CHANGing Consciousness Epistemically (CHANCE): A method to fully know the content of consciousness of other individuals in scientific experiments

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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. In science, the cC of a subject (e.g., study participant) has been examined *indirectly* by measuring the subject's behavioral reports, bodily signs, or neural signals. However, these measures do not reflect the full spectrum of the subject's cC, which hampers an in-depth investigation of the cC and its neural basis. In this paper, we propose a method to consciously experience and *directly* know the full spectrum of the cC of other individuals in scientific experiments. The degree of epistemic objectivity of a specific entity has been reasonably judged by relevant individuals who have the ability to judge how faithful the entity is to fact. The epistemic objectivity of the entity is directly proportional to the number of relevant individuals who judge the entity as fact. Thus, even knowledge about a specific cC would be epistemically objective if multiple relevant individuals judged it as fact (i.e., as being true). We propose a method, called "CHANging Consciousness Epistemically" ("CHANCE"), to change the knowledge about a cC from being epistemically subjective to epistemically objective. The CHANCE method comprises two empirical steps: (1) identifying the minimally sufficient, content knowledge-specific neural correlates of consciousness (msckNCC) and (2) reproducing a specific msckNCC in different brains.

Introduction

When a person is hungry and eats an apple, he or she may consciously experience something pleasant. When a person is hurt, he or she 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 properties of experience," "*what it is like* property of experience" (Nagel, 1974), "raw feelings of conscious experience" (Ramachandran and Hirstein, 1997), or "qualia" (Peirce, 1866). In this paper, we use the term "cC" synonymously with the aforementioned terms.

The cC arises at least from the human brain (Click and Koch, 1990; Craig, 2009; Dehaene and Changeux, 2011; Freeman, 2007; Koch, 2004; Lau and Rosenthal, 2011). The cC is ontologically subjective and qualitative, 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, and they have made significant progress (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 subjects (i.e., study participants) did or did not experience a specific cC. Knowledge about subjects' cC is examined *indirectly* through their verbal report or by their pressing a button in response to a "yes" or "no" question such as "did you see a dot?" (Figure 1a, open 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, the behavioral reports) about a subject's cC vary because of criterion shifts about what constitutes a "yes" response (i.e., having a cC) for a specific subject, 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 "brief glimpse", "almost clear image," "absolutely clear image", or a post-decision wagering [e.g., "would you bet that your response was correct?" (Persaud, McLeod, and Cowey, 2007)] to examine knowledge about a subject's cC more accurately (Kunimoto et al., 2001; Schurger and Sher, 2008). However, these confidence measures do not always match subjects' behavioral reports about the cC (Kanai, Walsh, and Tseng, 2010). Hence, the optimal behavioral measures of a subject's 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), and the neural activity underlying these cognitive functions is difficult to separate from that underlying cC (Cohen and Dennett, 2011; Koch et al., 2016; Tsuchiya et al., 2015). Taken together, the behavioral reports do not reflect a subject's cC in its entirety and causes an 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) [Figure 1a, open arrow]. These approaches can overcome some of the aforementioned problems in the report-based paradigm, although they can cause difficulties such as missing percepts because of a no-report or because of the inclusion of 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 subject's responses to a simple question (e.g., "Did you see a dot?") or to a simple stimulation (e.g., viewing a flower picture) in typical experimental paradigms and therefore provide only limited information on the subject's cC. Thus, there are no means to address the cCs that are essential for human life, but which exist beyond any report, sign, and neural signals such as a feeling of selfhood and a raw feeling of well-being. Therefore, no behavioral report, bodily sign, or neural signal reflects the full spectrum of a subject'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 subject's cC and find its neural basis more precisely and extensively.

To scientifically develop a novel method of knowing cCs of other individuals with accuracy, we first needed to rethink what science can address with regard to subjectivity and objectivity. We then proposed a method, called "CHANging Consciousness Epistemically" ("CHANCE"), which changes knowledge about the cC from epistemically subjective to epistemically objective. This method would enable an individual to consciously experience and *directly* know the full spectrum of cCs of other individuals in scientific experiments.

