CHANGing Consciousness Epistemically (CHANCE): An empirical method to convert subjective content of consciousness to scientific data

Daisuke H. Tanaka and Tsutomu Tanabe

Department of Pharmacology and Neurobiology, Graduate School of Medicine, Tokyo Medical and Dental University (TMDU), 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519 Japan.

Abstract

The content of consciousness (cC) constitutes an essential part of human life and is at the very heart of the hard problem of consciousness. The cC of an individual (e.g., study participant) has been examined *indirectly* by measuring the person's behavioral reports, bodily signs, or neural signals. However, these measures do not reflect the full spectrum of the person's cC. In this paper, we define a method, called "CHANging Consciousness Epistemically" ("CHANCE"), to consciously experience the cC that would be identical with that experienced by another person, and thus *directly* know the full spectrum of their cC. In addition, the ontologically subjective knowledge about a person's cC can be considered epistemically objective and scientific data. The CHANCE method comprises 2 empirical steps: (1) identifying the minimally sufficient, content-specific neural correlates of consciousness (mscNCC) and (2) reproducing a specific mscNCC in different brains.

Introduction

When a person is hungry and eats an apple, she may consciously experience something pleasant. When a person is hurt, he may consciously experience something painful. These subjective conscious experiences constitute a core part of human life and are central to properly understanding the nature of consciousness (Chalmers, 1995; M. Tye, 2018). This conscious experience is called "content of consciousness" (cC) [Koch, Massimini, Boly, and Tononi, 2016], and it appears to be similar to other commonly used terms such as "phenomenal consciousness," "*what it is like* aspect of experience," or "qualia". In this paper, the term "cC" is used synonymously with the aforementioned terms.

The cC arises from brain (Click and Koch, 1990; Craig, 2009; Dehaene and Changeux, 2011; Freeman, 2007; Koch, 2004; Lau and Rosenthal, 2011) and is ontologically subjective and qualitative (Searle, 1998), whereas the brain is ontologically objective and physical in nature. This fact raises an intriguing question, called the hard problem of consciousness (Chalmers, 1996): "How does cC arise from the brain?" Numerous scientific studies have been conducted in experimental psychology and cognitive neuroscience to reveal the neural basis of cC, through which significant insights have been elucidated (Dehaene and Changeux, 2011; Koch et al., 2016; Tsuchiya, Wilke, Frassle, and Lamme, 2015). By using typical experimental paradigms, researchers record and compare the elicited neural activity, based on whether individuals (e.g., study participants) did or did not experience a specific cC. A participant's cC is examined *indirectly* through a verbal report or by pressing a button in response to a "yes" or "no" question such as "Did you see a dot?" (see Figure 1a, thin arrow) [Del Cul, Baillet, and Dehaene, 2007; Lutz, Lachaux, Martinerie, and Varela, 2002; Ress, Backus, and Heeger, 2000; Sandberg, Timmermans, Overgaard, and Cleeremans, 2010; Super, Spekreijse, and Lamme, 2001; Tong, Meng, and Blake, 2006]. However, both of these reports (or more generally, behavioral reports) about a person's cC vary because of criterion shifts about what constitutes a "yes" response (i.e., having a cC) for a specific person, especially when the cC is at or near perceptual thresholds (Kunimoto, Miller, and Pashler, 2001). Some researchers additionally use confidence measures such as the "perceptual awareness scale" (Sandberg et al., 2010) in which responses range from "no experience" to "absolutely clear image" or a post-decision wagering [e.g., "Would you bet that your response was correct?" (Persaud, McLeod, and Cowey, 2007)] to gain accurate information about a person's cC (Kunimoto et al., 2001; Schurger and Sher, 2008). However, these confidence measures do not always match the person's behavioral reports about the cC (Kanai, Walsh, and Tseng, 2010). Hence, the optimal behavioral measures of the cC remain open to debate (Dehaene and Changeux, 2011).

