A conjecture for objectification of the content of consciousness

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Abstract

The content of consciousness has strictly escaped from scientific approach mainly because it is subjective but not objective. We propose the content of consciousness can become objective in a specific condition. We firstly considered the subjective-objective distinction and found that it was not necessarily black-and-white but was continuously graded. We also found two factors affecting the degree of objectiveness: number of individuals who confirmed the specific subject, and reproducibility to confirm the subject. We stated that the specific content of consciousness could be regarded as objective if it was reproducibly confirmed by multiple individuals. Finally, we raised four neurological premises to test the statement: (1) a content-specific and sufficient neural correlates of consciousness (cssNCC) exists in human brain, (2) a specific cssNCC gives rise to a specific content of consciousness, (3) the cssNCC is sharable among multiple individuals and (4) the cssNCC is spatiotemporally stable enough to manipulate repeatedly.

1: Introduction

When you were hungry and ate an apple, for example, you would consciously experience something pleasurable. When you were hurt, you would consciously experience something painful. These conscious experiences consist a core part of our human life and there is nothing that we know more intimately than the conscious experience. The conscious experience is often called 'the content of consciousness' in the research field of consciousness (Koch et al., 2016), so we follow and use this term throughout the present paper to represent the conscious experience.

Accumulating evidences suggest that the content of consciousness arises from the brain (Click and Koch, 1990; Koch, 2004; Dehaene and Changeux, 2011; Tononi and Koch, 2015; Koch et al., 2016). The fact that, while the content of consciousness is subjective and phenomenal, the brain is in nature objective and physical, raises intriguing question *why* the content of consciousness arises from the brain. This question is called the 'hard problem' of consciousness as coined by philosopher David Chalmers (Chalmers, 1996), and it remains unclear how this question can be solved.

One of important steps to answer the hard problem would be to answer *how* the content of consciousness arises from the brain. Scientific methods, in general, have provided most powerful way to answer this kind of "how" questions in nature. Thus, one naïve idea is to apply scientific method to answer *how* the content of consciousness arises from the brain. This idea has been hampered, however (Chalmers, 1996), mainly because scientific methods can be applied only to objective issues but not to subjective ones. The content of consciousness is subjective because the content of consciousness of a certain individual can't be normally "confirmed" by others, hampering us to deal with the content of consciousness as subjects in science. The verb "confirm" is used throughout the present paper to represent to be sure and agree to say that something is definitely true.

The content of consciousness has been typically evaluated by the verbal report or by the button-press by participant (subject) in response to a yes or no question (such as "did you see a dot?") in an experimental setting of neuroscience. Both the verbal report and the button-press (or, more generally, the behavioral report of the content of consciousness), however, rely on the cognitive functions such as introspection and reportability (Cohen and Dennett, 2011) of which performance themselves can be quite variable among the subjects (Kunimoto et al., 2001). Thus, the behavioral report doesn't necessarily reflect the content of consciousness of the subjects (Koch et al., 2016). Although many trials have been made to reliably measure the content of consciousness (Del Cul et al, 2007; Sandberg et al., 2010), all methods had no choice but to use behavioral report to estimate the content of consciousness because of its subjective property (Chalmers, 2013). Thus, objectification of the content of consciousness, if possible, could be a major breakthrough in consciousness research, leading to scientific direct investigation of the content of consciousness.

The purposes of the present paper are to think back how we obtain knowledge in science and what the objectiveness is and find, in the end, a potential way to objectify the content of consciousness.

2: Brief introduction of the content of consciousness in relation to science

Definition of the contest of consciousness at present

Although there is at present no satisfactory, universally accepted definition of human consciousness, consciousness appears to consist of two basic elements: the level of consciousness (i.e., the state of consciousness or access consciousness) and the content of consciousness (i.e., conscious experience, phenomenal consciousness or qualia) (Block, 1995; Chalmers, 1996; Kanai and Tsuchiya, 2012; Koch et al., 2016). The term 'the content of consciousness' appears to mean same concept represented by other expressions by different researchers: conscious experience (Chalmers, 1996), qualia (Ramachandran and Hirstein, 1997; Kanai and Tsuchiya, 2012), phenomenal consciousness (Block, 1995; Cohen and Dennett, 2011), 'what it is like' character of experience (Nagel, 1974) or 'raw feels' of conscious experience (Ramachandran and Hirstein, 1997). In the present paper, we use the term 'the content of consciousness' as synonymous with these other expressions and focus on the content of consciousness but not the level of consciousness.

Several studies considered properties of the content of consciousness to define its concept more strictly (Koch, 2004; Searle, 2005). For example, Ramachandran and Hirstein proposed three functional characteristics of the contents of consciousness, qualia: 1) they are irrevocable, we cannot simply decide to start seeing the sunset as green, or feel pain as if it were an itch; 2) qualia do not always produce the same behavior, given a set of qualia, we can choose from a potentially infinite set of possible behaviors to execute; 3) they endure in short-term memory (Ramachandran and Hirstein, 1997). Tononi and his colleagues proposed five phenomenological properties of consciousness: intrinsic existence, composition, information, integration and exclusion (Oizumi et al., 2014; Tononi and Koch, 2015). Although these assumptions are definitely important to characterize and understand the content of consciousness, it remains open whether they are indeed valid or not (Tononi and Koch, 2015). Although, therefore, the content of consciousness hasn't fully characterized and defined in the literature yet, we individuals can experience it more directly and vividly than anything else in the world and, in this intuitive sense, no explanation is required to know what it is.

Mental phenomena except for the content of consciousness have been functionalized and objectified in advance to be studied in science

Again, it's widely accepted that scientific methods can be applied only to objective issues but not to subjective ones, such as the content of consciousness. On the other hand, reportability, one of mental phenomena related to the content of consciousness, for example, has been regarded as a subject of science, even though the reportability itself is just a kind of abstract concepts and not objective issue. Then, how objectiveness of mental phenomena which are regarded as subjects of science, such as reportability, attention and working memory, had been established before they were studied by scientific methods? It has been proposed that all questions related to mental phenomena in science are questions about the performance of *functions* of those phenomena (here, 'function' is used in the sense of any causal role in the production of behavior that a system might perform) (Chalmers, 1996; 2013). In other words, all mental phenomena of interest have been functionalized in advance to be studied by scientific methods (Fig.1). To explain and obtain knowledge about the mental phenomena in science, then, we just required to clarify the mechanism such as neural or computational mechanism to understand the function of these phenomena (Chalmers, 1996; 2013) (Fig.1). In deed, the performance of the function of the reportability, for example, can be objective and detected by scientific methods and has enabled us to evaluate its status. Thus, objectiveness of mental phenomena had been established through the functionalization. That is, functionalization has been applied to objectify the mental phenomena as a common way to deal with them in science (Fig.1).

