Individualisation and Individualised Science: Integrating Disciplinary Perspectives

By

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Abstract

Recent trends in a range of scientific fields have seen a shift towards research and methods concerning individual differences and individualisation. This article brings together various scientific disciplines—ecology, evolution, and animal behaviour; medicine and psychiatry; public health and sport/exercise science; sociology; psychology; economics and management—and conceptually integrates their research on individualisation. We clarify the concept of individualisation by distinguishing three kinds of individualisation studied in these disciplines: Individualisation$_{ONE}$ as creating/changing individual differences, Individualisation$_{TWO}$ as individualising applications, and Individualisation$_{THREE}$ as social changes influencing autonomy, risk, and responsibilities. This also elucidates how individualisation is related to individual differences. Drawing on recent work in philosophy of biology, we analyse conceptual links between individualisation and individuality and clarify the different sorts of individuality that the disciplines study. This paper promotes interdisciplinary research concerning individualisation by establishing a common conceptual-theoretical basis, while leaving room for disciplinary differences.

Keywords

Individualisation; individualised science; individuality; individual differences; philosophy *in* science

1. Introduction

Individuals of the same species differ. This is true for all manner of organisms, including plants, non-human animals, and humans (Müller et al. 2020; Müller and Junker 2022). For example, animals differ morphologically, physiologically, behaviourally, even in terms of their 'personality' (for instance, whether the animal is disposed to act in a bold or shy manner in a risky scenario; Kaiser and Müller 2021). Animals—and/or humans specifically—differ in the way they get ill and react to the same treatment; differ in how

they interact with other individuals, how they are seen by other individuals and are socially recognised as autonomous subjects; differ in how they execute certain tasks and in terms of their preferences and in the decisions that they make (e.g., purchase decisions, mate choices, educational and occupational choices).

For many scientific purposes, especially in biological and psychological fields, it is becoming increasingly clear that population-level average values for individual traits—the standard measure of much analysis—are insufficient (e.g., Wolf and Weissing 2012; Schwarz et al. 2021; Kuper et al. 2022a). These values obscure the differences/variation between individuals, stymying efforts to understand and predict, *inter alia*, population processes, interactions with other species, or response to environmental change. Perhaps unsurprisingly, then, the perspective of intraspecific trait variation as noise around an optimum value is waning (Moran et al. 2021).

Scientists increasingly aim at understanding not only that individuals differ but also how, and why, and what the consequences are. This has ignited a research agenda: *individualisation*. This agenda, as we see it, is at least two-pronged. On the one hand, scientists investigate *how* individual differences[1] develop (i.e., the causes, mechanisms, or processes of individualisation; how individual differences arise, change, stabilise, and persist), as well as *why* individual differences initialise and develop. On the other hand, scientists are interested in the consequences of individualisation (e.g., in terms of ecological-evolutionary or social consequences) and in the implications of individual differences for a very wide range of contexts of application, including designing nature reserves, improving animal welfare, medical or psychiatric treatment, health/nutrition recommendations, marketing strategies, and pedagogy (e.g., internally differentiated teaching). This gives rise to individualised science, for example, personalised and precision medicine (e.g., Abettan 2016; Ashley 2016).

Many disciplines are concerned with individualisation, understood in terms of individual differences.[2] This provides the opportunity for fruitful, collaborative exchange between the disciplines. A prominent example is the research association "Individualisation in Changing Environments" (InChangE) of the University of Muenster and Bielefeld University (funded by the Ministry of Culture and Science of the State of NRW from November 2021 to October 2024). InChangE explores the causes, mechanisms, and consequences of individualisation in changing environments in an interdisciplinary

[1] It would be more precise to always speak of *inter*-individual differences since we mean differences between individuals (and not, e.g., differences inside of an individual). For reasons of simplicity and because it is an established term, we will, however, use the term 'individual differences'.

[2] 'Individualisation' as an established theoretical term in sociology is not best elucidated in terms of individual differences, as we will clarify in Sections 2.4 and 3.1. However, we also show that individual differences are nevertheless an important target of sociological research.

discourse between natural sciences, social sciences, and humanities. The interdisciplinary collaborations in InChangE consist, for example, in linking research questions and results, exchanging methods, learning from each other how to overcome methodological challenges, and complementing each other's research by sharing and integrating results—this makes it possible, for instance, to test a hypothesis about humans via nonhuman animal studies. In InChangE it became clear that successful interdisciplinary collaboration, however, requires developing at least a minimal common conceptual-theoretical basis to avoid misunderstandings and to emphasise points of contact (and convergence) between the disciplines (see, e.g., Andersen 2016). This is what this article does and where philosophy can be scientifically relevant. Our contribution to InChangE can thus be characterised as 'philosophy in science' (Pradeu et al. 2021). The common conceptual-theoretical basis that we develop is minimal because it concerns only a few, very central concepts: 'individualisation', 'individual differences', and 'individuality'. Our philosophical analysis of these concepts is descriptive because it takes seriously how the concepts are understood and used in the scientific disciplines. In addition, our analysis is also normative because when unifying some concepts, we are also prescribing how these concepts should be understood/used (Kaiser 2019). Developing a common conceptual-theoretical basis for the interdisciplinary study of individualisation does not assume (or promote) a unity-of-science view because we are only unifying some quite general concepts (and related theoretical assumptions), such as the three individualisation concepts. Moreover, conceptual unification often is not as complete as it theoretically could be (because sometimes more unification hinders interdisciplinary collaboration). For instance, we propose not a single concept of individualisation, but rather three; we do not argue for a single concept of individuality but rather highlight a plurality of kinds of individuality (between the disciplines and often also in one discipline).

The goal of this paper is twofold: our philosophical analysis is supposed to be scientifically and philosophically relevant. First, we seek to foster interdisciplinary integration of studies of individualisation and individualised science. We do so by clarifying and unifying central concepts, while also carving out key distinctions. Moreover, we draw connections between the research questions of different disciplines, and identify theoretical-conceptual questions that are priorities for future research. Second, while there has been some philosophical discussion about topics such as methodological individualism in the social sciences (e.g., Epstein 2009; Zahle and Kincaid 2019; Heath 2020), personalised medicine (e.g., Abettan 2016; Maughan 2017), and biological individuality (e.g., Godfrey-Smith 2009; Clarke 2010; Pradeu 2016; Lidgard and Nyhart 2017), the recent trend in various disciplines to study individual differences and individualisation has not been brought together and philosophically analysed so far. The

second goal of this paper is thus to draw philosophical attention to the scientific study of individualisation and to use this case to make novel contributions to existing philosophical debates about individuality, individualisation, and individuals.

Section 2 presents six summary outlines of individualisation from within several different disciplines: ecology, evolution, and animal behaviour; medicine and psychiatry; public health and sport/exercise science; sociology; psychology; economics and management. Each disciplinary perspective is written by at least two of this paper's co-authors; together we span the full range of disciplines represented. Attention is given to the general state of play within a discipline. Sections 3 and 4 present our philosophical analysis. Here we draw together threads from the disciplinary summary outlines, establishing a common conceptual-theoretical basis for the interdisciplinary study of individualisation that leaves room for disciplinary differences. In Section 3 we specify what individualisation is and how it is connected to individual differences. We distinguish three kinds of individualisation: Individualisation$_{ONE}$ as a process giving rise to or changing individual differences; Individualisation$_{TWO}$ as the tailoring of interventions, services and products for individuals, given their differences; and Individualisation$_{THREE}$ in the sense of sociological individualisation theory. We explain why researchers need to investigate individual-environment interactions to understand Individualisation$_{ONE}$. Section 4 draws on the debate on biological individuality in philosophy of biology as a springboard to offer more general insights into the relation between individualisation, individual differences, and individuality. Our main claim will be that, in general, being different from others is one way of expressing individuality. Section 5 concludes, identifying some prospects for future philosophical analysis.

2. Individualisation Across Disciplines

2.1 Individualisation in Ecology, Evolution, and Animal Behaviour

Individuals of the same species, population, and even family/group differ in many respects, for example, in behaviour, morphology, and physiology (Müller et al. 2020; Müller and Junker 2022; Kaiser and Müller 2021). Determining *how* (proximate questions), *when* (e.g., at which life stages) and *why* (ultimate questions) individual traits arise is a major focus of past and current research in ecology, evolution, and animal behaviour. However, even this type of research has mostly been satisfied with mean values of difference/individual-level traits in a population (or species) for the purposes of analysis, and has ignored remaining individual differences. This perspective conceives of intraspecific variation as noise around an optimum value.

A relatively recent paradigm shift has refocused much biological research squarely on individual differences (Wolf and Weissing 2012; Bolnick et al. 2003), now considered in animal personality research (Dall et al. 2012; Kaiser and Müller 2021), conservation biology (Smith and Blumstein 2013; Powell and Gartner 2011), the study of individualised niches (Krüger et al. 2021, Müller et al. 2020), and animal welfare science (Richter and Hintze 2019; Carere and Maestripieri 2013).

