailed by the peculiarities of psychical phenomena.

In many so-called '*quantitative methods*', by contrast, in which the persons generating the data are asked to indicate their assessments (ratings) on predefined rating scales (e.g., personality questionnaires), psychologists and social scientists do not enquire about the conversion and encoding decisions that these persons have made while generating the data. Nor do they commonly make explicit these persons' interpretations of the questionnaire statements and answer categories that are used to indirectly explore psychical phenomena. Questionnaires are commonly worded in everyday language often using rather general everyday statements (e.g., "is the life of the party") to enable their application to a wide range of phenomena (e.g., situations, behaviours and experiences) yet without specifying any particular ones. Unlike observers, raters are commonly not trained about how to interpret and use the questionnaire scales; instead, researchers capitalise on raters' common-sense knowledge to interpret the meaning of the item statements and answer categories provided.

But unlike scientific terms and concepts, people's everyday terms and concepts are often fuzzy and context-sensitive (Hammersley, 2013). A questionnaire scale's meaning evolves as a product of cognitive information processing in the particular moments and contexts in which raters generate their responses. How they do that and what specifically they consider is commonly not enquired. Meanwhile, various studies have demonstrated that standardised questionnaire statements are interpreted very differently, both within and among persons (e.g., Arro 2013; Lundmann and Villadsen 2016; Rosenbaum and Valsiner 2011; Uher and Visalberghi 2016; Valsiner et al. 2005). Thus, in assessment methods, it remains unknown what specific phenomena and properties the persons under study (as well as the researchers studying them) are actually considering with regard to the items statements used and what specific decisions they have made to convert information about them into the fixed scales provided.

The metatheoretical concepts and methodological principles highlight that, to be *appropriate* for particular study phenomena, data generation methods must *1)* enable the persons generating the data to directly perceive the study phenomena while they are generating them (direct accessibility) and *2)* enable at least consent-based commensurability to be established in the encoding systems or, for psychical phenomena, in the interpretations of and

inferences from the externalisations used to indirectly study psychical phenomena. Standardised assessment methods do not enable researchers to meet this latter criterion (in other-assessments none of them) and are thus not appropriate for the study of psychical phenomena. Commonly, standardised assessments (rating scales) are considered 'quantitative methods' because they are used to generate numerical data—by converting the responses to the scales' fixed answer categories into numerals and by treating these numerals as numbers. But standardised assessment methods do not allow researchers to specify the conversion rules that are being applied to generate the raw data (the ticks in the scales) in the first place. This precludes the establishment of traceability, a fundamental requirement of measurement (see Sections 1.1 and 1.2).

5.2 Introspective methods used in psychophysics: Methodical mismatches

The metatheoretical differentiation of various kinds of phenomena on the basis of their particular constellation of perceptual modes for humans highlighted that each kind of phenomenon can be studied only by a particular *class of methods* and that, vice versa, no method allows for exploring all kinds of phenomena. The frequent lack of differentiation between phenomena of different kind, such as between behaviour and psyche, therefore entails methodological mismatches that limit the abilities of studies to capture the phenomena toward which they are targeted.

In the history of psychology, various methods have been developed to quantify psychical abilities. The oldest of these methods were developed in psychophysics, a field of psychology devoted to exploring sensory perceptions and their relations to physical stimuli (G. T. Fechner, 1860). In psychophysical experiments, individuals are asked to report about how they perceive particular physical stimuli presented to them, such as just noticeable differences in the brightness of sources of light or the volume or pitch of sounds. Commonly, psychophysical methods are interpreted as introspective. But the stimuli presented to the persons generating the data are external to their bodies and can therefore be perceived also by the researchers. The crucial criterion of perceptibility by multiple individuals highlights that psychophysical methods explore individuals' perceptions of external physical phenomena and are thus extroquestive. In fact, it is the physical stimuli's extroquestive accessibility that first enables their identical repetition and systematic variation by the researchers (i.e., experimentation) as well as comparisons of the stimuli's quantitative variations with individuals' subjective intensity judgements as described, for example, in the Weber-Fechner Law (Fechner, 1888; Uher 2016a).

But apart from mere perceptions, which are always involved in any kind of investigation in physics and psychology alike (see Section 1.2), extroquestive methods do not allow for exploring psychical phenomena, such as the thoughts and emotions that individuals may have while judging and comparing the physical stimuli that they perceive in psychophysical experiments as well as the meanings and memories that individuals may associate with these stimuli. In individuals' perceptions, inward and outward perspectives, always merge together in any given moment (Wundt, 1896). Attempts to separate these perspectives by simply wording instructions differently, such as "tell me if you visually experience a sound" versus "tell me when the sound occurs" (Schwitzgebel, 2016), overlook that self-reports in psychophysical studies always involve the outward perspective as well—otherwise, individuals could not report about the external stimuli presented to them.