The content of consciousness is unable to be functionalized at present

The content of consciousness would become a subject in science, if it could be functionalized and objectified. However, the function of the content of consciousness remains unclear, unfortunately, although there are some speculations (Koch, 2014). Thus, the content of consciousness is unable to be functionalized at present (Fig.1). This could be the fundamental reason why it has been difficult to deal with the content of consciousness in science.

Then, are there any ways to objectify the content of consciousness without functionalization? If there were the ways, the content of consciousness would become a subject of science without functionalization. To explore this possibility, we firstly rethink the definition of objectiveness and raise a potential way to objectify the content of consciousness in the following parts.

3: Rethinking of objectiveness and proposal of Objective consciousness conjecture (oBJe)

Subjective/objective duality has been challenged

Natural science and its viewpoint of the Universe are based on a clear formulation of dualism proposed by Descartes (Descartes, 1644). According to him, the Universe consists of two fundamentally different substances: *res cogitans*, a substance which thinks, and *res extensa*, a substance which extends in space. *Res extensa* is the stuff of which the material world is made, including brains, while *res cogitans* is the stuff of consciousness. Science has developed to deal with only *res extensa*, objective issues, but not *res cogitans*, subjective ones. With this history as a backdrop, it has seemed to widely believed in science community that subjective issues (first-person account) are qualitatively different from and opposed to objective ones (third-person account). This conventional belief of subjective/objective duality seems to prompt many scientists to postulate a clear border between them (Fig. 2A).

It's noteworthy, however, that the definition of subjectiveness and objectiveness has been still controversial. For example, it has been proposed that subjectivity corresponds to the sense of an observing self but not the contents of consciousness (James, 1985; Baars, 1996) while some others has regarded the contents of consciousness as subjective (Nagel, 1974; Chalmers, 1996; Koch, 2016). In addition, from the first place, the belief of subjective/objective duality has been challenged in one of the fields of philosophy, called neurophenomenology (Varela, 1996). The neurophenomenology states that it becomes less and less obvious how to distinguish between subject and object and that the usual opposition of first-person vs. third-person accounts is misleading (Varela, 1996). These arguments prompted us to rethink what we intuitively believed about subjective/objective duality and, in particular, the definition of subjectiveness, objectiveness and their relationship.

Objectiveness is continuously graded

The definition of subjectiveness and objectiveness seems to be more ambiguous than intuitively believed. When you walk in a park, for example, and count the number of blue birds flying in the park, the number of the birds can be regarded as a kind of data and the data appears to be objective. But, it may become 'less' objective if, when you counted the birds, no one was walking around and no one observed the birds. It may become 'far less' objective if you never saw the birds again in the park in the following days and years. On the contrary, it may become 'more' objective if many people saw the birds with you at that time and you and others repeatedly observed them many times in the following days as well. In more details, the data appears to be ‘more’ objective if you counted the birds with 20 individuals than you did as one individual. As well, the data appears to be ‘more’ objective if you saw and counted the birds repeatedly for 20 consecutive days than you did it for only one additional day. Next, let’s think more realistic and scientific situation. The data obtained in scientific studies can be regarded sufficiently objective and reliable to be published in scientific journals. However, all data published in scientific journals may not necessarily be objective and reliable homogeneously. In some experiments, for example, multiple researchers performed the same experiments repeatedly and other researchers analyzed the data in a blinded manner, while, in some other experiments, only one researcher performed all the experiments and analyzed the data by himself/herself. One may argue that results obtained in the former cases are more objective and reliable compared to those obtained in the latter case since, in the latter case, some subjective aspects of the researcher who performed all the experiments and the analyses might be included in the resultant data. Taken together, it appears to be true that objectiveness of a certain issue is not always black and white in nature, but there are some degrees of objectiveness for any issues. That is, some can represent ‘low’ objectiveness and the others can represent ‘high’ objectiveness. The terms ‘subjective’ and ‘objective’ appears to be located in antipole of the same axis and most subjects appear to be located in between and represent a certain degree of objectiveness (Fig. 2B).

Although the degree of objectiveness of a certain issue seems to be vaguely judged by relevant human community, it is possible that various factors would affect the judgment of the degree of objectiveness of each issue.

Two factors that affect the degree of objectiveness

There appear to be two factors, at least, that affect the degree of objectiveness of the subject of interest: the number of individuals who confirmed the specific subject, and the degree of reproducibility to confirm the subject. A specific earthquake, for example, which is experienced and confirmed by millions of individuals is highly likely to be regarded objective and thus represents high objectiveness (Fig. 2C, right circle). On the other hands, the one confirmed by only several individuals or just one individual doesn’t seem to be regarded objective and thus represents low (Fig. 2C, middle circle) or zero (Fig. 2C, left circle) objectiveness, respectively. This is because the confirmation of an earthquake by only one individual or several individuals could be explained by, for example, lightheadedness or hallucination, instead of experiencing real earthquake. It's noteworthy that this argument focuses on the specific or an individual earthquake but not the concept of earthquake itself. The concept of earthquake can be regarded objective by the summation of different many experiences in different many individuals. Thus, in general, when we focus on a specific subject, more numbers of individuals who confirmed the subject seem to lead to a judgment of higher degree of objectiveness of the subject.

An earthquake occurs unpredictably when we are not ready. Furthermore, a specific earthquake occurs only one time, so repeated confirmation of a specific earthquake is not possible in nature. On the other hand, an apple on the table, for example, can be confirmed repeatedly whenever we want. This reproducibility is regarded as one of the requirements in science and seems to increases the degree of objectiveness of the subject. Thus, compared to an apple confirmed by several individuals only one time representing low objectiveness (Fig. 2D, left circle), the same apple on the table confirmed by the same number of individuals but in a reproducible manner seems to be much more objective (Fig. 2D, right circle).