Knowledge about cC can be changed from epistemically subjective to epistemically objective

Epistemic objectivity occurs in degrees

Scientists have invented and developed activities to address epistemically objective entities but not subjective ones (Chalmers, 1996, 1999; Descartes, 1644/1972; Galileo, 1623/1957; Searle, 1998; Velmans, 2007). Scientists seem to draw boundaries between epistemically objective and subjective entities, and believe that these entities are qualitatively different from each other (Berridge, 1999; Berridge and Kringelbach, 2015; LeDoux, 2014; K.M. Tye, 2018). However, the subjective–objective distinction seems more blurred than what many scientists acknowledge. For example, researchers in one scientific laboratory may repeatedly conduct an experiment to obtain a datum, 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 datum obtained in the first situation would be more faithful to the facts (i.e., the truth) and therefore the more epistemically objective of the two. This greater objectivity is because, in the latter situation, a datum 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 edges of the same axis, and most entities are in between and have some degree of objectivity.

The degree of epistemic objectivity is assessed by relevant individuals

The degree of epistemic objectivity of an entity is reasonably assessed by relevant 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, with respect to the facts and the degree of epistemic objectivity, is usually judged by leading scientists in relevant research fields (e.g., editors and reviewers of journals). In the example of an apple on the table, scientists and nonscientists may be able to judge its faithfulness to fact and epistemic objectivity. Depending on the entity of focus, relevant individuals who can judge its epistemic objectivity can change, and various factors may affect their judgment.

At least one factor appears to affect the degree of epistemic objectivity of a specific entity: the number of relevant individuals who judge the entity as fact. A large number of relevant individuals judging the entity as fact results in a judgment of greater faithfulness towards the entity with respect to fact, and thus greater epistemic objectivity of the entity. This argument is consistent with "intersubjective agreement" in which agreement among different subjects' judgments is often taken as indicative of objectivity (Steup, 2018). Taken together, a specific entity would be epistemically objective if multiple relevant individuals judged it as fact.

Knowledge about cC can be epistemically objective

Based on the fact that each individual's judgment is always achieved subjectively in the ontological sense, the aforementioned argument that "a specific entity would be epistemically objective if multiple relevant individuals judged it as fact" can be revised to "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 "*knowledge about the cC* would be epistemically objective if multiple relevant individuals subjectively judged it as fact (i.e., as being true) in the ontological sense."

This last argument provides an intriguing idea to empirically convert knowledge about the cC from epistemically subjective to epistemically objective: knowledge about cC can become epistemically objective, if multiple relevant individuals subjectively judged it as fact (i.e., as being true) in the ontological sense (Figure 1b). This assertion (Figure 1b) is notably in sharp contrast with the former ordinal means in scientific studies of cC (Figure 1a). In all such previous studies of cC, behavioral reports, bodily signs, or neural signals were used as "readouts" of the subjects' cC (Figure 1a, open arrow). The measures of these readouts were then judged as facts by multiple relevant individuals and were recognized as epistemically objective data (Figure 1a). Hence, a subject's cC was *indirectly* examined by measuring its readouts. However, the full spectrum of the subject's cC was not reflected in these readouts. If knowledge about a subject's cC were changed from epistemically subjective to epistemically objective, as proposed, it could be examined *directly* in science (Searle, 1998) [Figure 1b]. To make this operational, a condition has to be fulfilled: multiple relevant individuals subjectively judge the knowledge about the cC as fact (i.e., as being true) in the ontological sense (Figure 1b).

CHANCE: A method that makes knowledge about cC objective

We propose a method, called CHANging Consciousness Epistemically (CHANCE), which enables knowledge about a specific cC to be subjectively judged as a fact (i.e., as being true) in the ontological sense by relevant individuals, and changed from epistemically subjective to epistemically objective (Figure 1b). The CHANCE method comprises two empirical steps: (1) identifying the minimally sufficient, content knowledge-specific neural correlates of consciousness (msckNCC) and (2) reproducing a specific msckNCC in different brains.