While individuality is considered in terms of individual differences, individualisation is the process during which individual differences initialise and change over time by way of the development of individual traits or an individual phenotype. Sometimes these differences are easily detectable by studying prominent phenotypes, for example, individual differences in size, shape, or colouration. However, many individual phenotypic differences are less obvious and need to be studied by way of more intricate methods—for example, by examining body odours, gut microbiota composition, individual immune systems, or behaviour. How individual variation in perceptual capacity gives rise to task specialisation/division of labour in eusocial insects (Beshers and Fewell 2001), and how individual differences in sensory apparatus give rise to variation in temporal foraging patterns and speed/accuracy trade-offs in bees (Chittka 2022) are two examples of individualisation research programs.

Besides analysing phenotypic differences, a common way to pinpoint individuals (and their differences) is by genetic markers (e.g., parts of the genomes that are highly polymorphic and considered selectively neutral such as microsatellites that are also used to establish relatedness and population structure in animals including humans). While the genome of an individual remains largely stable over its lifetime, many traits develop only during a specific life stage in interaction with environmental factors. Consider the unique colour patterns of individual fire salamanders, which develop during their late larval stage. Although unique, an individual fire salamander's colour pattern is highly influenced by food availability during that stage (Caspers et al. 2020), but once individuals metamorph and leave the water, their colour pattern remains constant throughout life. While the amount of yellow in the patterns of post-metamorphic fire salamanders is probably under selective pressure, with more yellow leading to reduced predation risk (Caspers et al. 2020), the pattern itself is most likely not under selection, similar to the patterns of human fingerprints. Other traits are highly plastic and change due to different environmental conditions, seasons, and social contexts. For example, the behavioural and hormonal phenotype of a male guinea pig is shaped by his social environment during adolescence, but can be reshaped if the social environment changes later in life (Mutwill et al. 2020).

Both examples show how the environment of an individual plays an important role and that individualisation is a result of the interaction between an individual, its genes and internal states, and its biotic and abiotic environment. Methods and concepts in biology, such as reaction norms, take into account and measure how phenotypes and traits vary across an environmental gradient, influencing differences between individuals and populations. In contrast, other concepts gleaned from developmental biology emphasise how canalisation suppresses the expression of alternative phenotypes or traits during ontogeny in different environments, reducing environmental influence on a trait, which has the potential to lead to reduced individual differences (Gonzales et al. 2018).

Overall, individual differences, their causes, and their consequences are becoming more central in biological research. Moreover, with the development of the concept of an individualised niche, the focus of how and why individuality originates, develops, and becomes evolutionarily stable has become central. Indeed, the interaction between the individualised phenotype and the environment results in individualised niches via three processes/mechanisms of adjustment, potentially increasing the fitness of an individual: niche choice, niche conformance and niche construction (Trappes et al. 2022). The concept of the individualised niche represents an integrative framework to study the causes and consequences of individualisation (Krüger et al. 2021).

2.2 Individualisation in Medicine and Psychiatry

There is a long-standing tradition, historically associated with the Hippocratic Oath, according to which medical practitioners commit to the medical interests of individual patients and thereby to dealing with the illnesses of individual patients. Yet with the introduction of a modern scientific approach to medicine and psychiatry in the 19th century, these fields aimed to establish scientifically rigorous standards and norms, requiring something of a shift. Quantification underlies the modern scientific conception of medicine and psychiatry, generating tension with the historic idea of an experienced, expert doctor dealing with their patients as individuals in a more ‘holistic’ way. But that historic, holistic approach is not the only conception of individualising medicine. Indeed, modern individualised approaches to medical treatment (and prevention) are currently gaining traction.

First, the term ‘personalised medicine’ has become increasingly popular, referring to an increasingly sought-after approach in practice, which is to tailor (that is, ‘individualise’) medical treatment or intervention. Despite the name ‘personalised medicine’, this does not entail an ‘individual-level’ approach, in the sense of an

individually bespoke, exclusively designed, person-specific treatment. Rather, practitioners of personalised medicine individualise treatment and prevention by taking into account the specific characteristics of individual patients and relating them to *strata*—that is, narrower subsets of the more general samples of the population that make up the cohorts of standard randomised control trials—rather than comparing individual patients to the general mean (the 'one-size-fits-all' approach; Brittain et al. 2017; Baune 2020a). Such strata comprise those individuals from the larger sample that match or approximate the individual patient at hand in terms of particular genetic characteristics or other determining factors (from subjective data, objective medical test and experimental data, to blood-based biomarkers, digital mental health markers, brain imaging markers, and so on). The reasoning is as follows. Given that individuals differ, individuals sharing a diagnostic label may well have a variety of clinical presentations and respond in a heterogeneous fashion to therapeutic interventions or lifestyle recommendations. Actual responses in a clinical trial can range from no response to dramatic response, given individual variation. Particular individual characteristics may covary with response level, enabling stratification. Thus, knowing certain characteristics of a patient in a clinical encounter and comparing them to (a sufficiently large sample of) individuals that share those characteristics gives that patient a better chance of optimal treatment—say, via response to a specific drug instead of another, or a specific preventative strategy—and still in an evidence-based way (Baune 2020a, b). The stratification approach, then, allows a focus on medically relevant similarities, reducing the influence of variation compared to use of the larger sample. Whenever strata comprise large enough sample sizes, personalised medicine aims to better capture and relate the patient at hand vis-à-vis the medical or psychiatric matter at hand, compared to the one-size-fits-all approach.

Many HIV patients are prescribed the relatively safe drug Abacavir, for example; however, there is a small chance of a toxic reaction to the drug in hypersensitive patients, correlated with a single genetic variant (see Abettan 2016). Screening HIV patients for this genetic variant (i.e., to see whether they would belong to this genetically classified stratum) and subsequently prescribing the appropriate drug is thus an example of the personalised approach; indeed, one that has become a routine step in prescribing HIV treatment. Likewise, individuals with certain psychiatric risk profiles can be said to belong to 'risk strata'. Psychiatry researchers examine, *inter alia,* immune function deviations in patients with psychiatric illnesses compared to healthy controls (e.g., Wingo and Gibson 2015). Following this, stratification could be based on genetic risk profiles for the disposition to develop the immune dysfunction that causally contributes to the development of the psychiatric illness. An individual patient in a clinical encounter with a

certain genetic risk profile could then be compared to the relevant strata and treated (or provided with preventative measures) accordingly.

Second, personalised medicine often goes in hand with 'precision medicine', the aim to describe an individual's specific case of an illness or disease at a higher level of resolution than previously possible, enabled by new advances in genomics, medical technologies, bioinformatics, and algorithms for analysis. These new advances allow for distinguishing 'precise' subcategories of disease, of which each might call for distinct therapies. The broad categories of cancer and cystic fibrosis are examples (Ashley 2016). Indeed, the precision approach has proven especially fruitful in oncology, for example, where pathology is often finely circumscribed and thus diagnosis can be precise. This then may facilitate personalised oncological treatment, tailored to a particular instance of tissue damage/change.[3] In contrast, in psychiatry, pathology is generally circumscribed more coarsely, making precision medicine challenging to implement.

In short, individualised approaches to medicine and psychiatry (both personalised and precision) aim to reduce noise. Firstly, the inference that the treatment will work well for the patient is stronger when it comes from a better understanding of the individual's characteristics (again, providing it is still compared against a large enough sample; this necessitates the huge sample sizes that medical researchers work with). This enables a structured/stratified assessment and modelling of a range of determining factors to predict risks and treatment responses—and, secondly, in combination with precision medicine, this enables the identification of the precise subtype of an individual's disease. Perhaps unsurprisingly, then, there is an increasing number of scientific publications and themed conferences on this topic, which supports the impression of rising importance of the personalised and precision concepts in medicine and psychiatry. Despite the potential promise (Abettan 2016; Baune 2020a; McCarthy 2017), little work has been undertaken to precisely define the concepts and systematically translate individualised medicine into clinical practice. Most work in this regard is piecemeal, aiming to show how an individualised approach can play out clinically in reference to a particular disease or illness (see, e.g., McCarthy 2017, for an individualised approach to type 2 diabetes).

Generally, however, individualised approaches in medicine/psychiatry are still largely at the conceptual stage and are not yet adequately developed or empirically established for clinical practice. There are also legitimate concerns over the hype surrounding individualised approaches: there are many successful cases, but also failed

[3] One example is the case of CAR T-cell therapy treatment. Treatments are customised for individual patients via the collection and re-engineering of a patient's T-cells to produce CARs (chimeric antigen receptors), proteins that recognise and bind to particular proteins or antigens on the surface of cancer cells (see, e.g., Jackson et al. 2016).

attempts to individualise treatment of more complex illnesses, and these failures receive far less air time (Maughan 2017). That said, bolstered by its successes, individualised approaches are very likely to be something that we will see further explored by medical and psychiatric researchers in the years to come (Baune 2020b).