In addition, behavioral reports demand various cognitive functions such as attention (Koch and Tsuchiya, 2007; Lamme, 2003), working memory (Soto and Silvanto, 2014), expectation (Kok, Rahnev, Jehee, Lau, and de Lange, 2012; Melloni, Schwiedrzik, Muller, Rodriguez, and Singer, 2011), and meta-cognition (Kanai et al., 2010). If the person experienced cC while these cognitive functions did not work, he or she would not report one's own cC; thus researchers may underestimate the putative neural activity underlying the cC. In addition, the neural activity underlying these cognitive functions is difficult to separate from those underlying cC (Cohen and Dennett, 2011; Koch et al., 2016; Tsuchiya et al., 2015), causing an overestimation in the putative neural activity underlying the cC. Taken together, behavioral measures do not fully reflect a person's cC and can cause both an underestimation and overestimation in the putative neural activity underlying the cC.

Several studies have assessed cC through bodily signs, such as pupil size (Frassle, Sommer, Jansen, Naber, and Einhauser, 2014), or through neural signals in the absence of behavioral reports (Garcia, Srinivasan, and Serences, 2013; Haynes, 2009; Horikawa, Tamaki, Miyawaki, and Kamitani, 2013; Nishimoto, Vu, Naselaris, Benjamini, Yu, and Gallant, 2011) [see Figure 1a, thin arrow]. These approaches can overcome some of the aforementioned problems in the report-based paradigm. However, they can also cause both an underestimation in the putative neural activity underlying the cC by missing percepts due to a no-report and an overestimation by including unconscious neural processing (Tsuchiya et al., 2015).

Furthermore, current methods, regardless of whether they are based on reports or no-reports, are limited to measuring a person's responses to a simple question (e.g., "Did you see a dot?") or to a simple stimulation (e.g., viewing a flower picture), consequently only providing limited cC information. No behavioral report, bodily sign, or neural signal reflects the full spectrum of a person's cC (Chalmers, 1996, 1999; Nagel, 1974; Velmans, 2007) [Figure 1a, open arrow]. Therefore, it is crucial for researchers to develop a novel method that can be used to accurately know a person's cC.

An ideal method for researchers to accurately know the person's cC is to consciously experience an identical cC. However, this idea begs both technical and philosophical questions: Can a cC be induced in a researcher so that it is identical with the participant's cC? Can the researcher's cC be considered scientific data? To address these questions and define a novel method to accurately know another person's cC, we first evaluated sufficient condition to be considered scientific data. We then defined a method, called "CHANging Consciousness Epistemically" ("CHANCE"), that changes subjective cC to scientific data. This method would induce the participant's cC in a researcher, and the researcher's cC that is identical with the participant's cC would offer scientific data.

One may argue that we propose a novel method of measuring a behavioral report, bodily sign, or neural signal with the guise of being *direct*. However, this is not the case, as we propose that the CHANCE method allows one to experience and *directly* know the cC of other individuals without using those measures. The CHANCE method does not demand any measures of a person's cC but provides researchers with conscious experience and knowledge about another person's cC.

The Content of Consciousness Can Become Scientific Data in Theory

Scientific Data are Epistemically Objective Data and Vice Versa

The sufficient condition to be considered scientific data was reviewed. Scientific data have been obtained by researchers who have devised techniques to obtain epistemically objective data, but not subjective ones (Chalmers, 1996, 1999; Descartes, 1644/1972; Galileo, 1623/1957; Searle, 1998; Velmans, 2007); thus, scientific data are epistemically objective data and vice versa. Therefore, if a cC was epistemically objective, it would be considered scientific data. It is widely believed, however, that the cC is epistemically subjective, but not objective, as researchers use behavioral reports, bodily signs, or neural signals as "readouts" to know a person's cC in scientific investigations (Figure 1a). On the other hand, the possibility that the cC can be changed from epistemically subjective to epistemically objective (Figure 1b) has not been investigated.