Step one: identifying an msckNCC

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 their concepts, we assumed a neural event that was minimally sufficient to produce knowledge about a specific cC without any other support mechanisms: we named the event as "minimally sufficient, content knowledge-specific neural correlates of consciousness" ("msckNCC") [Figure 2a]. When an msckNCC occurs in a subject's brain, the subject should experience and know a specific cC in all possible instances and conditions; however, even without the msckNCC, the subject may still experience and know the cC through neural events other than the msckNCC. An msckNCC is sufficient on its own to produce knowledge about a specific cC without any other support mechanism, which seems to be in contrast with Chalmers' NCC (for content) [Chalmers, 2000]. Chalmers (2000, pp. 25-26) claimed 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 msckNCC were isolated from the human brain and put in a jar, it would still produce knowledge about a specific cC. An msckNCC alone is essentially truly sufficient to produce knowledge about a specific cC in all possible instances and conditions. An msckNCC produces knowledge about only one specific cC but not other cCs (Figure 2a). To ensure that an msckNCC is minimal, each neuronal, synaptic, and molecular event—or more generally, a neural event comprising the msckNCC—should be tested to determine whether it is indeed necessary to produce knowledge about a 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 msckNCC can still produce knowledge about 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 knowledge about a cC. In this condition, not all neural events in the brain would be necessary to produce knowledge about the cC. The unnecessary neural events could be removed from the brain. By repeated removals, only the msckNCC would ultimately remain in the jar and still produce knowledge about a cC. Therefore, it is not very unrealistic to assume that an msckNCC in a jar produces knowledge about a cC.

To empirically identify an msckNCC, the relevant neural events need to be empirically induced with high spatiotemporal resolution, whereas the effects of the induction on knowledge about a cC need to be subjectively experienced in the ontological sense by a researcher or individual who wants to evaluate the effects (Figure 2a). Thus, the brain of a researcher or individual who wants to evaluate the results needs to be empirically manipulated in the experiment. The results obtained by the experiment would be knowledge about a cC, and only available to the researcher or individual whose brain was manipulated. The results would therefore be epistemically subjective. 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, confidence, and judgment to each individual. The relevant neural events would be viewed as an msckNCC, if the following conditions are verified: (1) a researcher or individual whose brain is manipulated knows a specific cC, when the relevant neural event is specifically induced, whereas *any other neural events* are activated or inhibited (i.e., verification of *sufficiency*) and (2) a researcher or individual whose brain is manipulated does not know the specific cC when any neural event among the relevant ones is inhibited, whereas *any other neural events* are completely inhibited (i.e., verification of *minimality*). The manipulated individual should experience and know a specific cC when a specific msckNCC occurs, regardless of whether *any other neural events* occur. Once an appropriate msckNCC is identified, the occurrence of the msckNCC would indicate the production of knowledge about a specific cC.

One may argue that it is unrealistic to verify the aforementioned two conditions for identifying an msckNCC and quite challenging to develop techniques verifying both criteria. 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 msckNCC. For nonhuman animals, several interesting techniques have been developed to manipulate neural activities such as combining optogenetics and modern methods in system neuroscience (Kim, Adhikari, and Deisseroth, 2017). However, their spatiotemporal precision seems to be insufficient to conduct the experiments that would be necessary to verify both criteria. These are technical difficulties, rather than theoretical limitations, and may be overcome in the future.

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

Some researchers may argue that the requirement of an msckNCC to establish the CHANCE method results in a circular argument: establishing CHANCE may enable knowledge about a cC to be directly available in science and lead to a neural bases classification. 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 knowledge about the cC before and after the establishment of CHANCE. Knowledge about a cC is epistemically subjective before the establishment of CHANCE (Figure 2a), whereas this knowledge can become epistemically objective after implementing CHANCE (Figure 2c). When using the CHANCE method, knowledge about a cC is studied in an epistemically subjective (i.e., nonscientific) manner during the initial process (Figure 2a); however, once it is established, knowledge about a cC is studied in an epistemically objective (i.e., scientific) manner (Figure 2c). Thus, epistemically subjective knowledge about the neural mechanism of knowledge about a cC is used to establish CHANCE (Figure 2a). Once CHANCE is established, the epistemically subjective knowledge can be changed to epistemically objective scientific knowledge (Figures 1b and 2c). Ontologically subjective knowledge about a cC and its neural mechanism is epistemically objective; thus, it becomes scientific data (Figure 2c).