Objectiveness is originally based on subjective experiences and confirmations

Here, it's noteworthy that each individual's experience and confirmation themselves are achieved subjectively (Varela, 1996). When you see an apple on the table and confirm it, for example, you consciously and subjectively do it. When you read and see scientific data on the research papers and confirmed it, you consciously and subjectively do it. That is, the evaluation of objectiveness of a certain subject is originally based on those subjective experiences or confirmations by each individual who evaluate the subject.

The content of consciousness can be regarded as highly objective in a specific condition: proposal of Objective consciousness conjecture (oBJe)

The last consideration, each individual's confirmation itself is always achieved subjectively, proposes that the above statement "an apple which was confirmed by several individuals in a reproducible manner represents high objectiveness (Fig. 2D)" can be rewritten with more precision as "an apple which was 'subjectively' confirmed by several individuals in a reproducible manner represents high objectiveness". This statement can be generalized as "the issue which was subjectively confirmed by several individuals in a reproducible manner represents high objectiveness". According to this generalized statement, even "the content of consciousness can be regarded as highly objective if it is subjectively confirmed by several individuals in a reproducible manner (Fig. 2E)". This last statement seems to be logically true but not empirically verified yet. Thus, we name the last statement Objective consciousness conjecture (oBJe). oBJe shows a potential way to objectify the content of consciousness: the content of consciousness can become highly objective if it's reproducibly was confirmed by multiple individuals. oBJe also contains a conjecture of judgment of deterministic human community which finally judge the objectiveness of a certain issue: the deterministic human community can judge the content of consciousness which was reproducibly confirmed by multiple individuals as highly objective. In these senses, oBJe is not only a logical conjecture but also a social conjecture.

oBJe should be falsifiable by empirical tests to be regarded as a scientific conjecture (Popper, 2002). To empirically test this conjecture, we should firstly establish quite challenging condition: the specific content of consciousness is reproducibly confirmed by multiple individuals. In the following part, we raise a potential way to empirically establish this condition.

4: Four neurological premises to test oBJe

To empirically test oBJe, a specific content of consciousness should be reproducibly confirmed by multiple individuals. We found that it was possible in theory to establish this condition if we were allowed to assume four properties of neurological basis of the content of consciousness. Thus, oBJe can be scientific conjecture if the four premises are empirically testable and falsifiable. In the following part, we explain the four premises and also propose possible tests to verify each premise.

Premise 1: Existence of the content-specific and sufficient neural correlate of consciousness (cssNCC)

It's widely accepted that specific neural mechanisms that exist at least in our human brains are required and sufficient to experience the content of consciousness subjectively. Koch and his colleagues argue that the minimal neural mechanism that are jointly required and sufficient to experience a specific content of consciousness is named the content-specific neural correlates of consciousness (NCC) (Click and Koch, 1990; Koch *et al*., 2016). In accordance with their concept, we assume that a specific content of consciousness arises from a specific neural mechanism that exists in the subject's brain. To be more precise, however, we don't claim necessity: while Koch and his colleagues claim that a content-specific NCC is the minimal neural mechanisms which are not only sufficient but also required to experience a specific content of consciousness (Koch et al., 2016), the neural mechanisms we assume here is the minimal ones which are jointly sufficient but not necessarily required to experience a specific content of consciousness. For clarity, we name the neural mechanism we assume here the content-specific and sufficient NCC (cssNCC) (Fig. 3A). When the cssNCC is activated, the subject should experience the content of consciousness, while, even without the cssNCC, the subject may still experience the content of consciousness. To ensure minimality of the cssNCC to give rise to content of consciousness, each neuron, synapse or, more generally, neural mechanism consisting the cssNCC should be tested whether it's activity is indeed required for the content of consciousness arisen from the activation of the cssNCC.

One of the ways to falsify this premise is to verify that activation of non-neural mechanisms is sufficient to experience the content of consciousness under the condition where all neural mechanisms are completely inactivated, except for the minimal neural mechanism required for the survival of the subject, such as the brain stem. In this falsifying test, it is also important to verify that the remained neural mechanism for survival isn't the cssNCC to exclude the possibility that activation of non-neural mechanisms gave rise to the content of consciousness through the indirect activation of the remained neural mechanisms.

In order to empirically find the cssNCC, we need to develop sophisticated methods to activate the neural mechanisms of interest with high spatiotemporal resolution in humans. Although several interesting methods including optogenetics (Aston-Jones and Deisseroth, 2013) have been developed to manipulate neural activities in non-human animals, their precision would be still not enough to perform experiments demanded here and be required to be far more improved.

Throughout these tests, the content of consciousness itself is subjectively detected by each test participant. The scientists/individuals who want to evaluate the results of experiments containing detection of the content of consciousness are required to join the experiment as participants and need to experience the content of consciousness by themselves. This is in remarkable contrast to other standard scientific research where people can understand experimental results just by evaluating the published data. Thus, the process to confirm the results containing the content of consciousness would be more laborious compared to standard scientific experiments. However, this methodological limitation won't decrease a confidence obtained in each participated researcher who evaluates the results, compared to other standard scientific results, because both methods provide subjective confidence in the end to each individual as well.

One may argue that the premise of the existence of the cssNCC as one of the bases of oBJe leads to a circular argument: oBJe enables the scientific study of the content of consciousness leading to clarify their neural mechanisms, but in order to be able to use oBJe we first need to know what these mechanisms are. This potential argument comes from no distinction between the degree of objectiveness of the content of consciousness before and after the verification of oBJe. Before the verification of oBJe, the content of consciousness is subjective (Fig. 2E, left), while this can become highly objective after the verification of oBJe (Fig. 2E, right) (discussed below in details). Thus, oBJe enables the study of the content of consciousness in more objective manner, and in order to be able to use oBJe, it's tentatively enough for us to subjectively know the mechanism of the content of consciousness. In other words, subjective knowledge of neural mechanism of the content of consciousness is tentatively enough to verify oBJe, and if once oBJe was verified, we can conclude that the subjective knowledge can be turned into objective one (discussed below in details).