2.3 Individualisation in the Public Health Sciences and Sport/Exercise Science

The public health sciences aim to prevent disease, prolong life, and encourage healthy lifestyles through organised social efforts. Public health's initiatives promote the making of informed choices at all levels of society, including private and public organisations, communities, families, and individuals (Winslow 1920; Wanless 2004; Griffith et al. 2005). Examples include the World Health Organisation's poster campaign foregrounding individual responsibility in handwashing and personal hygiene in order to reduce the use of antibiotics and prevent communities from developing antimicrobial resistances (Chandler 2020) and the World Health Organisation's global action plan on physical activity providing recommendations to help countries increase levels of physical activity within their populations (WHO 2022). Worldwide improvements in health have seen public health initiatives increasingly focus on new epidemics of non-communicable diseases, for example, cardiovascular diseases, musculoskeletal disorders, diabetes and mental disorders (Lopez et al. 2008; WHO 2020).

Health promotion generally targets not only the societal level but individual behaviour and resources, lifestyle risk factors, and the wider determinants of health, such as poverty and education (Wanless 2004; WHO 2022). These targets of analysis shift public health's focus towards individual health, emphasising the role of an individual's circumstances with respect to their health maintenance and disease pathogenesis (Arah 2009). Developments in molecular genetics and genomics support this refocus, for they have elucidated ways in which the human genome interacts with diverse environments and individual health-related behaviour (Ilkilic et al 2007). As a new field, public health genetics is striving for the integration of (epi)genetic information into strategies for disease prevention as well as the development of novel tools and technologies, rendering the field a highly-relevant interface between individuals and societies. Dumit et al. (2021) predict that public health initiatives will benefit from the personalisation of public health genetics. This vision is, however, currently controversial among public health scholars, as the causes of non-communicable diseases are complex on the one hand, and only a few risk factors are responsible for many diseases and deaths on the other (Jahn and Probst-Hensch 2018).

One important aim of public health initiatives is to strengthen individual health literacy and influence individual behaviour towards healthier lifestyles. Personalised services for both individuals and communities result in more health opportunities as well as the "empowerment of communities, their ownership and control of their own endeavours and destinies" (WHO Europe 1986). Cunningham et al. (2000), for example, report a pilot internet questionnaire that asks individuals about their drinking habits, and then provides personalised assessments—advice tailored to the answers of a person. In general, the more precisely information is adapted to the particular case of an individual, the better the advice from a human expert or algorithm, facilitating, on balance, more efficient individual health promotion (Caspari and Bös 2006).

Such information can also be derived by more objective measures such as physiological assessment. Within sport/exercise science, the development of tailored exercise recommendations is an important topic. Training studies consistently report wide variation in the effects of regular exercise training, including individuals who demonstrate an adverse response to specific training interventions and other individuals showing the expected (and desired) responses. Based on such variation in response to exercise, it has been suggested that individuals can be divided into 'responders' and 'non-responders' (Mattioni et al. 2021). Being a responder or non-responder to exercise training, however, depends on training principles such as exercise modality, intensity, duration, and frequency, strongly implying the need for the tailoring of recommendations. Current approaches go one step further showing that certain individual characteristics such as fitness level or sex (and within sexes, the fluctuating levels of sex hormones) directly impact responses to exercise. That is, the same absolute dosage of exercise induces different physiological responses depending on the fitness or hormonal state of a person (Julian and Sargent 2020). This calls not only for individualised approaches to health advice in general, and exercise advice specifically; it also indicates the variety of research questions. Similarly, sport/exercise science aims to explain individual differences in motor performance and learning (Hübner et al. 2019) to derive appropriate therapeutical approaches, design training programs (Mack et al. 2023), or to support developmental processes whether in children or older adults.

Another important aim is the design of health-promoting human environments; the full range of environmental features play significant roles in health-relevant individual development (Gebhard 2020). The socio-political environment is also key: state intervention to empower citizens proves fundamentally difficult in Western societies and can have a negative impact on individual self-esteem, especially when the target group called to self-care finds itself confronted with structural or material problems that are beyond their influence but under state control (Berg et al. 2019). This problem is

exacerbated when local health authorities conceptualise health inequalities and their social determinants as personal matters and thus the responsibility of individuals (Mead et al. 2020).

Even when public health initiatives are aimed at target groups, the intention is to reach every single individual within the group. Hence, individualisation in public health can be described as personalised health-related services or products, or information tailored for a certain target group. Similarly, in relation to health literacy, individualisation has been defined as "adapting or tailoring services and information to the needs of individuals. The aim is to provide a person with the maximum amount of information that is important to them from their perspective" (Caspari and Bös 2006, our translation). Sport/exercise science has a long tradition of developing such tailored recommendations; nevertheless, there are still many unsolved questions with respect to the 'fine-tuning' of individualised approaches. Finally, in an individualised society, in which thinking has shifted from being oriented on traditional collectives to individuals, individualisation of health implies greater individual responsibility for one's own health (Berg et al. 2019; Berger 2020; Bolam et al. 2004) as per the concept of sociological individualisation theory (see Section 2.4).

2.4 Individualisation in Sociology

The difference between 'individual' and 'society' is a central justification of sociology as a discipline. Within their reflections on the individual, early sociologists discussed the variety of individual options on the one hand, and social expectations on the other, that opened up in the 19th century, for example, with respect to dissolving estates of the realm. For Georg Simmel, Max Weber, and Emile Durkheim, increasing reference to the 'I' was not good news, but "a disease of an anti-social individualism" (Rammstedt 1985, p. 494, our translation).

In the 1990s, a particular concept of individualisation became particularly important in sociology, when efforts increased to conceptualise and analyse empirically observable social change, especially with respect to both industrial production and changing gender relations. The individualisation processes identified here (e.g., Beck and Beck-Gernsheim 1994, 2002) affect individuals in a specific way, in that they detach from traditional and hitherto predominant social forms. Such individualisation processes occur in many social domains, such as the workplace: "individuals take on a new role as coordinators of their personal work biographies: they become actors who actively shape their individualised work orientations and commitment patterns, which a few decades ago used to be shaped much more on a collective basis" (Kirpal et al. 2007, p. 285).

This concept of individualisation was used in part to critique then mainstream postmodernist theorising. Postmodernists of the 1970s emphasised the positive aspects of the recent and ongoing breakdown of various traditional social norms and structures, especially those occurring in so-called 'WEIRD' societies—breakdowns that resulted in increased individual autonomy, rights, and freedom of choice. Individualisation theorists aimed to show the limits of this perspective by arguing that it overstates the extent to which individuals are free (Beck 1992; Beck and Beck-Gernsheim 1994, 2002; Giddens 1991, 1994). The greater autonomy found in Western society today compared to even 60 years ago—just two generations—naturally may be liberating for many individuals, perhaps especially women and other marginalised groups. But, the idea goes, greater personal freedom does not erase risks and responsibilities. How these change in an individualised society became the target of a research agenda within sociology (Beck and Lau 2005). 'Individualisation' in this sense, then, refers to the process whereby increased social change (and increased future uncertainties due in particular to the shift away from traditional norms and structures) force each individual to dedicate more effort and time to their daily life choices—forcing individuals to accept increased levels of risk and responsibility for the consequences of those choices. Since greater autonomy must be exercised in societies undergoing individualisation than in previous generations, knock-on effects are inevitable: chief among these is the increasing extent to which individuals are required to construct and be held accountable for their own lives, which has significant implications for responsibilities.

Sociological individualisation theory has its critics (see, for review, Dawson 2012). Plausibly, in distinguishing their framework from postmodernism, individualisation theorists have in turn overstated the extent to which individuals are 'disembedded' in an individualised society—especially in so widely projecting a particular experience of modern societies—necessitating an 'embedded' conception of individualisation (Dawson 2012). For a start, individuals socially integrate in new ways (e.g., networks, scenes). Rather than throw the baby out with the bath water, sociologists now see individualisation as socially situated (Adams 2003; Ødegårda and Berglund 2008). This has reignited sociological interest in poststructuralist approaches (for example, processes of subjectivation; see Foucault 1975), and praxeological approaches (such as production and reproduction of habitus; see Bourdieu 1987), two starting points for much contemporary sociological epistemological inquiry (e.g., Adkins 2004; Lehmann 2009; McNay 1999).

These debates have also found expression in social structure analysis, in particular in the sociology of the life course, as well as sociological gender studies. Social structure analysts examine changes in social structures on the basis of individual decisions and behaviour, in conjunction with cultural, institutional, and structural framework

conditions. 'Individualisation' in this context of inquiry means the process whereby "markets and welfare states address the individual *as an individual* rather than as a group member", especially given that "individualism has become accepted as a cultural model, especially in the sense of responsibility for one's own actions" (Diewald 2013, p. 554, our translation and emphasis). In other words, the explanatory targets of this individualisation research are individuals and their social environments.