Step two: reproducing an msckNCC in different brains

The second step is to reproduce an msckNCC in different brains (Figure 2b). To test whether a specific msckNCC 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 msckNCC 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 msckNCCs reproduced in different brains should be identical (Figure 2b). To ensure that the reproduced msckNCCs are indeed identical, the precise identification of the neural events of the msckNCC—for example, specific neural or synaptic activity patterns—in the aforementioned first step 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 msckNCC such as GNW activity in different brains. Therefore, technical developments are needed to achieve this step.

Verification of the two steps makes knowledge about cC objective

If the previous two steps are verified, then the occurrence of a specific msckNCC would produce sufficient knowledge about a specific cC regardless of the existence of other mechanisms in the background (i.e., the first step) [Figure 2a], and a specific msckNCC would be reproduced in different brains (i.e., the second step) [Figure 2b]. Based on Leibniz's Law which states "the law 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 msckNCCs (i.e., the second step) should share *all* of the same properties, including the ability to produce the knowledge about a specific cC (i.e., the first step) [Figure 2c]. Thus, the reproduced identical msckNCCs should produce knowledge about identical cCs in different individuals (Figure 2c). The relevant individuals who judge the faithfulness of the shared knowledge about the identical cC can then join the experiment. Knowledge about the identical cC that is shared and judged subjectively as a fact (i.e., being true) in the ontological sense by multiple relevant individuals can be considered epistemically objective (Figures 1b and 2c). 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 data base of a communal science" (Velmans, 1999, p. 304).

One may argue that it is unclear how it is possible to ascertain that knowledge about a cC in multiple individuals is not varied by the influence of the surrounding unreproduced neural activity. This argument appears to arise from a misunderstanding of the first step, which focuses on the specific msckNCC that produces the knowledge about one specific cC, regardless of the activity of any other neural mechanisms (Figure 2a). Even if unreproduced neural events varied among individuals, these events would not influence the specific msckNCC-induced knowledge about the cC because knowledge about a specific cC can be entirely produced by a solely specific msckNCC under any other neural activity (i.e., the first step) [Figure 2a].

Some readers may suggest the need to demonstrate that knowledge about the cC shared among multiple individuals is indeed identical. As mentioned previously, the identicalness of the cCs experienced and known by each individual is a logical consequence of the first and second steps and Leibniz's Law—namely, a specific msckNCC produces knowledge about a specific cC, regardless of any other neural activity (i.e., the first step), an identical msckNCC is reproduced in multiple individuals (i.e., the second step); thus, identical msckNCCs should produce identical cC-containing knowledge (i.e., the logic of Leibniz's Law). Therefore, the identicalness of knowledge about shared cCs among multiple individuals is logically guaranteed without the direct empirical demonstration of it.

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

Discussion

The degree of epistemic objectivity judged by relevant individuals

We consider that the number of relevant individuals who judge a specific entity as fact appears to affect the degree of epistemic objectivity of an entity (Figure 1b). At least one factor that can facilitate judgment of a specific entity is its reproducibility: an experimental result that is copied in further experiments is considered as faithful with fact and epistemically objective, whereas an experimental result that is not reproducible may be considered as an artifact and not objective. A specific apple on the table that continues to exist for several weeks is judged as a fact (i.e., it truly exists) and epistemically objective. This reproducible existence tends to increase the faithfulness of the entity with respect to the fact and thus facilitate judgments on it. Knowledge about an identical and shared cC (Figure 2c) is reproducible because the underlying msckNCC is reproducible (i.e., the second step). The identical msckNCC necessarily produces knowledge about an identical cC (i.e., the first step and Leibniz's Law), thereby supporting the idea that knowledge about an identical cC shared by multiple relevant individuals would be epistemically objective (Figures 1b and 2c).

