Consciousness, brains and the replica problem

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Although the conscious state is considered an emergent property of the underlying brain activity and thus somehow resides on brain hardware, there is a non-univocal mapping between both. Given a neural hardware, multiple conscious patterns are consistent with it. Here we show, by means of a simple gedankenexperiment that this has an important logic consequence: any scenario involving the transient shutdown of brain activity leads to the irreversible death of the conscious experience. In a fundamental way, unless the continuous stream of consciousness is guaranteed, the previous self vanishes and is replaced by a new one.

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I. INTRODUCTION

The problem of consciousness has become a hot topic of scientific enquiry over the last two decades (Searle, 2000, Crick and Koch, 1995, 2003). But in spite of this increasing attention from the neurosciences, old questions remain open and the phenomenon itself differs from other biological phenomena in that it is a subjective, first-person ontology (Searle, 2000). Such special status generates a number of nontrivial questions, some of them right in the boundaries between science and philosophy. Most neuroscientists, with few exceptions, would agree (even with different perspectives) that consciousness is a self-organized, emergent property of brain activity and neuronal wiring, although the nature and organization of the brain-mind mapping is largely unknown (Locke, 1995; Dennett, 1991; Hesslow, 1994; Svenson, 1994; von Wright, 1994; Crick and Koch, 2003). Multiple questions emerge from the previous scenarios, including the nature of the new consciousness emerging after recovery from long-term cryogenization or technological replacement (Moravec, 1988; Egan, 1994; Minsky 1994). Similar problems arise in different contexts, such as teleportation (Penrose, 1989). How can a transient shutdown of brain activity affect the conscious experience? All the previous situations inhabit the realm of speculation and might never be achieved. The potential implications are mostly a matter of philosophical speculation. There is, however, an experimentally feasible scenario where no such speculation is at work.

Recently, advances in suspended animation suggest the possibility of preserving human life in a reversible state where completely halted or deeply slowed cellular activity would be possible (Alam et al., 2005). Such state has been obtained experimentally using different organisms (Nystul and Roth, 2004; Blackston et al., 2005) and nothing prevents to reach similar results using humans. In fact, evidence from accidental, long-term suspended animation is available from a number of case studies. In these cases, humans experiencing severe hypothermia over several hours and showing lack of any vital sign (no pulse nor brain activity) were able to recover without any long-term complications. Ongoing research on using profound hypothermia, together with appropriate organ preservation fluids confirm that such reversible states can be induced in a repeatable manner (Alam et al., 2005). The method, used in swine animal models, results in clinical brain death, but none of the surviving hypothermic animals displayed detectable neurological deficits or cognitive impairment.

How can a shutdown of brain activity alter the nature of the self-conscious experience? In principle, you might think that your consciousness is temporarily stopped, just to be back afterwards. In other words, you and your consciousness weak up altogether. Is that really the case? To put the question in a more specific form, we consider a mental (Gedanken) experiment, which we will call the replica problem. Below we show, using a logic argument, that something much more fundamental is at work when considering scenarios involving consciousness and its relation to hardware. Together with brain death (no matter if permanent or transient) the death of subjective consciousness needs to be considered.

II. THE REPLICA PROBLEM

The following experiment is an imaginary one, not expected to be ever possible. It is thus a Gedankenexperiment, used as a logic argument to show the unexpected consequences of the one-to-many brain-mind mapping. It is important to stress that this is a thought experiment and is thus not expected to be possible. In this context, we are aware that quantum mechanics forbids the realization of the ideal experiment to be described below (Scarani et al., 2005) but that is not relevant to our discussion, particularly because quantum effects should not be expected to have a real relevance in large scale neural dynamics. However, although the special case considered here would require a high-level technology not available today, some equivalent scenarios (such as the induction of profound hypothermia discussed above) are likely to
be soon applied to human beings.

Let us take a given individual brain A, experiencing a given (self-)conscious activity. We can indicate that the conscious experience C is somehow generated by this brain A using a mapping:

\[ A \rightarrow C \] (1)

Where C must be interpreted as an emergent property of brain activity and involves both subjectivity and self-awareness. Let us now imagine that thanks to a very advanced technology a full copy of A can be obtained instantaneously at \( t = t_0 \). Considering instantaneous formation is not strictly necessary, but makes the argument simpler, since it liberates us from considering the further divergence of the two replicated systems. Let us call this new brain hardware \( A' \). This replica, if active, would generate a different conscious experience, which we indicate as \( C' \). Clearly we have now:

\[ A' \rightarrow C' \] (2)

the important point here is that, although exactly the same hardware is being used, we have \( C \neq C' \) (different subjective conscious experiences). This is true in spite that no single experiment made by some external observer would be able (at \( t = t_0 \)) to distinguish between A and \( A' \). The existence of a replica of A generates a somewhat strange situation, since clearly indicates that brain activity does not univocally define consciousness. This is what we name the replica problem. This problem has been explored by a number of authors (see [http://www.benbest.com/philo/doubles.html](http://www.benbest.com/philo/doubles.html)) and is our starting point.