The Content of Consciousness Can Become Epistemically Objective

Epistemically objective and subjective entities have been considered qualitatively different from each other (Berridge, 1999; Berridge and Kringelbach, 2015; LeDoux, 2014; K.M. Tye, 2018). However, the subjective–objective distinction in the epistemic sense seems more blurred than what many have previously acknowledged. For example, researchers in one scientific laboratory may repeatedly conduct experiments to obtain data, whereas a specific researcher in another laboratory may conduct the same experiment only once. Most researchers would hopefully agree that, although the data obtained in each laboratory would be epistemically objective, the data obtained in the first situation would be more faithful to the facts (i.e., the truth). Therefore, this information would be the most epistemically objective of the two scenarios. This greater objectivity is because, in the latter situation, data may be obtained by chance or because of a specific researcher's subjective biases (i.e., personal beliefs or preferences). Thus, the epistemic objectivity of a datum (i.e., an entity) may exist in degrees (Reiss and Sprenger, 2017). In the epistemic sense, the terms "subjective" and "objective" may be at the opposite poles of the same axis, and most entities between these polarities have some degree of objectivity. These arguments against the common belief that an epistemically subjective entity is qualitatively different from epistemically objective one (Berridge, 1999; Berridge and Kringelbach, 2015; LeDoux, 2014; K.M. Tye, 2018) raise the possibility that the cC can be changed from epistemically subjective to epistemically objective and have a certain degree of epistemic objectivity, in theory.

An entity's degree of epistemic objectivity is reasonably assessed by individuals who have the ability to judge how faithful the entity is to fact (Reiss and Sprenger, 2017). For example, the faithfulness of scientific results is usually judged by scientists in relevant research fields (e.g., editors and reviewers of journals). In addition, each scientist's judgment is always achieved subjectively in the ontological sense (Vaerla,1996; Velmans, 1999). When a scientist observes experimental results or sees scientific data and judges how faithful they are to fact, the scientist consciously and subjectively does so in the ontological sense. Also, a large number of individuals judging the entity as fact results in a judgment of greater faithfulness towards the entity with respect to fact, and consequently greater epistemic objectivity. This argument is consistent with the "intersubjective agreement" in which a consensus among different individual judgments often indicates objectivity (Steup, 2018). Taken together, a specific entity would be epistemically objective if multiple relevant individuals subjectively judged it as fact in the ontological sense.

Based on this argument, even "*a cC* would be epistemically objective if multiple relevant individuals subjectively judged it as fact (i.e., as being true) in the ontological sense". This argument provides an intriguing idea to empirically convert a cC from being epistemically subjective to epistemically objective (Figure 1b). If a person's cC was to be changed from epistemically subjective to epistemically objective, it could be considered scientific data. To make this operational, a condition has to be fulfilled: multiple relevant (e.g. experts in the research field) individuals must subjectively judge the cC as fact in the ontological sense (Figure 1b).

A Method that Makes the Content of Consciousness Scientific Data

We define a method, called CHANGing Consciousness Epistemically (CHANCE), that enables a specific cC to be subjectively judged as a fact in the ontological sense by multiple relevant individuals; thus, it has changed from being epistemically subjective to epistemically objective and, therefore, scientific data (Figure 1b). The CHANCE method comprises 2 empirical steps: (1) identifying the minimally sufficient, content-specific neural correlates of consciousness (mscNCC) and (2) reproducing a specific mscNCC in different brains.

Step One: Identifying Neural Bases

Specific neural bases in the human brain are sufficient to produce a cC (Click and Koch, 1990; Craig, 2009; Dehaene and Changeux, 2011; Freeman, 2007; Koch, 2004; Koch et al., 2016; Lau and Rosenthal, 2011; Tononi and Koch, 2015). Koch et al. (2016, p. 308) argued that "the neurons (or, more generally, neuronal mechanisms), the activity of which determines a particular phenomenal distinction within an experience" are the content-specific neural correlates of consciousness (NCC). Chalmers (2000, p. 31) defines an NCC for a cC as follows: "An NCC (for content) is a minimal neural representational system *N* such that representation of content in *N* is sufficient, under condition *C*, for the representation of that content in consciousness." Inspired by these concepts, we assumed there exists a neural event that is minimally sufficient to produce a specific cC without any other support mechanisms. We named the event mscNCC [Figure 2a, Step 1]. When an mscNCC occurs in a person's brain, he or she should experience a specific cC in all possible instances and conditions; however, even without the mscNCC, the person may still experience the cC through neural events other than the mscNCC. An mscNCC is sufficient on its own to produce a specific cC without any other support mechanism. This appears to be in contrast with Chalmers' NCC (for content) [Chalmers, 2000, pp. 25-26] which asserts that "nobody (or almost nobody) holds that if one excises the entire inferior temporal cortex or intralaminar nucleus and puts it in a jar, and puts the system into a relevant state, it will be accompanied by the corresponding state of consciousness." We claim that if an mscNCC that produces a specific cC were isolated from the human brain and put in a jar, it would still produce the cC. An mscNCC alone is essentially truly sufficient to produce a specific cC in all possible instances and conditions. An mscNCC produces only 1 specific cC. To ensure that an mscNCC is minimal, each neuronal, synaptic, and molecular event — or more generally, a neural event comprising the mscNCC — should be tested to determine whether it is indeed necessary to produce the specific cC.