Premise 2: Specificity of the cssNCC for the content of consciousness

Second premise is that activation of a specific cssNCC gives rise to a specific content of consciousness, but not others (Fig. 3B). While a specific cssNCC should give rise to only one specific content of consciousness, a specific content of consciousness doesn't necessarily arise from only one specific cssNCC. A specific content of consciousness may arise from the multiple different mechanisms (Tononi and Koch, 2015). Also, this second premise does not necessarily mean that a specific cssNCC is completely segregated from other cssNCCs: a part of neural mechanisms of a specific cssNCC may overlap with other cssNCCs.

This second premise is correct if, when a specific cssNCC is kept active, the subject continues to experience the specific content of consciousness, regardless of the activities of any other mechanisms. These "any other mechanisms" are defined as in literally all biological mechanisms except for the specific cssNCC of focus. Neural activities of the prefrontal cortex, for example, which is not included the cssNCC of focus could be included in the "any other mechanisms". One of the ways to falsify this premise is to verify that, even though the specific cssNCC is kept active, the subject stops experiencing the specific content of consciousness when activities of any other mechanisms were changed. Once this premise was verified, the detection of the activity of a specific cssNCC can be regarded as strong empirical evidence for the generation of a specific content of consciousness. That is, once this premise was verified, that verification unveils a tight connection between an activation of a specific cssNCC and an emergence of a specific content of consciousness regardless of any different activities of any other mechanisms.

One may argue that this premise is implausible because we know that the content of consciousness is highly sensitive to context: for example, the brightness of two patches, where their absolute luminance is identical, is experienced very differently when they are surrounded by different contexts. However, this case doesn't necessarily mean that a specific cssNCC gives rise to two different contents of consciousness, depending on any other activities. Instead, this case is interpreted as follows: experience of brightness of patch A surrounded by context A is generated by a specific cssNCC, while experience of brightness of patch A surrounded by different context B is generated by a different cssNCC. That is, different experiences of brightness of the identical patches in absolute luminance surrounded by different contexts are generated by different cssNCCs. Specific stimulus information (luminance of patch) doesn't always activate a specific cssNCC but can activate other cssNCCs, depending on other information such as surrounding context.

Premise 3: Sharing of the cssNCC

Third premise is that cssNCC can be shared among multiple individuals (Fig. 3C). Although this premise may sound neurologically impossible, in support of a neurological reality of this premise, sensory information and its underlying neural substances are indeed shared in craniopagus twins conjoined at the head (Squair, 2012). Note that sharing of the cssNCC does not necessarily mean a physical sharing a part of the brain among individuals. In the present paper, at least, reproduction of specific activities of identical neural mechanisms in different brains can be also regarded as sharing of the neural mechanisms among the multiple individuals.

In order to test whether the cssNCC can be shared among multiple individuals, we firstly need to develop novel and sophisticated technologies to share the cssNCC. One naïve idea would be to surgically tie brains of multiple individuals or make a 'bridge' of neurons (Ramachandran and Hirstein, 1997) to share the cssNCC among them, although current technologies are far from achieving it. Another idea could be to photocopy the neural mechanisms of the cssNCC in one brain to another. For example, if the essential neural mechanisms of the cssNCC is governed by the specific activity patterns in specific neural networks, the same neural mechanisms may be possible to reproduce in other brains. Of course, considerable degree of technical advance would be required to achieve it in many related research areas including neural decoding using brain-machine, -computer or -brain interface technologies (Wolpaw et al., 2002; Hochberg et al., 2006; Min and Muller, 2014), optogenetics and chemogenetics (Aston-Jones and Deisseroth, 2013). With this "photocopy" idea, unambiguous confirmation of identicalness of the cssNCC replicated in different brains could be crucial. For this empirical confirmation, detailed identification of the neural mechanisms of the cssNCC, e.g., specific neural or synaptic activity pattern, in advance would be crucial.

To test whether the specific cssNCC is truly shared or not, it's required and eventually sufficient to show that the specific cssNCC for one participant is also the cssNCC for others. That is, we should test whether a specific cssNCC of interest is the minimal neural mechanism which is sufficient to give rise to a specific content of consciousness in each participant. Here, it's crucial to note that empirical confirmation of identicalness of the content of consciousness experienced by different participants is not required. The identicalness of the specific cssNCC manipulated experimentally, but not the identicalness of the content of consciousness experienced by different participants, is crucial for this sharing test. Indeed, we naturally realize that it's impossible to directly compare the content of consciousness of different participants, and, again, this comparison is not required for this sharing test. We should focus on whether the identical cssNCC gives rise to a specific content of consciousness in each subject and we don't need to care, during this sharing test, whether the cssNCC gives rise to identical content of consciousness in different participants (you would understand its reason afterwards).

One of the ways to falsify this sharing premise is to verify that the participant doesn't experience any content of consciousness regardless of the activation of the potentially shared neural mechanisms of which activation gives rise to specific content of consciousness in other participants.

One may argue that it's not clear how we can be sure that all of the contents of consciousness are contained only in the part that is shared by multiple participants. We don't insist that all of the contents of consciousness should arise only from the shared part. Shared cssNCC may give rise to only specific content of consciousness, such as red color or black line, but not others. We believe that a single pair of the specific cssNCC and the specific content of consciousness are tentatively enough for the sharing test.

Premise 4: Stability of the cssNCC

The cssNCC is stable spatiotemporally enough to repeat experiments (Fig. 3D) for demonstration of above three premises 1-3. This characteristic of the cssNCC ensures reproducibility of empirical results.

One of the ways to falsify this premise is to verify that activation of a specific cssNCC gives rise to a specific content of consciousness at only one time point but not other time points. If this fourth premise is not verified, it's difficult to repeat experiments to test all other premises 1-3, and crucially decrease reproducibility of each result.

This fourth premise doesn't contradict experimental evidence: NCC is hypothesized to be stably located in specific parts of the cerebral cortex (Koch et al., 2016). It's not known specifically, however, which cortical areas, layers or neuronal populations are involved, which aspect of their activity matters, and what extent the set of neural elements that constitute the NCC is fixed (Tononi et al., 2016).

Relationships among four premises

As has been already clear, the premise 1 is the basis of other premises and the premise 4 is the basis of other premises to be empirically tested in a reproducible manner. All aforementioned four premises 1-4 are empirically falsifiable, ensuring that oBJe is a scientific conjecture (Popper, 2002).