We see this also in sociological gender studies. Buschmeyer and Lengersdorf (2016), for example, distinguish 'hegemonic masculinity', the predominant masculinity concept in sociological gender studies, with non-hegemonic formations. Gender expression is increasingly heterogeneous, and individual variation in the expression of masculinity, for example, may challenge inferences that rely on a unitary concept of it. New social norms have reshaped a range of other social concepts and constructions, such as 'fatherhood', resulting in a variety of socially legitimate ways of being fathers (Lengersdorf 2013, 2014). This calls for the study of individuals in order to better understand how individual fathers differ qua fatherhood. Finally, although one can speak of the social de-institutionalisation of gender-specific normal life courses in many regions of the world, which has resulted in more individualised decision-making opportunities and autonomy, one must also speak of novelties that arise. Individuals face new opportunities and new challenges for integrating gainful employment with family and other commitments in everyday life and over one's life course, largely determined by one's position in social, organisational, and familial structures (Kirpal et al. 2007).

2.5 Individualisation in Psychology

Although 'individuality' and 'individualisation' are currently not mainstream terms in psychology, psychological science has an established focus on both, the description of individuality (in what ways individuals are psychologically different from others or even unique), and the process of individualisation (how it comes to be that individuals differ). In addition, 'individualisation' is often used in contemporary psychology when referring to individualised services (e.g., psychotherapy, an intervention) that are tailored to individuals or specific groups. For example, personality psychology research on variation in psychological dynamics considers contingencies that can be directly related to application, working better for some individuals because of differences in reaction to circumscribed situations (Kuper et al. 2022b; Mota et al. 2023).

The field of psychology most concerned with individualisation is personality psychology. Personality psychology is deeply concerned with individual differences, and has been, since its inception (McAdams 1997; see also Corr and Matthews 2020). It

integrates insights and methods from cognitive psychology (commonly interested in, *inter alia*, rules of cognition, affect, motivation, and behavioural regulation), social psychology (commonly interested in normative effects of contexts and social interactions), developmental psychology (commonly interested in normal developmental trajectories across the lifespan), and quantitative psychology (concerned with psychological research methods and statistics including longitudinal and multi-method data, adding a different perspective that focuses on how people differ). Thus, personality psychology aims to understand more fully how individuals function psychologically, whether in certain respects like all other persons (i.e., generalities), like some other persons (i.e., individual differences), or like no other persons (i.e., uniqueness), following Kluckhohn and Murray (1953).

The study of individuality and individualisation in personality psychology has quite some history. An early concept, coined by Carl Jung (1934/1950), was *individuation*—the process of becoming an individual with a self and identity (Schlamm 2014). Historically, this concept did not take hold much because psychoanalytic concepts and thinking were eschewed once behaviourism became the dominant psychological paradigm. Other paradigms followed behaviourism, but Jung's individuation concept, with its psychoanalytic roots, was not revived in mainstream psychology. However, the contemporary self and identity literature (which has some ties to personality and social psychology) is indeed concerned with processes of self and identity formation that may capture key aspects of becoming an individual in one's society (e.g., Cote and Levine 2002). Differential approaches, originating from Stern (1911), have been more influential (e.g., Allport 1937; Cattell 1946). These are concerned with quantitative analyses of individual differences and distinguish nomothetic, variable-oriented approaches (i.e., describing how individuals differ in given variables and how these differences co-vary) from idiographic, person-oriented approaches (i.e., describing the similarities and differences of given individuals across variables).

Following this differential approach, contemporary personality psychology is quantitatively oriented. Most research follows a nomothetic, variable-oriented approach (Kuper et al. 2022a), but there is an emerging trend for more idiographic, person-oriented analyses as well (e.g., Beck and Jackson, 2020). Further, modern comprehensive analyses of individual differences include descriptive, predictive, and explanatory foci (Mõttus et al., 2020). With regard to description and prediction, there is evidence for (a) ubiquitous and strong interindividual differences in all sorts of psychological phenomena (including behaviours, motivations, emotions, cognitions, social perceptions, and life narratives), and (b) robust effects of these differences on life outcomes such as well-being, social

relationships, occupational success, and longevity (e.g., Beck and Jackson 2022; Soto 2019; Roberts et al. 2007).

Explanatory approaches especially in personality development and personality dynamics contribute to understanding the emergence of individual differences and are thus key for understanding individualisation. Firstly, research on personality development (for overviews, see Bleidorn et al, 2020, 2021) assesses people's individuality across time (e.g., assessments of individuals' self-concept, biological and behavioural regularities, and reputations across yearly assessments) and, thus, sheds light on the process of individualisation. It has shown that (a) personality is remarkably stable over time but also susceptible to change across the whole life-span (particularly in certain life phases such as young adulthood); (b) personality development is influenced by both genetic and environmental sources, with so-called shared environmental sources such as parental style and sociodemographic background being of less importance than non-shared sources such as peer-groups, romantic relationships, and job experiences (contradicting classic socialisation theories); and (c) individuals select into and experience social role transitions and life events differently leading to differential developmental trajectories and, thus, an increase in individual differences (i.e., individualisation).

The resulting changes in how much individuals differ from each other can be described and sorted in different ways and there is not yet an agreed upon taxonomy of individualisation processes (viz. changes of variables) in psychology. Table 1 summarises five exemplary 'types' of individualisation that might be of particular interest for other disciplines as well. For example, individualisation can refer to changes in a given variable (variable-oriented; see Types 1-3), to changes in the configuration of many different variables (person-oriented; see Type 4). Variables can be of any kind, including physiological, behavioural, motivational, cognitive or affective modalities. In addition, individualisation can refer to differential developments in the complex ways in which individuals construe their self-identity (see Type 5).

Table 1: Five exemplary types of individualisation

	Variable Investigated	**Operationalisation of 'Individualisation'**	**Increase in Individuality**
1.	Change in distribution of levels of a variable	The (difference in) density distributions (especially standard deviation) of a variable	If the standard deviation on a variable increases, individuality increases
2.	Change in rare, 'exotic' or 'special' variable	The (difference in) frequency, valence, or normativity of a variable that is rare or deemed 'exotic' or 'special' in a given society/culture	If an individual develops more or stronger rare/exotic/special tendencies, individuality increases

3.	Change in extreme level of a regularly occurring variable	The (difference in) extremity of a variable that is deemed 'normal' in a given society/culture	If an individual develops extreme levels of otherwise regular tendencies, individuality increases
4.	Change in configuration or combination of many different variables	The (difference in) profile of several variables (with their respective levels)	When changes in unique patterning of variables and their levels (as well as their deviations from the norm) occur, individuality increases
5.	Change in subjectivity, self-awareness, self-representations, self-identity, etc.	(Differences in) self-related (perceptual and cognitive) processes	If certain self-related processes increase, individuality increases

Secondly, research on personality dynamics has contributed to unravelling the processes that might drive these differential developments (e.g., Back 2021; Geukes et al. 2018; Wrzus and Roberts 2017). It has shown that individuals do not only differ in typical momentary behavioural and experiential state levels, but also in the degree to which there is intra-individual variation in behaviour across time and situational characteristics (e.g., Geukes et al. 2017) and in how individuals react to circumscribed situations (e.g., Kuper et al. 2022b). Changes in these state parameters may precede lasting trait changes (Roberts and Jackson 2008). Personality dynamics research has also shown that a range of motivational, behavioural, affective, and self-reflective processes underlies these state and trait changes, with one particularly important domain of processes being social in nature (e.g., self-esteem boosts when feeling valued: Hutteman et al. 2015; affective reactions to status perceptions: Kroencke, in press; behavioural co-regulation in peers: van Zalk et al. 2020).

While many of these dynamic processes that might trigger differential changes in individuals are currently explored, psychological research has just started to explore how they overlap, influence each other, and relate empirically to the range of existing individualities and (different types of) individualisation.

2.6 Individualisation in Economics and Management

Research in economics and management traditionally adheres to methodological individualism (Weber 1922). Accordingly, "social phenomena must be explained by showing how they result from individual actions, which in turn must be explained through

reference to the intentional states that motivate the individual actors" (Heath 2020).[4] Modern research in these fields not only indexes actions to preferences, but also considers endowment, prior information, information processing, and capacity to make economic choices (see Davis 2003, pp. 47-49).