One may argue that a few consciousness researchers, except for proponents of panpsychism (Koch et al., 2016; Tononi and Koch, 2015), would assume that an mscNCC can still produce a cC if it is isolated from the human brain and put into a jar. This argument may mostly originate from intuition or common sense. Many consciousness researchers would likely agree that, if a whole human brain were put in a jar and activated appropriately, the brain would produce a cC. In this condition, not all neural events in the brain would be necessary to produce the cC; hence, the unnecessary neural events could be removed from the brain. By repeated removals, only the mscNCC would ultimately remain in the jar and still produce a cC. Therefore, it is not that unrealistic to assume that an mscNCC in a jar produces a cC.

To empirically identify an mscNCC, the relevant neural events need to be empirically induced with high spatiotemporal resolution, whereas the effects of the induction on a cC need to be subjectively experienced in the ontological sense by a researcher or individual who intends to evaluate the effects. Thus, the brain of a researcher or individual who intends to evaluate the results needs to be empirically manipulated in the experiment. The results obtained by the experiment would be a cC, and only available to the researcher or individual whose brain was manipulated. Therefore, those results would be epistemically subjective (Figure 2a, Step 1). This epistemically subjective result would make the experiment nonscientific. However, this methodological limitation would not decrease the confidence obtained by each participant who evaluates cC-containing results, compared to standard scientific results, because both methods would provide ontologically subjective knowledge and confidence for each individual. The relevant neural events would be viewed as an mscNCC, if the following conditions are verified: (1) a researcher or individual whose brain is manipulated experiences only 1 specific cC, when the relevant neural events are induced (i.e., verification of *sufficiency*) and (2) a researcher or individual whose brain is manipulated does not experience the specific cC when any neural event among the relevant ones is inhibited, even if all other neural events among the relevant ones are induced (i.e., verification of *minimality*). The manipulated individual should experience and know a specific cC when a specific mscNCC occurs, regardless of whether *any other neural events* occur. Once an appropriate mscNCC is identified, the occurrence of the mscNCC would indicate the production of a specific cC.

One may argue that it is unrealistic to verify the 2 aforementioned conditions for identifying an mscNCC and quite challenging to develop techniques verifying both criteria. Indeed, the neural events that are crucial in sustaining life, such as the neural events controlling respiration, may need to be inhibited transiently to test whether they are included in the mscNCC. For nonhuman animals, several interesting techniques have been developed to manipulate neural activities, such as combining optogenetics with modern methods in system neuroscience (Kim, Adhikari, and Deisseroth, 2017). However, their spatiotemporal precision seems to be insufficient to conduct the experiments necessary to verify both criteria. These are technical difficulties, rather than theoretical limitations, and may be overcome in the future.

One may also argue that it is implausible to assume that an mscNCC produces only 1 specific cC, but not other cCs because cCs are highly sensitive to context. For example, the brightness of 2 patches with identical absolute luminance is experienced differently when they are surrounded by different contexts (Adelson, 2000). However, this situation does not necessarily mean that a specific mscNCC produces 2 different cCs, depending on other neural activities. This situation is instead interpreted as follows: the brightness of patch A surrounded by context A is produced by a specific mscNCC, whereas the brightness of patch A surrounded by context B is produced by a different mscNCC. That is, the different brightness of identical patches in absolute luminance surrounded by different contexts is produced by the different mscNCCs. In other words, specific stimulus information (e.g., the absolute luminance of a patch) induces a specific mscNCC in a specific situation but induces another mscNCC in a different situation, depending on other information (e.g., surrounding context of the patch).