The content of consciousness can represent high objectiveness if aforementioned four premises 1-4 were verified

If aforementioned four premises 1-4 were verified, the shared cssNCC (premise 3) should give rise to identical content of consciousness in multiple individuals who share the cssNCC, because activation of a specific cssNCC give rise to a specific content of consciousness regardless of background activity of any other mechanisms (premise 2) (Fig. 3E). The identical content of consciousness shared among multiple individuals can be regarded as intersubjective and thus represent high objectiveness according to the oBJe, because they are subjectively confirmed by multiple individuals in a reproducible manner (Figs. 2E and 3E).

One may argue that it's not clear how we can be sure that the content of consciousness among multiple participants is not different from each other by the influence of neural activities which are not shared among them. This argument seems to come from misunderstanding of premise 2. The premise 2 assumes that activation of a specific cssNCC gives rise to a specific content of consciousness regardless of the activities of any other mechanisms (Fig. 3B). Even if neural activities which are not shared among participants are different among participants, it doesn't influence the specifc-cssNCC-induced content of consciousness experienced by participants, because an activation of the specific cssNCC gives rise to a specific content of consciousness regardless of any other neural activities (premise 2).

Others may argue that we need to demonstrate that the shared content of consciousness is indeed identical among multiple individuals. As mentioned above, identicalness of the content of consciousness among multiple individuals is a logical consequence of the fulfillment of premises 2 and 3: a specific cssNCC gives rise to a specific content of consciousness regardless of any other activities (premise 2) and the identical cssNCC is shared among the multiple participants (premise 3). Therefore, identicalness of shared content of consciousness among multiple individuals is guaranteed by logic without direct empirical detection of the content of consciousness itself.

5: Discussion

We propose an Objective consciousness conjecture, oBJe, stating that a content of consciousness can become objective if it was reproducibly confirmed by multiple individuals. To test oBJe, we firstly need to establish the condition that a content of consciousness is reproducibly confirmed by multiple individuals. One potential way to establish this condition is to empirically verify the four neurological premises about the properties of the neural basis of the content of consciousness: (1) a content-specific and sufficient neural correlates of consciousness (cssNCC) is exist in human brain, (2) a specific cssNCC gives rise to a specific content of consciousness, (3) the cssNCC is sharable among multiple individuals and (4) the cssNCC is spatiotemporally stable enough to manipulate repeatedly. Taken together, oBJe illustrates a potential way to objectify the content of consciousness, which has been believed impossible in all philosophy, psychology and neuronscience.

oBJe can answer Nagel's question and deny both 'Inverted Qualia' and 'Philosophical Zombie'

If oBJe was established, we would have an answer for Nagel's famous philosophical question: 'what is it like to be a bat?' (Nagel, 1974). Simply, this Nagel's question claimed that, to know whether a subject is conscious, an observer must know what it is like to be the subject. This demands that an observer should somehow share the contents of consciousness of the subject (Baars, 1999). This could be achieved if cssNCC was found (premise 1), a specific cssNCC gives rise to a specific content of consciousness (premise 2), and cssNCC was sharable among multiple individuals (premise 3): in this situation, the observer would share, in theory, exactly identical content of consciousness with the subject and know what it is like to be the subject. As well, in this situation, we can deny the possibility that the observer and the subject experience 'Inverted Qualia' (Shoemaker, 1982; Block, 1990) since they share identical content of consciousness. We can also deny another possibility that the subject is 'Philosophical Zombie' (Chalmers, 1996) since the subject experiences identical content of consciousness experienced by the observer.

oBJe can separate consciousness from function

Cohen and Dennett claimed that consciousness cannot be separated from function and that it's impossible to prove the existence of consciousness independent of function and access (Cohen and Dennet, 2011). oBJe can overcome this claim. We consider to combining their 'perfect' thought experiment (Cohen and Dennet, 2011) and oBJe as follows. The cssNCC is reproduced among several participants according to the third premise of oBJe. The projections from the cssNCC to higher brain areas of one participant were surgically cut according to the 'perfect' experiment (Cohen and Dennet, 2011). Here, while the participant who received the surgery would experience the content of consciousness but report no experience, other participants would experience the content of consciousness as well and report the experience. This modified 'perfect' experiment proves the existence of the content of consciousness without access consciousness. By this way, we can objectively test the existence of the content of consciousness independent of function and access. That is, the content of consciousness can be objectively investigated independent of cognitive functions for the first time by using the oBJe. This independency from function clearly represents one of unique advantages of oBJe (Fig. 4, bottom arrow with blue box).

oBJe can leap some obstacles involving first-person data

It has been claimed that there are several obstacles involving first-person data to construct a science of consciousness: Privacy, Methods and Formalisms (Chalmers, 2013). "Privacy" means that first-person data concerning subjective experiences are directly available only to the subject having those experiences and only indirectly available to others (Chalmers, 2013). oBJe states that the "first-person data concerning subjective experience" can be directly available to others, so those data are not private at all. "Methods" means that our methods for gathering first-person data are quite primitive (Chalmers, 2013). In oBJe, it's not required to gather first-person data since it can be directly experienced and presented to others. "Formalisms" claims that general formalism to express first-person data is lacking, and this is required for data gathering and theory construction (Chalmers, 2013). In oBJe, gathering of first-person data isn't required as discussed above, so formalism for this isn't required as well. On the other hand, the development of a certain formalism may be required to write down any conclusions of experiment conducted according to oBJe and describe a theory explaining relationship between the content of consciousness and neural mechanisms.

oBJe leaves the 'hard problem' hard

Philosopher David Chalmers (Chalmers, 1996) has raised a so-called 'hard problem': *why* the content of consciousness arises from the brain. Even if oBJe was established, it would still unable to answer this question. Instead, what oBJe can do is to enable to detect the content of consciousness objectively. This would quite helpful for scientific approach to try to answer *how* the content of consciousness arises from the brain and which neural mechanisms give rise to the content of consciousness (Koch et al., 2016).

Does oBJe change the content of consciousness not only to be objective but also to be a target of science?