The general approach in economic modelling (1) defines 'decision makers', that is, agents, which may represent a range of entities including firms, consumers, parliaments, countries, etc.; (2) defines the sets of actions available to the decision makers and their implications for the state of the world (i.e., who is affected and in which ways); and (3) defines the epistemic scope of the decision makers. This is in order to predict their choices, given their action sets and their beliefs about the choices of others. Steps 1 and 2 describe the context of the interaction—that is, the 'environment'—while step 3 describes the decision makers. The definitions in step 3 generally comprise preferences regarding states of the world, or functional representations thereof, such as utility, profit, or welfare functions, and, depending on the context of inquiry, also endowment, information, and choice procedure. Admittedly, the distinction between environment and decision makers as described may not be immediately obvious in all cases. A decision maker's skill set might be represented in their action set ('environment') or in their preference ordering over the possible outcomes of their actions ('individuality'). The standard approach in economics is to define different skill sets of agents as different 'types' of agents, where type is an individual trait. All agents' preferences are tightly connected with their types, implying that preferences can express differences in skill set while being defined independently of the environment (action sets), maintaining methodological individualism.

Current research further emphasises that analysing individual actions of decision makers in 'modern' markets with a large number of interactions between decision makers (e.g., word-of-mouth communication events and through social influence taking place) may entail a complex system displaying behaviour difficult to foresee, due to it being mathematically intractable and potentially chaotic (Foote 2007). This research utilises agent-based modelling and simulation instead of equilibrium analysis (for overviews, see Macal 2016; Rand and Stummer 2021) in accounting for heterogeneity, the decision makers' individual traits (e.g., their preferences), and their individual embeddedness in a social network of peers. All the while, these methods track individual experiences made

[4] Although some scientists do operate with such a view, we note that methodological individualism (understood as the view that social phenomena must be explained by the actions of individuals) is a controversial theoretical commitment that has received much philosophical attention (e.g., Zahle and Kincaid 2019; Heath 2020). Our impression is that no such commitment is necessary for epistemic success in individualisation/individualised science in general. However, this claim needs to be worked out in detail and defended in a different paper.

during the course of the interaction (e.g., an individual's decisions and the observation of the reaction of others in response to these decisions). Frequently, this research observes that the combination of prior heterogeneity and individual experience drives the decision makers' individuality, understood as the motives behind their decisions, their preferences, information, choice procedure, and funds (endowment).

Indeed, in relation to research in economics and management, *individuality* amounts to the aggregate of qualities and characteristics of an individual relevant to decision making. For example, Davis (2015, p. 76) states that "individuality ... is the utility function representation of the individual" (and similarly in Davis 2003, 2010). Approaches that are more general would also allow for endowment, information, and choice procedure to contribute to a decision maker's individuality (Davis 2003).

Since 'individualisation' is not a theoretical term in economics and management, we offer two operationalisations. According to the first, individualisation is the process by which an economic agent develops their own individual motives or qualities/characteristics relevant to decision making (e.g., by changing preferences or learning Bayesian updating), or perhaps the development of a specific or unique distinguishing feature relevant to their decision making. These describe a change of a decision maker's economic individuality that, along with experiences (including, for example, changing environments), has the potential to change the agent's decision-making behaviour.

According to the second, a third person treats a decision maker depending on their individuality, tailoring a specific action or material resource to their individual profile. Since individuality here is the aggregate of features relevant to decision making, most notably preferences, the decision maker is therefore treated explicitly in a way that is related to their individual preferences (wishes or needs). Consumers are heterogeneous in their behaviour and preferences; for example, how willing or reluctant a consumer is to try a new product greatly varies. This fact has pushed research away from the traditional abstraction of an average consumer who represents all. For bringing more realistic features and behaviours to modelling, individual differences make a difference.

Examples of individualisation in this second sense abound, specifically in management and business practice, as consumers frequently seek to find their individual needs and desires addressed by appropriate goods or services. An insurance firm, for example, might try to understand the differences between their consumers and offer tailored insurance premiums/contracts. While such tendencies were addressed early on with strategies such as product differentiation and market segmentation (Smith 1956), more recent developments—especially in information and communication technology—enable companies to offer even more individualised products and services to single

customers or groups of customers (Franke and Schreier 2010). In the literature, different terms are used to refer to this phenomenon, such as 'personalisation', 'customisation', or 'one-to-one marketing', which are often used synonymously with this sense of individualisation (Sunikka and Bragga 2008).

3. The Targets of Studies of Individualisation

The disciplinary perspectives in Section 2 reveal that scientists study quite diverse phenomena under the label of 'individualisation' and cognate terms, or when they characterise their field as individualised science (or as taking an individualised approach). The goal of this section is to provide an account that clarifies what the targets of these studies are. In Section 3.1 we ask 'What is individualisation?' and we distinguish different kinds of individualisation. Since studies of individualisation frequently refer to differences between individuals, in Section 3.2 we clarify what individual differences are and what kinds of individual differences various disciplines study. We also explain why individual-environment interactions are central to understanding how individual differences arise and change over time.

3.1 Three Kinds of Individualisation

One major kind of individualisation is the process that gives rise to or changes individual differences in a population or group. We call this sort of individualisation process *Individualisation*$_{ONE}$ (in short, 'individualisation as creating/changing individual differences'). Oftentimes, Individualisation$_{ONE}$ leads to an increase of individual differences, that is, as one or more individuals in a group (or species) become more different from each other (more on the quantification and operationalisation of individual differences in Section 3.2). Not all individualisation processes, to be sure, involve an increase in the total number of extant individual differences; some only change the ways in which individuals differ from each other, without raising the amount of differences. The traits in which individuals differ from each other can be of various sorts (more in Section 3.2). Individualisation processes can occur in different life phases of an individual, not only during initial development. Individualisation$_{ONE}$ is the focus of individualisation research in disciplines such as biology and psychology, but it also plays a role in sociology (e.g., in social structure analysis and gender studies), economics (e.g., when studying how economic individuals develop distinguishing features relevant to them being decision makers), and medicine (e.g., when investigating individual differences in the courses of a disease).

Examples of Individualisation$_{ONE}$ include the biological processes of how the individual colour patterns of fire salamanders develop and of how the behavioural and

hormonal phenotype of a male guinea pig is shaped by his social environment during adolescence. Psychological examples include how individual psychological/personality differences arise from and give rise to differential reaction to circumscribed situations. Sociological examples include how changing social norms and for instance varying family structures give rise to variable expressions of masculinity and fatherhood.

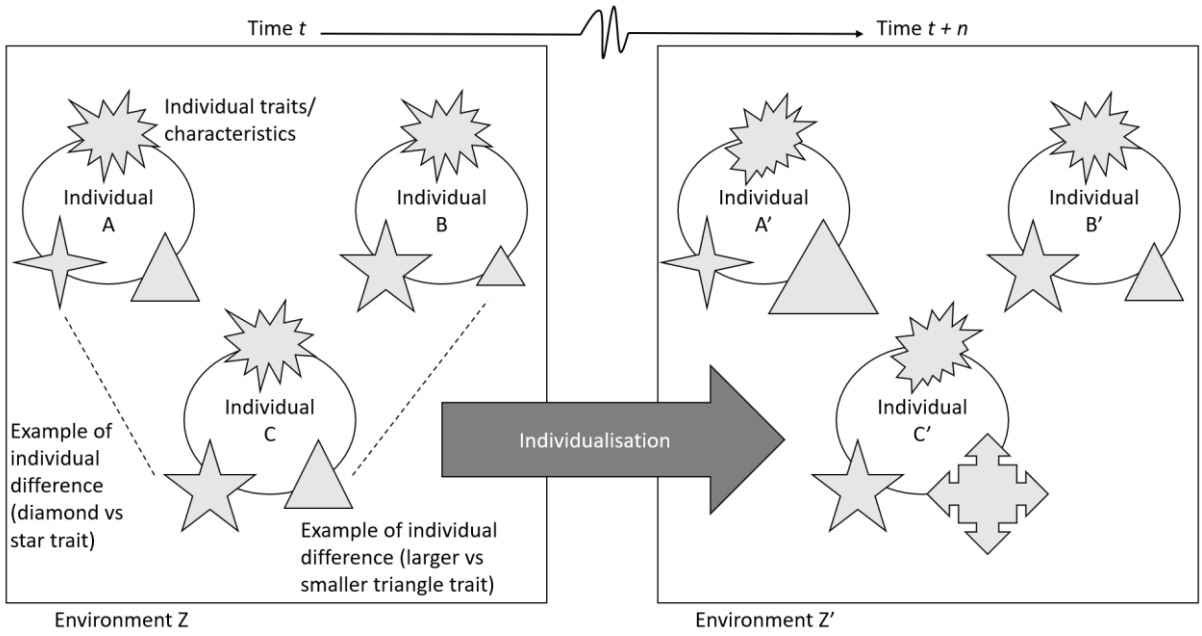

Figure 1. Individualisation$_{ONE}$, the process that gives rise to or changes individual differences (i.e., 'individualisation as creating/changing individuals differences'). In this example, individuals A' and B' underwent increases in their (differently sized) triangle traits, individual A' and C' underwent modification of their lightning traits, while C' also underwent the (radical) modification of a trait resulting in a qualitatively unique trait. Individualisation occurs in environments (Z → Z'), although specific environmental features and relations with individuals are not represented for simplicity's sake.