Still, some researchers may argue that the requirement of an mscNCC to establish the CHANCE method results in a circular argument: establishing CHANCE may enable a cC to be considered scientific data and lead to classification by neural bases. However, to establish CHANCE, one first needs to know what these bases are. This potential argument results from a lack of distinction between the degree of epistemic objectivity regarding the cC before and after the establishment of CHANCE. When using the CHANCE method, a cC is studied in an epistemically subjective (i.e., nonscientific) manner during Step 1 (Figure 2a); however, once both Step 1 and 2 in CHANCE are verified, a cC is studied in an epistemically objective (i.e., scientific) manner (Figure 2b). Thus, although epistemically subjective knowledge about the neural mechanism of a cC is used to establish CHANCE (Figure 2a, Step 1), once CHANCE is established, the epistemically subjective knowledge can then be converted to epistemically objective scientific knowledge (Figures 1b and 2b). Ontologically subjective cC becomes epistemically objective; thus, it would be considered scientific data (Figure 2b).

Step Two: Reproducing the Neural Bases in Different Brains

To test whether a specific mscNCC can be reproduced in different brains, sophisticated technologies first need to be developed that are capable of reproducing a specific neural event in different brains. For example, if the essential neural events of the mscNCC were specific activities in specific neural networks such as those in the Global Neuronal Workspace (GNW) [Baars, 1989; Dehaene and Changeux, 2011; Dehaene, Kerszberg, and Changeux, 1998], the same patterns of activation should be reproduced in different brains. The mscNCCs reproduced in different brains should be identical (Figure 2a, Step 2). To ensure that the reproduced mscNCCs are indeed identical, the precise identification of the neural events of the mscNCC — for example, specific neural or synaptic activity patterns — in the aforementioned Step 1 is crucial. Recent developments in noninvasive human brain-to-brain interface (Lee, Kim, Kim, Lee, Chung, Kim, and Yoo, 2017; Mashat, Li, and Zhang, 2017; Yoo, Kim, Filandrianos, Taghados, and Park, 2013) may aid in reproducing some neural events in different brains. However, current precision tools seem inadequate for reproducing potential neural events of an mscNCC such as GNW activity in different brains. Therefore, technical developments are needed to achieve this step.

Verification of the Two Steps Makes the Content of Consciousness Epistemically Objective

If the previous 2 steps are verified, then the occurrence of a specific mscNCC would produce a specific cC (Figure 2a, Step 1), and a specific mscNCC would be reproduced in different brains (Figure 2a, Step 2). Based on Leibniz's Law which states "that for anything *x* and for anything *y*, if *x* is identical with *y* then *x* and *y* share *all* the same properties" (M. Tye, 2018), the reproduced identical mscNCCs (i.e., the Step 2) should share *all* of the same properties, including the ability to produce the specific cC (i.e., the Step 1) [Figure 2b]. Thus, the reproduced identical mscNCCs should produce identical cCs in different individuals (Figure 2b). The relevant individuals who judge the faithfulness of the cC can then join the experiment. The identical cC that is shared and judged subjectively as a fact in the ontological sense by multiple relevant individuals can be considered epistemically objective (Figures 1b and 2b). Velmans accordingly argued that shared experiences among multiple individuals might be public and objective; "to the extent that an experience… can be *generally* shared (by a community of observers), it can form part of the database of a communal science" (1999, p. 304).

One may posit that it is unclear how it is possible to ascertain that a cC in multiple individuals does not vary by the influence of the surrounding unreproduced neural activity. This argument appears to arise from a misunderstanding of the Step 1, which focuses on the mscNCC that produces only 1 specific cC, regardless of the activity of any other surrounding neurons (Figure 2a, Step 1). Even if the surrounding unreproduced neural activity varied among individuals, these neural activities would not influence the cC produced by mscNCC because a specific cC can be entirely produced solely by a specific mscNCC under any other neural activity (Figure 2a, Step 1).

Some readers may suggest the need to demonstrate that the cC shared among multiple individuals is indeed identical. As mentioned previously, the equivalence of the cCs experienced and known by each individual is a logical consequence of the 2 steps in CHANCE and Leibniz's Law — namely, a specific mscNCC produces a specific cC, regardless of any other neural activity (i.e., the Step 1), and an identical mscNCC is reproduced in multiple individuals (i.e., the Step 2); thus, identical mscNCCs should produce identical cC (i.e., the logic of Leibniz's Law). Therefore, the identicalness of shared cCs among multiple individuals is logically plausible without the direct empirical demonstration of the equality.