Although oBJe can change the content of consciousness to be objective, it may still be controversial whether it can also change the content of consciousness to be a target of science. In empirical science, at least, review of research results by a third person would be one of the crucial processes. Even if oBJe was verified, the content of consciousness would remain undescribed and thus can't be evaluated by a third person. It is noteworthy, however, that the "third person" can understand and evaluate the results when he/she joins the experiment and experience the shared content of consciousness by himself/herself. That is, the content of consciousness in experimental results can be evaluated by anybody who participated in the experiment. As has been clear, however, the "third person" who joined the experiments isn't a third person anymore. More discussions in science community may be needed to determine whether this methodological demand or limitation can be acceptable as a kind of novel scientific methods or not. If this novel method was accepted as one of scientific methods, oBJe could pave the way for scientific investigation of the content of consciousness.

Establishment of oBJe depends not only on verification of four premises but also on decision of human community

Although several factors seem to affect objectiveness of a certain subject, the objectiveness of a certain subject has seemed to be vaguely judged, in the end, by a certain human community. oBJe include not only a logical conjecture but also a conjecture of decision making of deterministic human community. At present, it remains unclear which community or people judge the objectiveness of the content of consciousness when above-mentioned four premises were verified. At any rate, it seems to be important to establish a standard to judge the degree of objectiveness of a certain subject or thing of interest with agreements of relevant human communities.

Conclusion

At present, we neuroscientists don't have any method to directly investigate our subjective conscious experience, the content of consciousness. This limitation has hampered us to directly deal with the content of consciousness as subjects of neuroscience. In the present paper, we propose a conjecture oBJe stating that the content of consciousness isn’t definitely subjective but can be objective in principle. We also propose one potential way to empirically test the oBJe. Establishment of oBJe depends on not only the results of empirical tests but also a judgment of relevant human society which judges objectiveness of subjects. We believe that oBJe stimulates diverse theoretical and empirical researches and discussions in the fields of philosophy, psychology and neuroscience toward scientific understanding of the content of consciousness.

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Legends

Figure 1

Mental phenomena except for the content of consciousness have been fuctionalized and objectified in advance to be studied in science.

To obtain knowledge about mental phenomena, mechanisms of the function of the mental phenomena of interest have been identified. To identify the mechanisms, the functions of the phenomena, which are concrete targets to be studied, have been identified. This identification of function has been automatically achieved in most mental phenomena without experimental efforts, since, from the first place, the most mental phenomena are defined based on their functions. At any rate, this functionalization has objectified the ultimate targets to be understood (red box). The content of consciousness, on the other hand, isn't defined based on their functions, if any, and it's function remains unclear. This could be the fundamental reason why it has been difficult to objectify the content of consciousness and deal with it in science.

Figure 2

The content of consciousness can be highly objective according to Objective consciousness conjecture (oBJe).

(**A**) A conventional view of the relationship between the terms 'subjective' and 'objective' in science community. It is believed that subjective things are qualitatively different from objective things, and there is a clear border between them.

(**B**) Our view of the relationship between the terms 'subjective' and 'objective'. The 'subjective' and 'objective' appears to be located in the antipole of the same axis and objectiveness is graded. Most subjects appear to be located in between and all represent a certain degree of objectiveness.

(**C**) More numbers of individuals who confirmed the subject would guarantee higher degree of its objectiveness. A specific earthquake which is experienced by millions of individuals is highly likely to be regarded objective and thus represents high objectiveness (right circle). The one experienced by only several (middle circle) or one (left circle) individuals may not be regarded objective and thus represents low or almost-zero objectiveness, respectively, because the experiences of an earthquake in only several or one individuals could be explained by something other than real earthquake experience, such as lightheadedness or hallucination. Note that the real earthquake experienced and confirmed by individuals are through not only somatosensory detection of the earthquake itself but also visual and auditory experiences of shaking of the surrounding objects by the earthquake. Observation of the affected objects by the earthquake can be further additional evidence to judge the occurrence of the earthquake.

(**D**) Reproducibility would increase objectiveness of the subject. An apple confirmed by several individuals in a reproducible manner appears to represent higher objectiveness (right circle) compared to a same apple confirmed by the same number of individuals only one time (left circle).

(**E**) oBJe can objectify the content of consciousness. A specific content of consciousness in an ordinal situation, that is, a content of consciousness experienced by one individual at only one moment, seems to be absolutely subjective and represents zero for objectiveness (left circle). oBJe states that, if a specific content of consciousness was confirmed by several individuals in a reproducible manner, the content of consciousness could be regarded as highly objective (arrow and right circle).

oBJe: Objective consciousness conjecture

Figure 3

Schema of the four premises to test oBJe and a resultant logical consequence when the four premises were verified.

(**A**) Premise 1: existence of the content-specific and sufficient neural correlates of consciousness (cssNCC) which is defined as the minimum neural mechanisms jointly sufficient (but not necessarily required) to experience a specific content of consciousness.

(**B**) Premise 2: specificity of the cssNCC for the content of consciousness. Activation of a specific cssNCC gives rise to a specific content of consciousness, but not others, regardless of the background activity of any other mechanisms.

(**C**) Premise 3: sharing of the cssNCC. The cssNCC can be shared among multiple individuals. Note that sharing of the cssNCC does not necessarily mean a physical sharing of a part of the brain among individuals. Reproduction of specific activities of identical neural mechanisms in different brains can be also regarded as sharing of the mechanisms.

(**D**) Premise 4: stability of the cssNCC. The cssNCC is stable spatiotemporally enough to repeat experiments for empirical demonstration of above three premises 1-3 (**A**-**C**).