Other research inquiries are not concerned directly with the processes that give rise to or influence individual differences, but rather consider the phenomenon of individual differences explicitly in proffering individualised medical/psychiatric treatments, health recommendations, information, commercial products, marketing strategies, and the like. We characterise this second kind of individualisation, *Individualisation*$_{TWO}$, as the process of tailoring or adjusting interventions, goods, and services to the individual at hand and to its distinguishing features (in short, 'individualisation as individualising applications'). Individualisation$_{TWO}$ thus builds on information about individual differences. Whereas Individualisation$_{ONE}$ is the process leading to individual differences (by creating or changing them), Individualisation$_{TWO}$ starts from existing individual differences and makes epistemic use of them in contexts of application—by creating interventions,

goods, and services that are individualised in the sense of being tailored to those traits of individuals that distinguish them from others. This is why these sciences refer to themselves as individualised or personalised, such as 'personalised medicine'. Disciplines such as medicine and psychiatry, public health and sport/exercise science, and management are thus more concerned with Individualisation$_{TWO}$. The primary interest of individualisation research in these fields is to gain and use information about individual differences, for instance, to design personalised treatments of diseases, develop individualised nutrition recommendations, and address the individual needs and desires of consumers by way of individualised offerings.

Examples from marketing and business practice of Individualisation$_{TWO}$ include the tailoring of insurance premiums/contracts to individual risks and preferences and the tailoring of online advertising and search results to the search history, characteristics, and preferences of individuals. Medical/health examples include the tailoring of HIV treatment (viz., the screening of HIV patients for the genetic variant associated with a toxic reaction to Abacavir), the tailoring of exercise training regimes to the fitness level or sex of individuals, and the tailoring of advice pertaining to alcohol consumption to the needs of individuals. Moreover, Individualisation$_{TWO}$ is also discussed in more applied areas of other disciplines, such as in psychology (e.g., individualised psychotherapy) and biology (e.g., individualised animal welfare; Richter and Hintze 2019). Given that individualisation$_{ONE}$ and Individualisation$_{TWO}$ may sometimes both be at stake in a discussion, it is useful for clarity's sake to explicitly distinguish these.

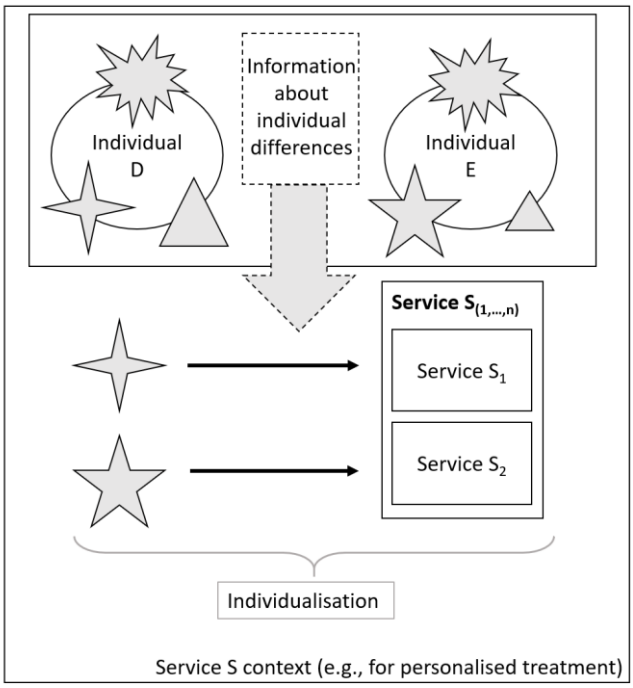

Figure 2. Individualisation$_{TWO}$, the tailoring of interventions, goods, or services

As mentioned above, Individualisation$_{TWO}$ (i.e., individualising applications) requires information about individual differences. One might go further and argue that it is likely to be more accurate or efficient when it also incorporates knowledge about the process of how individual differences arise and change over time, that is, knowledge about individualisation$_{ONE}$. This is plausible in many cases. For instance, knowledge about how the specific social environment of a person influences their drinking habits and makes them different from others is crucial for developing personalised assessments and health recommendations (public health). Likewise, the successful development of individualised treatments for type 2 diabetes requires knowledge about individual differences on several levels (e.g., molecular, pathophysiological; see, e.g., McCarthy 2017), but it might also be important to understand how these individual differences emerge and which roles (for instance) certain genes or environmental factors play. Hence, knowledge about individualisation$_{ONE}$ stands to influence Individualisation$_{TWO}$.

In turn, Individualisation$_{TWO}$ may also influence Individualisation$_{ONE}$. For instance, individualised medical treatment or psychotherapy could in principle decrease or increase individual differences or change the ways in which individuals differ from each other. Likewise, creating goods that are tailored to distinguishing features of individuals (e.g., devices that are individualised by the set of apps that they have pre-installed) may lead to a greater diversification of people's device usage behaviour, to a greater homogenisation, or to a change in the ways that people differ from each other. Moreover, through individualised applications, researchers may also better understand the development of these individual differences.

Within the broader discipline of sociology, sociological individualisation theorists utilise 'individualisation' as a term of art, to pick out the ways in which shifts from traditional ways of living to modern ways affect autonomy, risk, and social responsibility (Beck and Beck-Gernsheim 1994, 2002). This third kind of individualisation is the result of a process of social change: individuals break away from the bonds of close groups and become dependent on more distant or even anonymous social forces, leading to greater individual freedom but also greater individual responsibility—possibly, but not necessarily, amounting to greater individual differences. We call this *Individualisation$_{THREE}$* (in short, social changes influencing autonomy, risk, and responsibilities). Even though it is an important and influential concept (and kind) of individualisation, it is much less relevant to the recent trend across scientific fields to study individualisation specifically in terms of individual differences. The reason for this is that, in theory, Individualisation$_{THREE}$ could occur in a group or society with no or minimal individual differences among the group members; theoretically, new freedoms and responsibilities in a society need not covary with individual variation if their uptake is uniform across a society.

Contrary to the other two kinds of individualisation, Individualisation$_{THREE}$ is thus not necessarily related to individual differences. It is to be contrasted with a constrained sense of individual autonomy/freedom/risk, rather than with individual homogeneity. In the remaining sections of this article we therefore focus on the first two senses of individualisation. This does not imply, however, that we ignore sociology. Section 2.4 clearly shows that sociologists are interested in individuality in terms of individual differences (e.g., with respect to gender and life course), and are indeed studying individualisation$_{ONE}$, whether or not their work is couched in the framework of sociological individualisation theory (Individualisation$_{THREE}$).

3.2 Individual Differences and Individual-Environment Interactions

Individual differences are based on any characteristic or trait of an individual that varies in a species, population, or group. This is why individual differences are also referred to as 'intraspecific differences' or 'intraspecific variation'. These varying traits can be genetic, morphological, or physiological traits (biology, medicine), personality traits including behavioural and experiential—motivational, affective, cognitive—differences (psychology), preferences (economics), expression of socially recognised constructions, e.g., masculinity/fatherhood (sociology), health determining factors (public health and sport/exercise science), disease traits (medicine), and so on. Different disciplines focus on different aspects of the individual and on different kinds of traits or characteristics given their varied research questions, methods, and goals.

There is not only a diversity of kinds of traits of an individual that are studied. In addition, one kind of trait may also be operationalised and measured differently. In Section 2.5, five different operationalisations of Individualisation$_{ONE}$ processes are distinguished (psychology). They specify different ways in which psychological differences can increase: the differences in one trait among individuals increase, an individual develops a rare or more 'exotic' trait, an individual develops an extreme level of a normal trait, individuals develop unique combinations of traits (and of levels of traits), and individuals develop particular self-related processes. Except for the last one, when investigated purely qualitatively, these operationalisations allow scientists to quantify individualisation$_{ONE}$ (at least in principle) and thereby make claims about whether individual differences have increased or decreased, and to circumscribe these claims as about individual differences of a particular nature. These quite general ways to operationalise and quantify psychological Individualisation$_{ONE}$ may be fruitfully applied, *mutatis mutandis*, in other disciplines, for instance biology (more on this in Section 4.2).

When seeking to understand the process that gives rise to or changes individual differences in a group or population (i.e., Individualisation$_{ONE}$), scientists investigate how the traits of individuals (including their internal aspects, such as hormones, epigenetics, or immune system) change through individuals' interactions with the environment. Biologists, for example, investigate how the behavioural and hormonal phenotype of a male guinea pig is shaped by his interactions with other individuals that constitute his social environment. Psychologists study how much and by means of which processes the motives, interpersonal styles, and self-concepts of individuals change and stabilise in response to different life events, role transitions, occupational and relationship choices, and aging. Likewise, sociologists study how (conceptualisations of) gender differences are shaped by, for instance, the behavioural expectations of other individuals. Economists investigate how decision makers interact with each other and thereby influence their beliefs and constrain their available actions and the decisions they make.