The degree of the epistemic objectivity of an entity has apparently 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 knowledge about identical cCs if CHANCE were established (Figure 2c). In addition, it is unclear how many relevant individuals are necessary to judge knowledge about a cC as fact and what degree of epistemic objectivity is essential for knowledge about a cC to be considered a target of science. 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 what degree of epistemic objectivity is necessary to be a target of science.

An answer to Nagel's question and the denial of the "philosophical zombie"
If CHANCE were established and knowledge about an identical cC were shared among multiple individuals (Figure 2c), then scientists would be able to respond to Nagel's famous 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 (i.e., a researcher) should somehow share the cC of a subject (Baars, 1996), which would be realized on establishing CHANCE (Figure 2c). If CHANCE were established, the observer (i.e., researcher) would share knowledge about an identical cC with the subject and, thus, have "observer empathy" (Baars, 1996), knowing what it is like to be the subject. In addition, the observer would know that the subject does not know the *inverted spectrum* (Block, 1980, 1990; Shoemaker, 1982) and is not a *philosophical zombie* (Chalmers, 1996).

Addressing some obstacles in first-person data
First-person data concerning the cC appear to 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" (Chalmers, 2013, p. 32) and only *indirectly* available to others (Figures 1a and 3a). However, if one person's knowledge about a specific cC is shared among others (Figure 2c), the first-person data concerning the cC would be *directly* available to them, making it nonexclusive (Figure 3b). He also claims that current "methods for gathering first-person data are quite primitive" (Chalmers, 2013, p. 33). If one person's knowledge about a specific 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 3b). He also claims that general formalism to express first-person data is lacking, and is necessary for data gathering and theory construction (Chalmers, 2013). However, gathering first-person data would be unnecessary if one person's knowledge about a specific cC is shared, thereby removing the need for formalism. However, the development of formalism would be necessary to record in writing the results of the experiments, and to construct and describe a theory explaining the relationship between knowledge about a cC and its underlying neural mechanisms. Therefore, epistemic objectification of knowledge about 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.

CHANCE would open novel scientific studies of cC
How would scientific studies of cC change if CHANCE were established? In a former conventional experimental setting, researchers *indirectly* examine the subjects' cC through the subjects' behavioral reports, bodily signs, or neural signals (Figures 1a and 3a). However, none of these readouts of the cC contains adequate information about the full spectrum of a subject's cC [e.g., no verbal report from Subject A–C contains adequate information about the full spectrum of their knowledge about a specific cC (e.g., heart symbols) in Figure 3a]. This methodological limitation often makes reliably examining subjects' cC challenging (e.g., no reasoning of Researchers A and B contains adequate information about the full spectrum of knowledge about subjects' cC in Figure 3a).

If CHANCE were established, a clear distinction between an observer (i.e., researcher) and a subject disappears in experiments. A researcher or individual who wants to know the result of an experiment has to join the experiment and experience and *directly* know a specific cC (Figure 3b). A researcher or individual who joined the experiment subjectively knows the full spectrum about a specific cC in the ontological sense. The ontologically subjective knowledge about the cC of each researcher or individual would be epistemically objective and available as scientific data (Searle, 1998). In principle, any cC, even cCs that are difficult to express verbally would potentially be a target of scientific investigation.

Conclusion
Consciousness researchers in general *indirectly* examine the cC of a subject in scientific experiments

through behavioral reports, bodily signs, or neural signals. When using these methods, it is difficult for a researcher to know the full spectrum of a subject's cC. We propose the CHANCE method to enable a researcher to know the full spectrum knowledge about the cC of other individuals in a scientific experiment. The CHANCE method also enables a researcher's ontologically subjective knowledge about the cC to be considered as scientific data. Thus, a researcher would *directly* address the full spectrum of cC in science. We believe that the CHANCE method would create a means of investigating the neural bases of the full spectrum of cC and contribute to solving the *hard problem* of consciousness (Chalmers, 1996).