(**E**) A logical consequence when the four premises (**A**-**D**) were verified. When the cssNCC which gives rise to an experience of red filled circle in person *a* is simultaneously the cssNCC of person *b*, the cssNCC can be regarded as the shared cssNCC between person *a* and *b*. The activation of the shared cssNCC should induce identical experience of red filled circle to

both person *a* and *b* as a logical consequence of the premises 1 and 3. That is, the experience of red filled circle is shared between person *a* and *b*. Thus, the shared experience of red filled circle (or, more generally, the content of consciousness) is intersubjective and thus, according to the oBJe, it can be regarded as objective.
oBJe: Objective consciousness conjecture
cssNCC, content-specific and sufficient neural correlates of consciousness

Figure 4
Schema illustrating that oBJe skips the functionalization and enables to obtain scientific knowledge about the content of consciousness.
The functionalization has objectified the most mental phenomena to be understood in science (red box). The function of the content of consciousness, on the other hand, remains unclear. oBJe would directly objectify the content of consciousness and enable to study the mechanism of the content of consciousness without functionalization (blue box). Also see legends of Figure 1.
oBJe: Objective consciousness conjecture

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PUBLICATIONS

ARTICLES

1. Tanaka D#, Nakaya Y#, Yanagawa Y, Obata K and Murakami F. Multimodal tangential migration of cortical GABAergic neurons independent of GPI-anchored proteins, ***Development*** 130(23), 5803-5813 (2003) (#Equal contributors)

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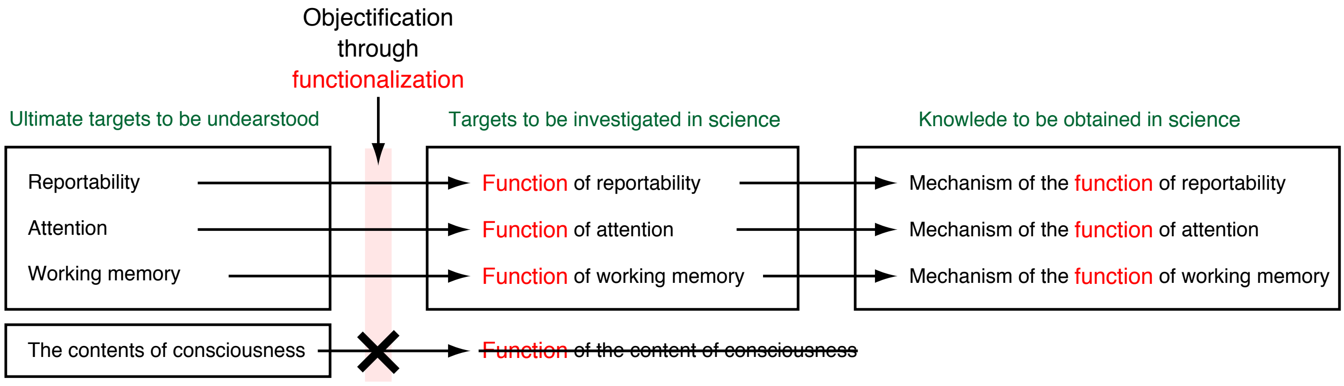
Objectification
through
functionalization
Ultimate targets to be undearstood
Targets to be investigated in science
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Reportability
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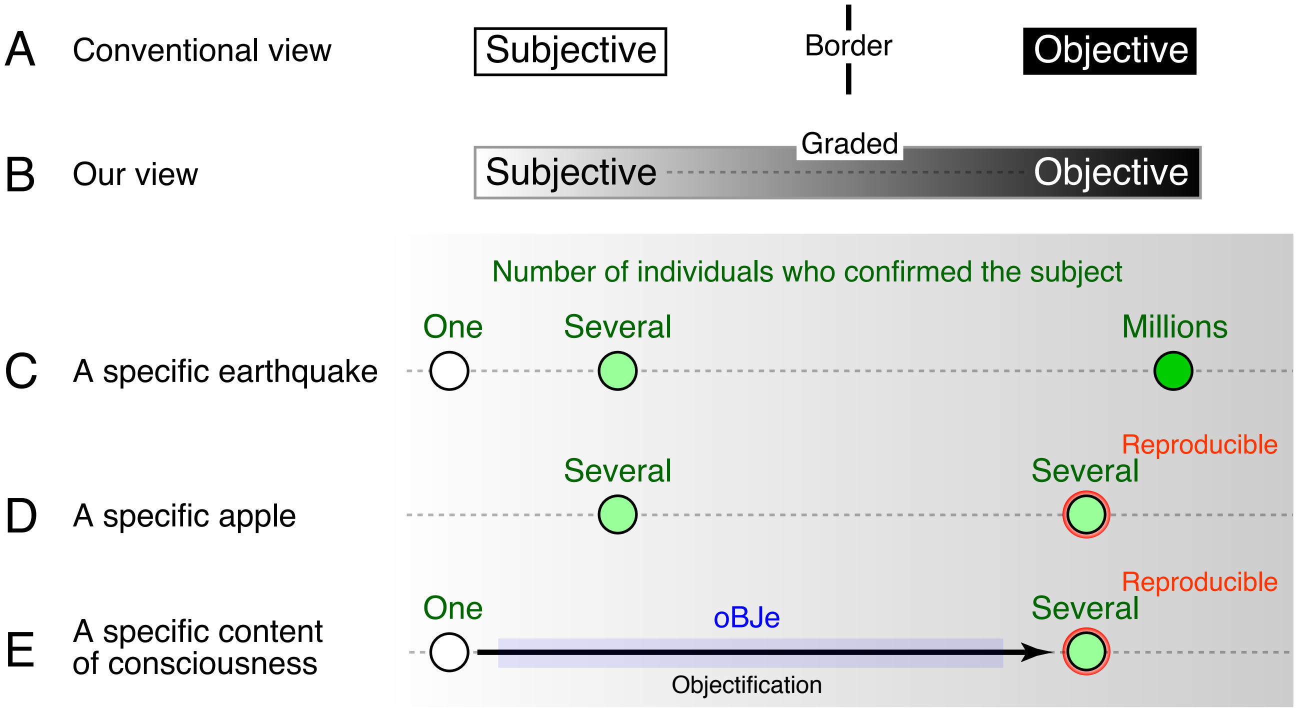
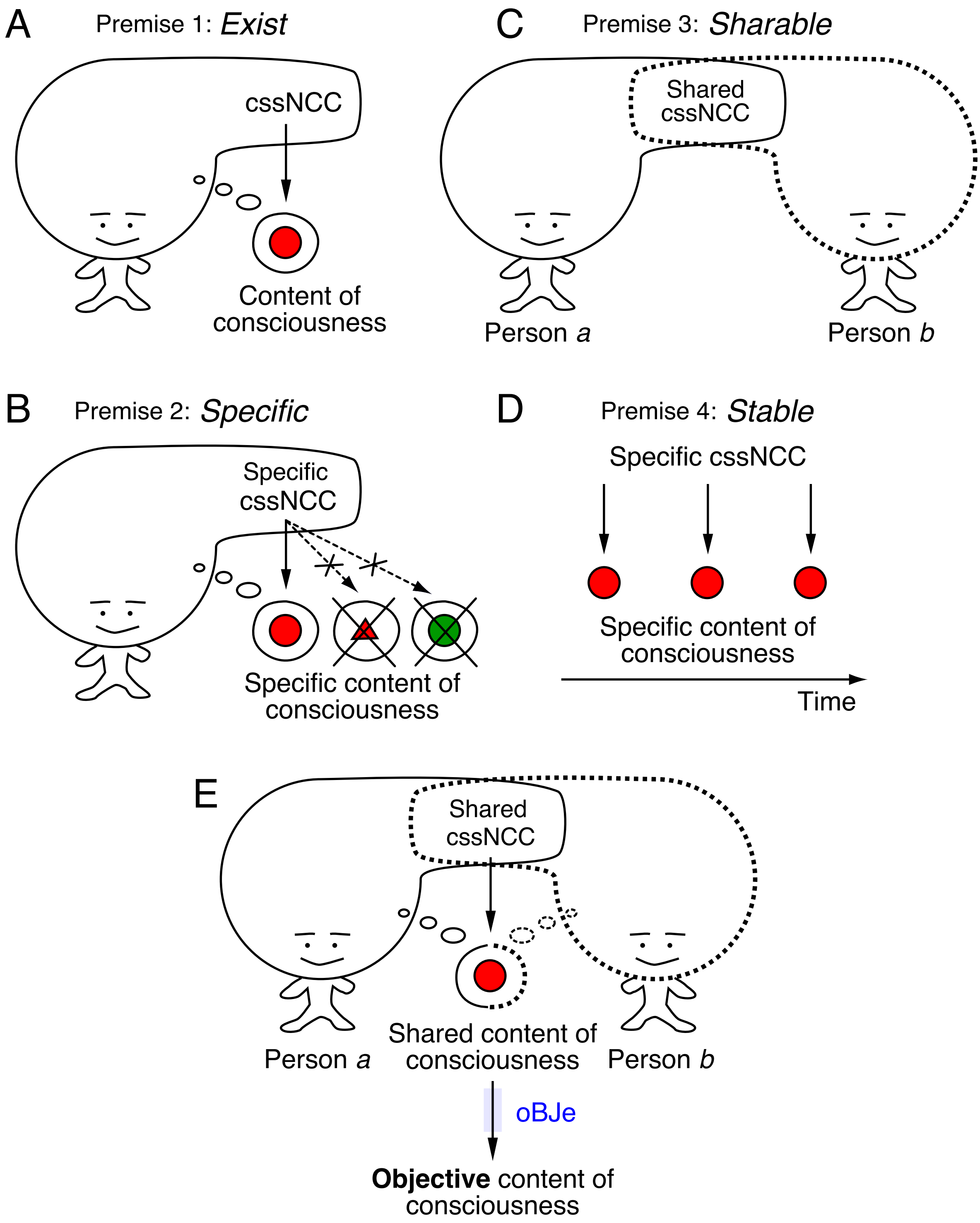
Figure 1