One may argue that, in the scenario of an *inverted spectrum* (Block, 1980, 1990; Shoemaker, 1982), an mscNCC that produces red content in 1 individual can be identical to an mscNCC that produces green content in another individual. This argument can originate from misunderstandings of the Step 1 and Leibniz's Law: if a specific mscNCC produced a specific cC regardless of any other activities (i.e., the Step 1), then the identical mscNCCs reproduced in different brains should produce an identical cC (i.e., the logic of Leibniz's Law). Therefore, if the mscNCCs reproduced in 2 individuals are identical, and if an mscNCC in 1 individual produces red content, another identical mscNCC in another individual should produce red content, not green.

Discussion

The Degree of Epistemic Objectivity Judged by Relevant Individuals

The number of relevant individuals who judge a specific entity as fact affects the degree of epistemic objectivity of an entity (Figure 1). At least one factor that can facilitate judgment of a specific entity is its reproducibility; an experimental result that is duplicated in further experiments is considered as fact and epistemically objective, whereas an experimental result that is not reproducible may be considered as an artifact and not objective. An identical and shared cC (Figure 2b) is reproducible because the underlying mscNCC is reproducible (i.e., Step 2). The identical mscNCC necessarily produces an identical cC (i.e., Step 1 and Leibniz's Law), thereby supporting the idea that an identical cC shared by multiple relevant individuals would be epistemically objective (Figures 1b and 2b).

The degree of the epistemic objectivity of an entity has been reasonably judged by relevant individuals (Reiss and Sprenger, 2017). However, it remains unclear as to who would judge the degree of epistemic objectivity of shared identical cCs (Figure 2b). In addition, it is unclear how many relevant individuals are necessary to judge a cC as fact and what degree of epistemic objectivity is essential for a cC to be considered scientific data. We argue that it is essential to develop a standard for quantifying specific entities with regard to the degree of epistemic objectivity and develop a consensus on the degree of epistemic objectivity necessary to be considered scientific data.

An Answer to Nagel's Question and the Denial of the "Philosophical Zombie"

If an identical cC were shared among multiple individuals (Figure 2b), then scientists would be able to respond to Nagel's well-known philosophical question: "What is it like to be a bat?" (Nagel, 1974). The question indicates that "to know whether you, the reader, are conscious, I must know what it is like to be you" (Baars, 1996). This request implies that an observer (e.g., a researcher) should somehow share the cC of a subject (e.g., study participant) (Baars, 1996), which would be realized upon establishing CHANCE (Figure 2b). The researcher would share an identical cC with the participant and subsequently have "observer empathy" (Baars, 1996), knowing what it is like to be the other person. Thus, the researcher would know that the participant does not experience the *inverted spectrum* (Block, 1980, 1990; Shoemaker, 1982) and that the individual is not a *philosophical zombie* behaving normally without cCs (Chalmers, 1996).

Addressing Obstacles in First-Person Data

First-person data concerning the cC contain something that is excluded in heterophenomenology (Dennett, 1991, 2001) and in critical phenomenology (Velmans, 2007) but is centrally important to the nature of the cC (Chalmers, 2013). Chalmers (2013) claims that first-person data are accompanied by obstacles when they are used in the science of consciousness. He claims that "first-person data concerning subjective experiences are directly available only to the subject having those experiences" (2013, p. 32) and only *indirectly* available to others through their readouts (Figures 1a). However, if a person's cC is shared among others (Figure 2b), the first-person data concerning the cC would be *directly* available to them, making the first-person data concerning the cC nonexclusive. Chalmers also claims that current "methods for gathering first-person data are quite primitive" (2013, p. 33). If a person's cC is shared among others, then gathering first-person data would be unnecessary because the first-person data concerning the cC would be *directly* available to others (Figures 1b and 2b). He contends that the general formalism to express first-person data is lacking, but necessary, for data gathering and theory construction (Chalmers, 2013). Contrastingly, gathering first-person data would be unnecessary if a person's cC is shared, thereby removing the need for formalism. However, the development of formalism would be necessary to record, in writing, the results of experiments and to construct and describe a theory explaining the relationship between a cC and its underlying neural mechanisms. Therefore, epistemic objectification of a cC would overcome several, if not all, obstacles involving first-person data (Chalmers, 2013), and would open a new method to incorporate them in the science of consciousness.