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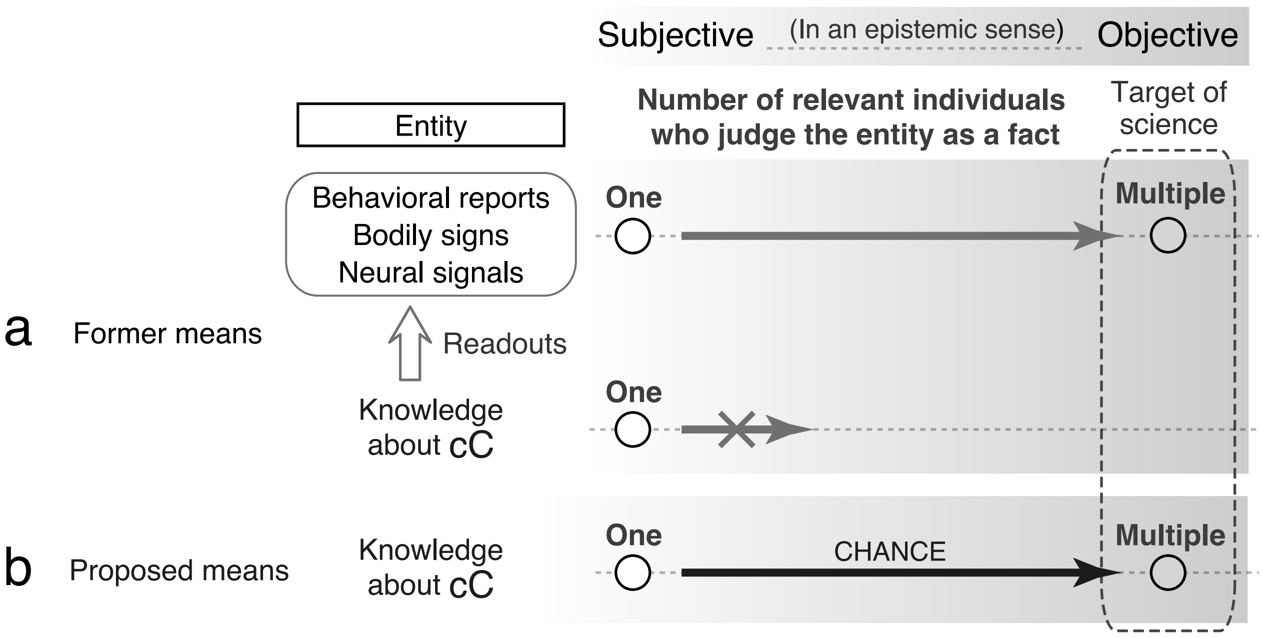
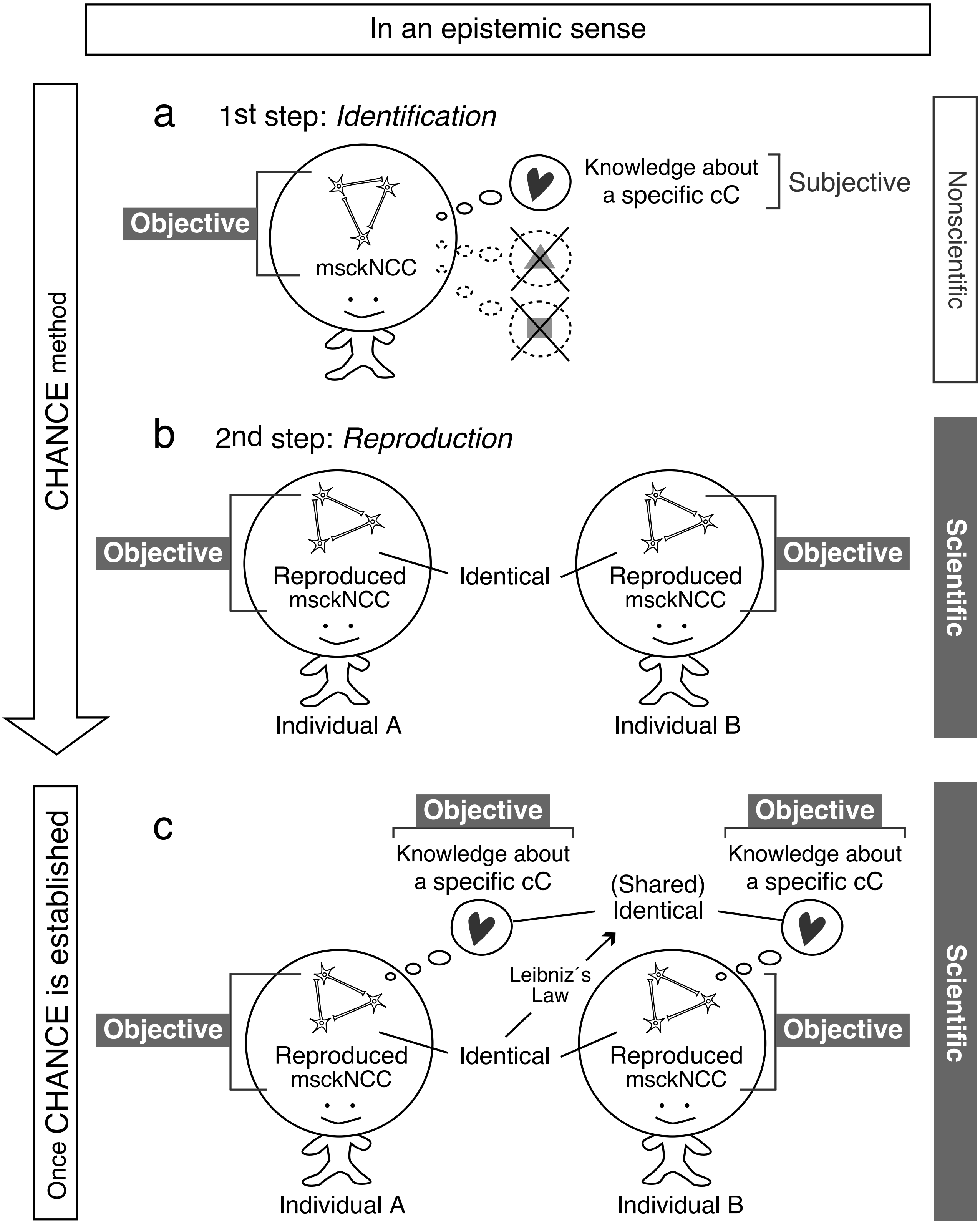