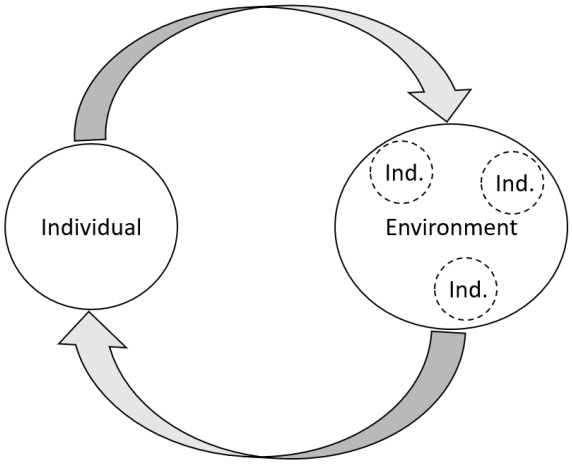

Figure 3. Individual-Environment Interactions. The individual acts on the environment, and the environment influences the individual (see, e.g., Levins and Lewontin 1985). An environment can include other individuals ('Ind.') and thus be a social environment or include a social component.

Even though all disciplines studying Individualisation$_{ONE}$ examine individual-environment interactions, only a few of them might often explicitly use the term 'environment'. It is more common in some disciplines to speak of studying individuals in situations (psychology), while others focus on individuals as being socially integrated/situated and embedded in society (sociology). Some disciplines take into account only specific environmental factors, such as other decision makers, the actions available to them, and the like (economics) or health/disease determining factors (public

health/medicine). Still, on a general level, all disciplines seek to understand how individual differences result from the interactions of individuals with features of their environments.

4. Relating Individual Differences to Individuality

In the previous section we argued that most recent studies of individualisation focus on two distinct kinds of individualisation, both characterised with reference to individual differences. Individualisation$_{ONE}$ is the process that gives rise to or changes individual differences, whereas Individualisation$_{TWO}$ uses information about individual differences to tailor interventions, services, or products to individuals. Section 2, however, indicates that in several disciplines the term 'individuality' is used besides 'individualisation'. This raises the question of how individualisation and individual differences are related to individuality. In the philosophy of biology there is a long-standing debate about biological individuality and some recent philosophical work on how individuality relates to individual differences. We will thus start from there (Section 4.1) and then take into account the other disciplines and generalise our theses (Section 4.2).

4.1 Biological Individuality

Philosophical discussions of biological individuality typically concern what a biological individual *is* (Clarke 2010; Pradeu 2016; Lidgard and Nyhart 2017; Kaiser and Trappes 2021). Participants in this discussion seek to detect properties or processes that are necessary or sufficient for something to be a biological individual, or that can tell us how to distinguish an individual from its environment or from groups of individuals or parts of individuals.

Identifying such properties and processes turns out to be extremely difficult. The living world is very heterogeneous, and there are many entities—alleged 'individuals'—that lack features that we ordinarily might think were necessary (e.g., ant colonies lack a clear-cut outer boundary; the green algae in a lichen lacks functional autonomy or independent survival from the fungus), and cases where it is hard to decide whether something satisfies our definition. These 'problem cases', ranging from bacterial assemblies and vegetal plant colonies, to mammalian pregnancy, symbiotic associations and holobionts, have been a major source of the philosophical debate on biological individuality.

Despite ongoing debate, there are some points of agreement. Many philosophers distinguish several kinds or dimensions of individuality depending on the type of property or process considered relevant (Godfrey-Smith 2009; Pradeu 2016; Love and Brigandt 2017; Lidgard and Nyhart 2017; Bueno et al. 2018). For instance, from an evolutionary perspective, individuals are conceptualised as the units of natural selection. Thus,

evolutionary individuals are members of a population displaying phenotypic variation, heritability, and differential fitness. Evolutionary individuality, then, is determined by mechanisms that promote between-individual selection (Clarke 2012, 2016). In contrast, immunological individuality depends on the activity of immune systems; individuality is delineated by the rate of immunological reactions to self and non-self tissue. Roughly, something is a proper part of an individual just in case it is actively tolerated by its immune system (Pradeu 2010, 2012). Metabolic individuality can be understood as the ability to resist decay through ongoing metabolic processes (Godfrey-Smith 2013). Although non-equivalent, each is a legitimate concept that refers to a different kind of individual, facilitating conceptual pluralism (Pradeu 2016).

Kaiser and Trappes (2021) argue that studies of individual differences and individualisation in ecology, evolution, and animal behaviour reveal an additional kind of biological individuality, which can be called phenotypic-ecological individuality (see also Trappes 2021, 2022). Phenotypic-ecological individuality concerns the way individuals differ from one another and are unique in their phenotype (including behaviour) and ecological relations (i.e., interactions with the environment). Phenotypic and ecological uniqueness means that an individual possesses a unique set of phenotypic traits and ecological relations, not necessarily that it has unique traits/relations that it shares with no other individual. The main claim is that 'being unique' (i.e., having a unique set of phenotypic traits and ecological relations) and 'being different from other individuals' is one way of exhibiting biological individuality and thus of being a biological individual (Kaiser and Trappes 2021; Trappes 2022).

Based on this claim we can argue that Individualisation$_{ONE}$ processes that create or change individual differences in a group or population also change the (phenotypic-ecological) individuality of individuals. An increase in individual differences also increases (phenotypic-ecological) individuality. It does so either by increasing the extent to which individuals differ from one another in their phenotype and ecological relations or by increasing the ways in which individuals differ. However, both sorts of increases might be difficult to measure because it presupposes quantifying many different phenotypic traits and ecological relations and weighing them against each other.

4.2 Individuality Across Disciplines

In this section, we expand upon the previous case from philosophy of biology and generalise our argument. We ask: Does the relation between individual differences, Individualisation$_{ONE}$ and (biological) individuality also hold more generally? Is it plausible

to claim, in general, that being different from other individuals is one way of exhibiting individuality and of being an individual?

The kinds of individual differences studied vary widely from discipline to discipline (recall Section 3.2). Biology investigates a wide spectrum of traits (and ecological relations or interactions with the environment), ranging from genetic, physiological (hormonal and immunological) traits, morphological features, to behavioural traits; even animal personality traits. Any kind of trait or ecological relation that influences the fitness of an individual is in principle of interest to biologists. Other disciplines are interested in other traits or aspects of individuals and foreground other interactions with other parts of the environment.[5] Public health, for example, focuses on the health of individuals and health-determining factors, especially of the built-material and social environments. Medicine/psychiatry focuses on diseases of individuals and disease-determining intrinsic and environmental factors. Economics focuses on economic agents—decision makers—and on the actions that are available to them and the rational decisions that they make. Personality psychology focuses on psychological traits and factors influencing them. Sociology focuses on social structures and the individuals within that are socially recognised as autonomous subjects.

In the previous section we introduced the claim that being different from other individuals is one way of exhibiting biological individuality and of being a biological) individual (Kaiser and Trappes 2021). We think that this claim can be generalised and applied to the other disciplines as well. Being different from other individuals is one way of exhibiting individuality and of being an individual. We refer to this sort of individuality as 'individual-differences individuality'. It is this kind of individuality that the different disciplines are concerned with when they study how individual differences arise or change ($\text{Individualisation}_{\text{ONE}}$) or when they practice individualised science ($\text{Individualisation}_{\text{TWO}}$).

Still, even though the concept of individual-differences individuality applies to all disciplines, they have different conceptions of it;[6] that is, they focus on different sorts of individual differences (in individual traits and individual-environment interactions). Biology focuses on differences in phenotypic traits and ecological relations and thus is concerned with phenotypic-ecological individuality; public health studies the health of

[5] Outside of biology it seems more adequate to speak of individual-environment interactions or relations, rather than of ecological relations of the individual. The reason is that 'ecological' seems to refer only to a subset of the diverse environments, situations, or contexts that are studied in the different scientific disciplines.