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Author for correspondence Tsutomu Tanabe; Department of Pharmacology and Neurobiology, Graduate School of Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519 Japan; Tel +81-3-5803-5167; Fax: +81-3-5803-0122; e-mail: t-tanabe.mphm@tmd.ac.jp

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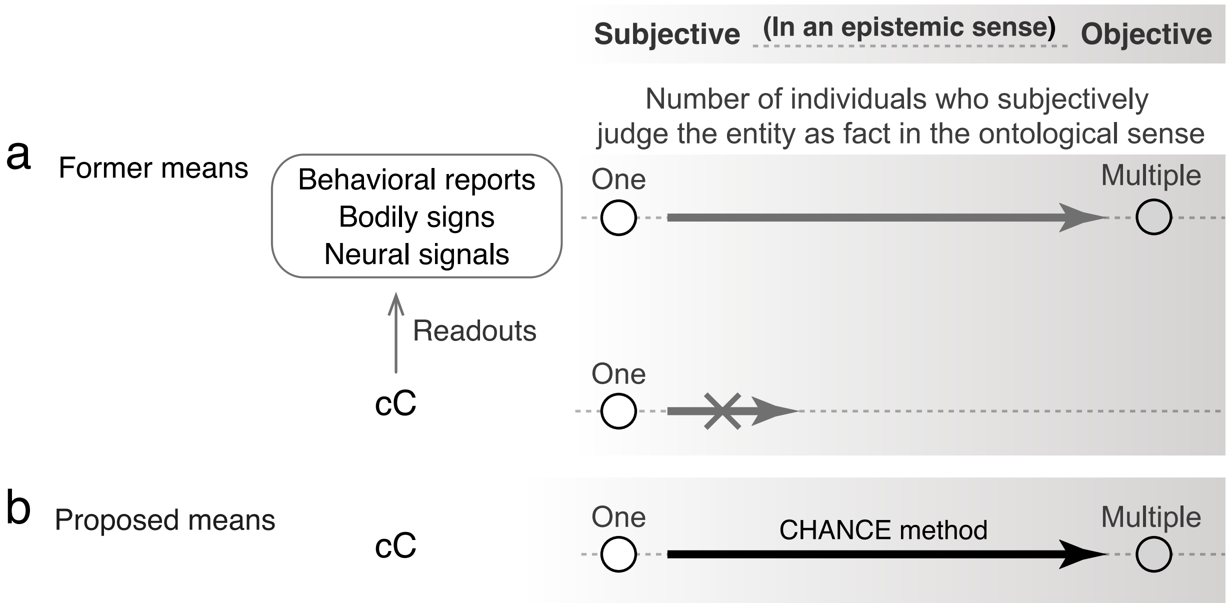

Figure 1. CHANCE method converts a cC from being epistemically subjective to epistemically objective.

(**a**) The former conventional means of addressing cC in science is depicted. The cC is judged as a fact only by the person of origin and is impossible to be objectified epistemically (bold lower arrow with the “X”). Behavioral reports, bodily signs, or neural signals are “readouts” of the cC (thin arrow). The data of the readouts are subjectively judged as fact in the ontological sense by multiple relevant individuals (e.g. experts in the research field); thus, they are considered epistemically objective and scientific data (bold upper arrow). However, no readout fully reflects the cC.

(**b**) A proposed means of addressing the cC is illustrated. The cC is empirically changed from being epistemically subjective to epistemically objective. If the cC is subjectively judged as fact in the ontological sense by multiple relevant individuals, then it would be considered epistemically objective and therefore, scientific data (bold arrow).