Subjective
(In an epistemic sense)
Objective
Entity
Number of relevant individuals who judge the entity as a fact
Target of science
Behavioral reports
Bodily signs
Neural signals
One
Multiple
a
Former means
Readouts
Knowledge about cC
One
b
Proposed means
Knowledge about cC
One
CHANCE
Multiple

Figure 1



In an epistemic sense
CHANCE method
Once CHANCE is established
a
1st step: *Identification*
Objective
msckNCC
Knowledge about
a specific cC
Subjective
Nonscientific
b
2nd step: *Reproduction*
Objective
Reproduced
msckNCC
Identical
Reproduced
msckNCC
Objective
Individual A
Individual B
Scientific
c
Objective
Knowledge about
a specific cC
Objective
Knowledge about
a specific cC
(Shared)
Identical
Leibniz´s
Law
Objective
Reproduced
msckNCC
Identical
Reproduced
msckNCC
Objective
Individual A
Individual B
Scientific

Figure 2

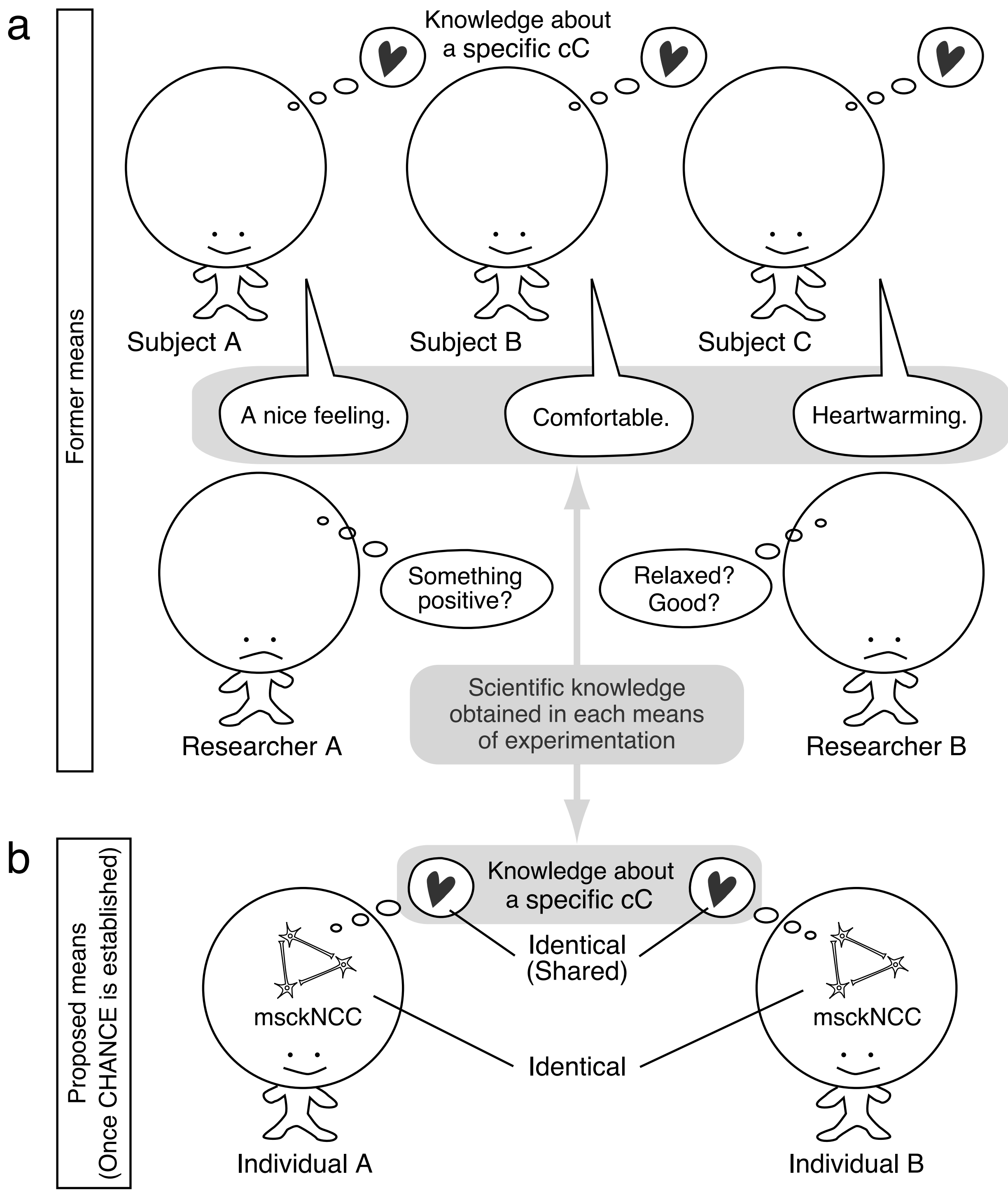

a
Former means
Knowledge about
a specific cC
Subject A
Subject B
Subject C
A nice feeling.
Comfortable.
Heartwarming.
Something
positive?
Relaxed?
Good?
Researcher A
Researcher B
Scientific knowledge
obtained in each means
of experimentation
b
Proposed means
(Once CHANCE is established)
Knowledge about
a specific cC
Identical
(Shared)
msckNCC
msckNCC
Identical
Individual A
Individual B

Figure 3