[6] We adopt the concept/conception distinction commonly mentioned in discussions of conceptual pluralism (e.g., Currie and Killin 2017) and in moral and political philosophy (e.g., Rawls 1971). For example, two theorists might agree on the concept of (say) moral flourishing, yet have different conceptions of what it amounts to: One might think it is in maximising happiness, another in virtuous action.

humans and health-determining factors and thus is concerned with health-related individuality; medicine and psychiatry focus on medical/psychiatric diseases and disease-determining factors and thus are concerned with disease-related individuality; economics focuses on the agency, rational decision making and action sets of individuals and thus conceives of decision-making individuality; psychology investigates psychological personality traits and, for instance, how individuals react to situations, and thus are concerned with what can be called personality individuality; sociology is interested in the autonomy of individuals and in the process of socially recognising subjectivity and thus is concerned with social individuality (Figure 4). We should emphasize that, probably, these different disciplinary conceptions of individual-differences individuality are only one way of conceiving of individuality in a specific discipline. Similar to biology which studies a plurality of kinds or dimensions of biological individuality (recall Section 4.1), other disciplines might also study different kinds of individuality, conceive of individuality differently, and/or come up with different concepts (or conceptions) of health-related, medical, economic, psychological, or social individuality. Figure 4 thus represents only a partial conceptual landscape for individuality.

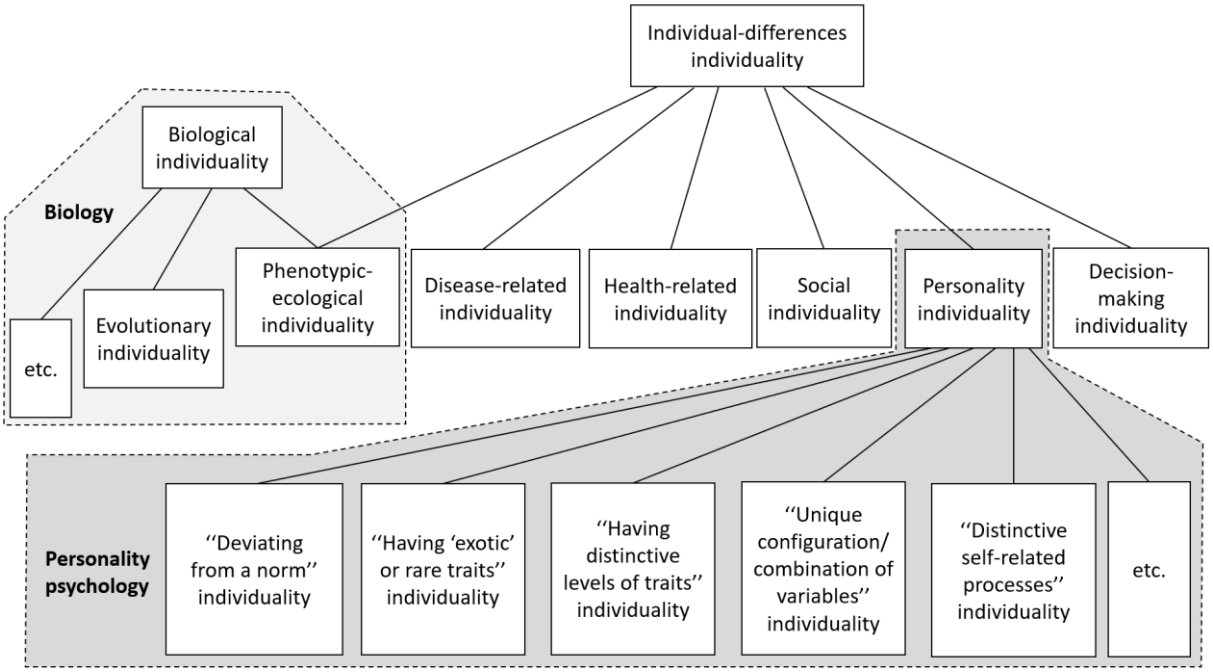

Figure 4. Partial conceptual landscape for individuality.

Interestingly, in some disciplines there might be another level of plurality of individuality concepts/conceptions. Psychology presents an illustrative example. Here we find different conceptions of the concept of personality individuality (which is itself a

conception of the concept of individual-differences individuality). Individualisation$_{ONE}$ processes in psychology can be operationalised in different ways (see Table 1 in Section 2.5). Individuality, for example, could be understood technically as deviating from a norm, as having 'exotic'/rare traits, as having distinctive levels of traits, in terms of unique configuration or combination of traits, or as exhibiting self-related (perceptual and cognitive) processes. Accordingly, individualisation and individuality can but need not be understood as an individual 'standing out'. As explained in Section 4.1, biologists often conceive of individual differences in terms of unique sets of phenotypic traits and ecological relations of individuals. This is close to the fourth operationalisation of individualisation in terms of unique entire configurations or combinations of traits.[7] For other disciplines, such as biology, it might be fruitful to apply these different operationalisations/conceptions of personality individuality to extend or enrich their studies of individual differences. For example, biologists could conceive of individual differences and phenotypic-ecological individuality not only in terms of unique sets of traits but also focus on the rareness of traits or distinctive levels of traits.

5. Conclusion and Prospects for Future Research

This paper provides a conceptual-theoretical basis for the interdisciplinary study of individualisation. Hence, this paper is an instance of philosophy *in* science (Pradeu et al. 2021) and seeks to make a significant contribution to studying individualisation/ individualised science. Moreover, this paper also provides novel philosophical insights into a prominent, yet still upcoming interdisciplinary scientific field that has not received sufficient philosophical attention so far. It thereby also contributes to existing philosophical debates concerned with individuality, individualisation, and individuals.

As the core of our conceptual-theoretical work, we distinguish three kinds of individualisation: Individualisation$_{ONE}$ is the process giving rise to or changing individual differences; Individualisation$_{TWO}$ is the tailoring of interventions, services, and products to individual differences; and Individualisation$_{THREE}$ is a special kind of social change that modifies autonomy and results in increases in responsibilities and risks. We reveal the interrelations between the first two kinds of individualisation and we explain the importance of studying individual-environment interactions when trying to understand how individual differences emerge and change (Individualisation$_{ONE}$). We argue that there is, in general, a close connection between individual differences and individuality because 'being different from others' is one way of expressing individuality. Finally, we identify a

[7] Still, some psychologists might not agree to the notion of phenotypic-ecological uniqueness if they have a narrower understanding of 'uniqueness' as referring only to the characteristics of a person that are shared with no other person (see Section 2.5).

plurality of individuality concepts/conceptions on different levels, within disciplines and across disciplines.

This paper presents only a first step in the philosophical analysis of interdisciplinary studies of individualisation. The disciplinary summary outlines in Section 2 raise more philosophical questions than the ones addressed in this paper. This is why we would like to conclude also by highlighting additional philosophical issues that are left open for future philosophical research. First, discussion of individualisation and individualised science provides a new context for the philosophical investigation of methodological individualism and other explanatory norms. Methodological individualism in the social sciences is characterised as the assertion that higher-level phenomena (e.g., social phenomena) must be explained in terms of the actions of individuals (Zahle and Kincaid 2019; Heath 2020). At first sight, this assertation seems at odds with the explanatory practices in studies of individualisation. The phenomena to be explained by way of individualisation research (e.g., how individual differences arise or change) are rarely higher-level phenomena. Still, the study of individual differences often requires studying groups of individuals or types of traits. Accordingly, explanations of individual differences may also be pitched at the level of groups of individuals or types of traits, and the assertion of methodological individualism might be reformulated to account for, or challenge, this. The extent to which individualisation/individualised science presupposes (or is hindered by) methodological individualism is an open philosophical question.

Second, individualisation is a promising concept for ongoing and future research in philosophy of science in practice. Such work could draw on existing distinctions and positions found within a discipline or research agenda—for example, within the debate over biological individuality—and use the methods and tools of philosophy of science to contribute. Discussions of metabolic individualisation, for instance, may help to make sense of transitions in individuality in mammalian pregnancy, and a concept of phenotypic-ecological individualisation might be useful for understanding how ecological associations arise and change over time. Recognising questions about individualisation thus broadens the problem agenda of (biological) individuality (Kaiser and Trappes 2021).

Third, in Section 3.2 we argue that the biological concept of individual-environment interactions can be used also in other disciplines to investigate Individualisation$_{ONE}$ processes. However, what the environment is, what the individual is, and which of its traits are most relevant (recall Section 4.2) differs from discipline to discipline. The different concepts of environment as well as how the disciplines demarcate the individual from its environment (e.g., biology and psychology assign behaviour to the individual, whereas economics characterise sets of available actions as

parts of the environment) are further interesting philosophical questions left for future research.

As the modern world 'individualises', we see shifts in the patterns underlying many domains. Take the provision of social health care and support, for example, which several years ago became highly individualised in various countries. In the case of Australia, this resulted in a poorly regulated, market-based 'cash for care' gig economy facilitated by the digital app environment, and understandably drew criticism (MacDonald 2021; Killin 2022). Or take the stratification methods of individualised medicine and psychiatry, which, in an individual insurance-based healthcare system, may lead to increased inequalities especially when stratification of, say, drug response, strongly correlates with ethnic categories (Kalow 2001; Johnson 2008; Abettan 2016). Philosophical analysis and critique of the consequences of individualisation (in its different guises) is a largely untapped priority for future research, and clearly has the potential for practical and political uptake.

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