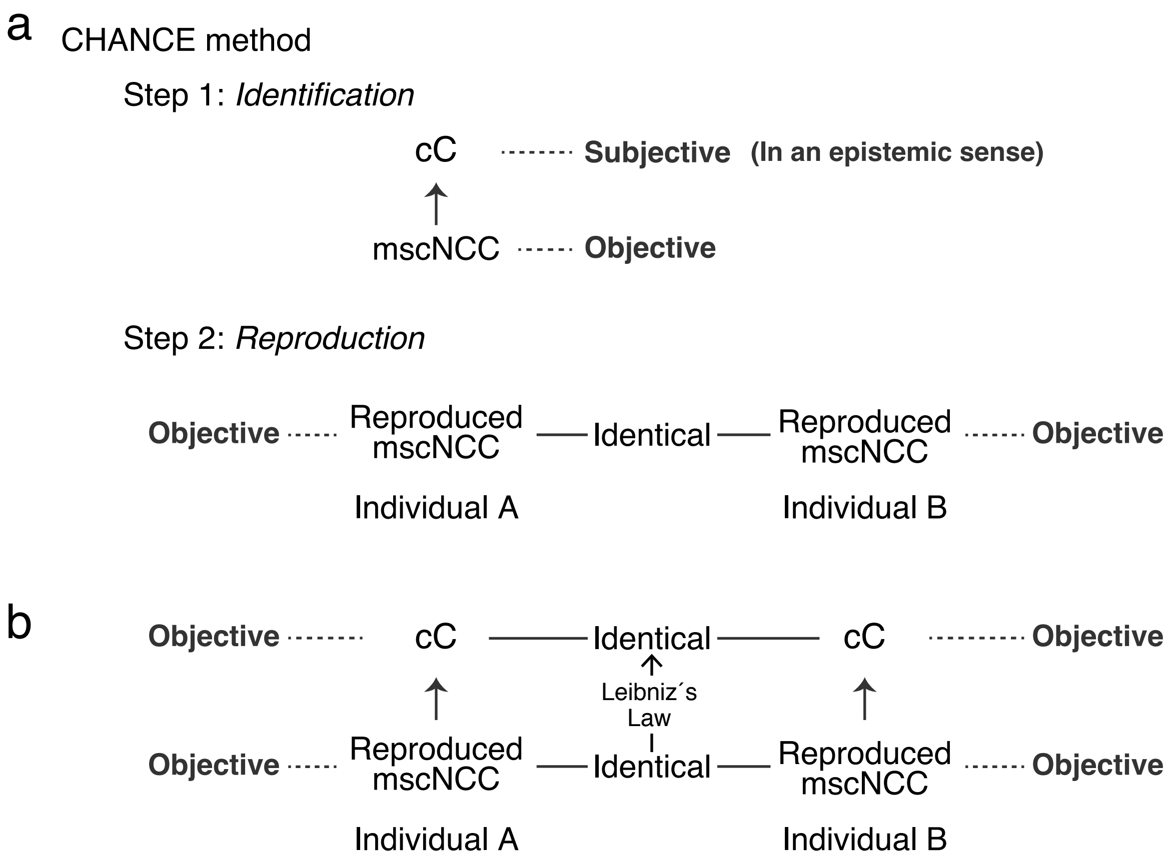

Figure 2. CHANCE method and a logical consequence of its establishment.

(**a**) The 2 steps in CHANCE is depicted. Step 1 involves identifying an mscNCC, defined as the minimum neural events that are sufficient to produce only 1 specific cC. An mscNCC itself is epistemically objective; however, a cC is epistemically subjective, making the experiments and the results obtained in this step nonscientific. Step 2 involves reproducing an mscNCC in different brains. The reproduced mscNCCs among different brains are identical. This step contains only the epistemically objective entity, the mscNCC; thus, experiments and the results obtained in this step are scientific.

(**b**) A logical consequence of the verification of the 2 steps in CHANCE (a). The mscNCC that produces a specific cC in Individual A is identical with the mscNCC of Individual B. The occurrence of the mscNCC in Individual B should produce the identical cC with that of Individual A as a logical consequence of the step 1, step 2 (a), and Leibniz’ s Law. An identical cC would be subjectively judged as a fact in the ontological sense by multiple individuals (i.e., Individuals A and B). If relevant individuals capable of judging the objectivity of the cC joined the experiment as participants, the shared identical cC would be considered epistemically objective, thus providing scientific data.