These insights have important consequences. Contrary to beliefs widespread in psychology, findings about individuals' perceptions of physical phenomena cannot be generalised to all psychical phenomena, which, given their non-spatial properties, differ

fundamentally from the spatially extended phenomena the perception of which is studied in psychophysics.

5.3 Standardised assessment methods for capturing transient phenomena: Mismatches in psychometrics

Psychophysicists "successes" stimulated the development of methods for quantifying further psychical phenomena (e.g., attitudes, personality) for which assessment methods (rating scales; (Thurstone, 1927, 1928) have become widely established in psychology and the social sciences. Today, assessment methods (and further methods, e.g., intelligence tests) are developed in *psychometrics*, the field concerned with developing theories and methods for "measuring" psychical phenomena. The metatheoretical concepts are now applied to scrutinise the ways in which assessment methods differ from observations.

Assessments are based on fundamentally different procedures of data generation than observations. Observations are nunc-ipsum extroquestive methods. The events to be recorded in observations are publicly accessible, enabling the shared perception of one and the same event by multiple persons. The same methodological principle underlies the real-time recording of transient physical phenomena supported by (wearable) technologies, in which automated processes are used to record human activity in real-life contexts (e.g., pedometer; Electronically Activated Recorder [EAR], (M R Mehl, Pennebaker, Crow, Dabbs, & Price, 2001). Observers as well as monitoring technologies record the occurrences and non-occurrences of specified events (e.g., behavioural acts) while or immediately after these occur. Consequently, the raw data are binary (or nominal), except when observers directly count the frequencies of events or when durations are measured using stopwatch by recording start and end of processes, which are ultimately binary events as well. But nunc-ipsum generated raw data cannot reflect any information about individuals' overall scores or even differences among individuals. Such information can be obtained only *after the data generation is completed* in subsequent steps of data *analysis*, in which the raw data are first aggregated across measurement occasions within individuals into individual summary scores that can then be compared among individuals.

Standardised assessments, by contrast, require raters to generate raw data that *directly reflect* individual summary scores (e.g., in some frequency ratings) and even relative differences among individuals (e.g., in personality ratings). This evaluation is possible only because assessments are introquestive and inherently retrospective and long-term memory-based methods. For this reason, standardised assessments cannot capture transient phenomena (e.g., behaviours, experiencings) as sometimes assumed (e.g., behaviour ratings). The application of assessments in some methods of experience sampling illustrates this.

Experience sampling methods involve self-reports about experiencings that individuals have in everyday life situations (Larson & Csikszentmihalyi, 2014; Matthias R. Mehl & Conner, 2012). Methods asking individuals at random occasions during the day to report in real-time about the experiencings they may have in these moments are *nunc-ipsum introquestive*. Methods asking individuals to report about the specific experiencings they have had on a specific day, such as in diary studies, are *retro-introquestive*. But methods asking individuals to provide such self-reports on rating scales, such as to evaluate the intensity of their current experiencings, require individuals to compare these ongoing events with similar experiencings they have had in the past, but which, necessarily, have already ceased to be and from which individuals can have retained only memorised psychical resultants. Thus, raters are required to compare their ongoing experiencings with the knowledge, beliefs and ideas they have developed about such experiencings in the past and to mentally generate an overall judgement that reflects differences over time and often also among individuals. But such differences cannot be directly

perceived an any given moment; they are abstractions and constructions of the human mind. Thus, standardised assessment methods always rely on long-term memory-based retro-introquestion. Their application for recording transient events like experiencings or behaviours, even if applied in the moments in which these occur, constitutes a methodological mismatch.

5.4 Outlook

The presented metatheoretical concepts and methodological principles provide novel lines of argumentation that substantiate psychologists' and social scientists' increasing criticism of their own disciplines' focus on standardised assessment methods and establish connections to concepts of data generation developed in metrology. The classification of data collection methods based on the study phenomena's accessibility for persons during data generation cuts across common method categorisations, which are based on properties of the data once they were generated (e.g., qualitative, quantitative). This sheds new light on commonalities and differences in the methods used in different sciences.

Researching the diverse kinds of phenomena that occur in individuals inherently requires the application of a plurality of methods and approaches, some of which are complementary to one another. The three meta-theoretical properties determining a study phenomenon's perceptibility by humans and the methodological principles derived from them constitute an elementary system to guide researchers through this plurality to select the methods that are appropriate to their particular study phenomena and to the demands that these phenomena's peculiarities impose on the persons generating the data.

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