Let us now consider A, with an associated conscious experience C. The brain-mind pair \( \{A, C\} \) thus fully defines the individual. Let us assume that brain activity is stopped through some process \( S \). If no brain activity is present, no conscious experience exists. The individual’s brain is dead, and will be indicated as \( \phi_c \), meaning ‘no consciousness’ (here the symbol \( \phi_c \) indicates lack of consciousness, without explicit reference to a given \( C \)). Now let us imagine that the brain is reactivated through some other process \( R \). The standard view considers the following causal set of events:

\[ \{A, C\} \xrightarrow{S} \{A, \phi_c\} \xrightarrow{R} \{A, C\} \] (3)

This logical chain of events corresponds to a common reasoning: my brain is frozen and stops working, but once a reverse process is used, brain activity returns and I wake up. Is that a correct answer? Which consciousness is experienced: the previous one \( (C) \) or a new one \( (C') \)? As shown below, a new consciousness is effectively at work, i. e. the correct sequence is in fact:

\[ \{A, C\} \xrightarrow{S} \{A, \phi_c\} \xrightarrow{R} \{A, C'\} \] (4)

and thus, in terms of consciousness, we never “wake up”. The reason is that the hardware does not univocally define the conscious experience, and thus there is no reason why the conscious activity emerging after recovering the stopped brain would be the same. However, you might argue that it is the same brain what is at work, and thus cannot be properly related with the replica problem, where two identical, but different brains are being used.
An additional experiment allows to better understand the implications of the replica problem. This extended replica problem can be used to see clearly why the new conscious experience is necessarily a different one. The basic steps to be described below are summarized in figure 1.

III. THE EXTENDED REPLICA PROBLEM

We now describe a special mental experiment involving the formation of a replica. In figure 1, individuals involving an active (and thus conscious) brain are indicated as framed black circles. If brain activity is stopped, the non-conscious state is indicated as an empty circle. If no brain is present, an empty box is shown.

Let us assume that we start with \( \{A, C\} \) and we make a material (but not active) copy \( A' \) of the initial brain. We have a new brain-mind system \( \{A', \phi_c\} \) with no conscious activity \( (\phi_c) \) and physically separated from the initial one (see upper part of figure 1a). If activated, \( A' \)'s brain would generate its own subjective conscious state, i.e.

\[
\{A', C\} \xrightarrow{R} \{A', C'\}
\]

with \( C' \) obviously different from \( C \) (lower right, fig. 1a). Now we shut down the activity of \( A \) i.e.

\[
\{A, C\} \xrightarrow{S} \{A, \phi_c\}
\]

And now let us replace \( A \) by \( A' \), i.e.

\[
\{A, \phi_c\} \rightarrow \{A', \phi_c\}
\]

Since the two brains are physically identical, no measurement would be able to detect any difference between the previous and the new hardware, and thus we have the equivalence:

\[
\{A, \phi_c\} \equiv \{A', \phi_c\}
\]

The logic implication is that they can be exchanged by each other (and any other exact copy) and would not be distinguished. But it is know obvious that the implanted brain, though identical, is not going to maintain the subjective conscious experience that we had at the beginning: it was a copy and following the previous implications we would have

\[
\{A, \phi_c\} \xrightarrow{R} \{A, C'\}
\]

The sequence of events described above is logically equivalent to starting from \( \{A, C\} \), stopping \( A \) from being active and restoring its function (ending up in \( \{A, C'\} \), as indicated in figure 1b. This completes our argument. To summarize: any process that either stops brain activity (and thus leaves us with a “just hardware” individual) or replaces a given brain structure by a completely new one (after stopping consciousness in its previous physical support) leads to a state of “dead consciousness”. As a consequence of the non-unique mapping between brain structure and consciousness, death of a given conscious experience will be irreversible.

IV. DISCUSSION

In this paper we have seen how the one-to-many mapping between brain and mind implies that any scenario involving transient brain death leads to the death of consciousness, as defined by a subjective, first-person ontology. The subjective nature of the self makes brain transfer and teleportation non-viable in terms of a reliable way of transferring the self to the new individual. These are, however, science fiction scenarios. However, as shown above, the same situation must be applied to surgery involving profound hypothermia: you (meaning your self) would never truly wake up once the normal brain function is recovered again. Someone else will, with exactly the same external features and memories as you, but experiencing a different consciousness. Under this view, no true immortality (the immortal nature of your self) is possible.

Although future technology might allow building a copy of our brains and make our memories and feelings survive, something will be inevitably lost. The argument provided here suggests that the “self” persists (it is alive) provided that the stream of consciousness flows in a continuous manner and is never interrupted. If it is, death of the self occurs in a non-reversible manner. This seems to provide an interesting twist to the mind-body problem.

Although the argument presented here is a logical one, further extensions of this study would involve brain states not necessarily associated to a complete lack of activity. More quantitative analyses could be made, involving different features of consciousness (Seth et al., 2006) and the possible localization of the conscious self-representation (Lou et al., 2004 and references therein). In this context, further questions arise: What are the minimum requirements in terms of brain activity able to sustain a conscious pattern? Are there partial changes inducing a loss of self-awareness related to our previous discussion?

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