A
Conventional view
Subjective
Border
Objective
B
Our view
Graded
Subjective
Objective
Number of individuals who confirmed the subject
C
A specific earthquake
One
Several
Millions
D
A specific apple
Several
Reproducible
Several
E
A specific content of consciousness
One
oBJe
Objectification
Reproducible
Several

Figure 2


A
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Premise 3: *Sharable*
Shared cssNCC
Person *a*
Person *b*
B
Premise 2: *Specific*
Specific cssNCC
Specific content of consciousness
D
Premise 4: *Stable*
Specific cssNCC
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Shared content of consciousness
Person *a*
Person *b*
oBJe
Objective content of consciousness

Figure 3

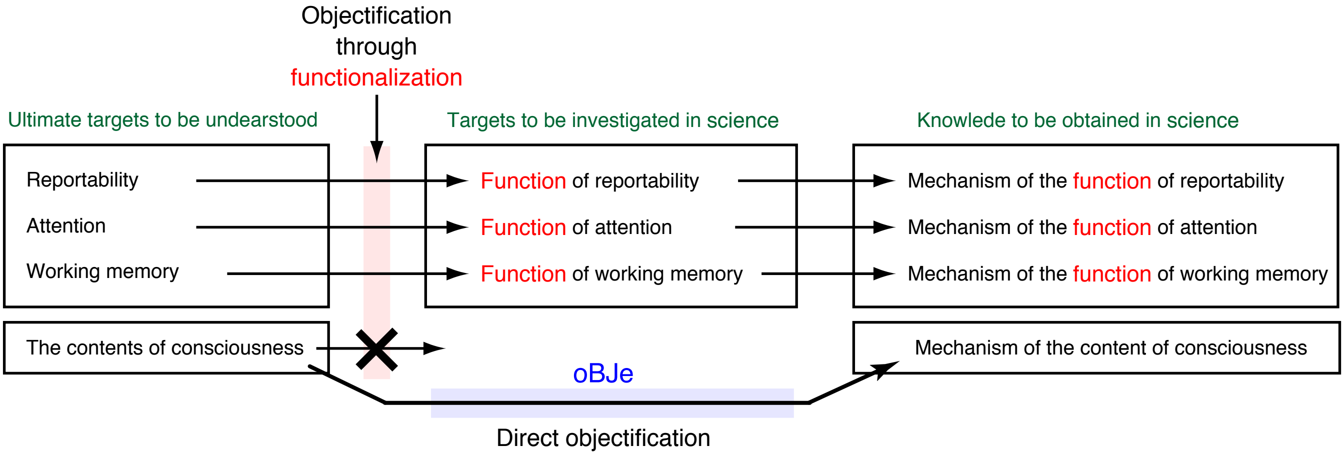
Objectification
through
functionalization
Ultimate targets to be undearstood
Targets to be investigated in science
Knowlede to be obtained in science
Reportability
Attention
Working memory
Function of reportability
Function of attention
Function of working memory
Mechanism of the function of reportability
Mechanism of the function of attention
Mechanism of the function of working memory
The contents of consciousness
Mechanism of the content of consciousness
oBJe
Direct objectification

Figure 4