Naturalizing the mind: binding common-sense functionalism and neuropsychology

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Abstract

A central puzzle discussed within contemporary philosophy of mind is the problem of mental causation, which raises the question of how is it possible that our mind constitutes the ultimate cause of behaviour, given that certain brain states seem to be causally sufficient for the production of the same behaviour. This problem found its contemporary canonical form in the work of Jaegwon Kim (Kim, 1998) and is known as the "causal exclusion problem".

I shall argue in this paper (section 1) that the causal exclusion problem turns out to be an argument in favour of the token identity solution to the problem of the nature of the mind/brain relation. Since ontological reductionism is not dissociable from epistemological reductionism, I shall present (section 2) the Esfeld-Sachse model of inter-theoric reduction by means of functionally defined sub-concepts. Using an example from neuropsychology (section 3), I will then show how it should be applied to the mind in order to establish systematic links between psychological and neuropsychological descriptions (section 4). For the same reason I will discuss an example of complex neuropsychopathology (section 5).

1. *Ontological and epistemological reductionism*

Ontological reductionism in philosophy of science is motivated by the causal exclusion argument (Kim, 1998), which favours the token identity solution to the problem of the mind/body relation. The causal exclusion problem arises through the inconsistency of the premises that i) mental property tokens cause physical property tokens to occur, ii) that mental properties are ontologically distinct from physical properties and iii) that any physical property token has a complete and sufficient physical cause.

Given theses premises, one has either a) to accept that mental properties systematically overdetermine occurrences of physical properties such as the production of behaviour, or b) to reject one of the initial premises. Systematic over-determination seems however difficult to defend. Given that there always are sufficient physical causes anyway if there are causes at all, considering additional mental causes for some physical effects appears to be redundant. If systematic over-determination is rejected, then one of the first three premises has to be let out. Since rejecting the causal efficiency of mental properties would be to throw away the baby with the bath's water and since rejecting the completeness of the physical domain would be highly counter-intuitive, it seems that solving the causal exclusion problem requires to subscribe to the token identity thesis, which we take to be the core of ontological reductionism: everything that there is in the world is identical with physical property tokens. There are no ontological layers and one and the same reality makes true descriptions at different levels. There are several descriptive modalities to grasp the very same causal relations and, thus, the identity thesis can prevent mental properties of being epiphenomenal.

Epistemological reductionism is a more contested thesis claiming that it is in principle possible to reduce every true description of what there is in the world to a description formulated in the terms of fundamental physics. Since the 1970s, the multiple realization argument (MR) has been considered as a conclusive argument against epistemological reductionism. Since the entities in the world that make true one particular high level description possibly fall under different lower level descriptions. The mainstream interpretation of MR concludes that bi-conditional links between high-level concepts and low-level concepts, in last resort physical ones, cannot be established and concepts of higher and lower level descriptions cannot be unambiguously coordinated. Therefore, in cases where MR applies, inter-theoric reduction is not possible. This is precisely the case with respect to the relation between folk-psychology and neuroscientific terms describing candidate causes of human behaviour.

Notwithstanding, ontological reductionism is not dissociable from epistemological reductionism. The former implies that one and the same kind of property token make true physical description as description of the special sciences. But if epistemological anti-reductionism is true, there would be some causal relation between entities that physics cannot grasp. In this case, there would be some entities which make true special-science descriptions and that physics cannot describe successfully. These entities would be something non-identical with physical property token and, consequently, ontological reductionism would be false. Reversely, epistemological reductionism entails ontological reductionism. If any true description of the world can be in principle reduced to a description couched in terms of fundamental physic, then all there is in the world is identical with physical property tokens and their configurations. Thus, ontological and epistemological reductionisms are not dissociable and, in the light of the causal exclusion argument, philosophy of mind has to go for inter-theoric reduction.

2. Functional reduction

Inter-theoretic reduction is back in the debate since Kim has published his kind-specific account of functional reduction (Kim, 1998, Kim, 2005). However, since this account pays a heavy tribute to the MR argument by loosing the homogeneity of high level descriptions inclosing a kind-specific limitation (Sachse, 2007:125), I shall rely here to the model of functional reduction by means of functional sub-concepts developed by Esfeld & Sachse (2007), which is beholden to the Kim account but does not include such a kind-specific limitation. Sachse (2007) applied in details this model to reduce classical genetics to molecular genetics. The three next sections will be devoted to the application of this model to the reduction of functionalized common-sense psychology to neuropsychology. Note that I will focus here on functionalized mental properties, leaving aside the problem of *qualia*.

The general account of functional reduction, also called the "Ramsey Lewis" reduction, runs as follow. The first step consists in the functionalization of the to be reduced properties by defining them in terms of a characteristic causal role. Common-sense functionalism, in the spirit of David Lewis (1994), offers such a possibility to interpret ordinary psychology as a functional special science. The causal role is implemented in the world by some configuration of physical property tokens. The discovery of such a configuration of physical property tokens making true the functional description of step 1) constitutes the second step of reduction. This description is couched in lower science vocabulary and, in the last resort, in the terms of physical sciences. Finally, one has to show how the physical description of the truthmaker of the high level description explains why this is a case of the relevant causal role.

The main problem of Kim's position is that it does not take the homogeneity of functional descriptions into account, since one and the same functional role can be realized by different physical types. That is why Kim is unable to find a systematic link between higher and lower levels of description under the form a descendant conditional. Hence, Kim's reductionist theory cannot provide a reduction of psychological phenomena *tout court* due to the phenomenon of multiple realization. Instead, he can offer species-specific reductions only.

The proposal of Esfeld & Sachse takes up the criticism of the common interpretation of multiple realization due to Bechtel & Mundale (Bechtel and Mundale, 1999) and McCauley (McCauley, forthcoming). As these authors have pointed out, multiple realization is an illusion arising from the fact that common functional descriptions are coarse-grained, whereas physical descriptions of realizers are fine-grained. This is why functional descriptions have a larger extension than physical descriptions. In order to establish co-extensionality between high and low level descriptions, the central idea of the Esfeld-Sachse model of reduction is to introduce more fine-grained functional descriptions by means of functionally defined sub-concepts.

The argument is the following (Esfeld and Sachse, 2007:5):

1) Assume that two physical entities, p_1 and p_2, fall under physical descriptions P_1 and P_2 and fall both under functional description F. There is in this case a systematic difference in

the way in which p_1 and p_2 bring about the effect that characterizes *F*. Since tokens p_1 and p_2 are different from the physical point of view, they fall under physical descriptions P_1 and P_2 and those types enter in different causal laws.

2) Any such physical difference leads to a systematic difference in the production of functional side-effects aside the production of the effect characterizing *F* and there are physically possible conditions under which those side-effects manifest themselves in a functional salient way. In other words, there are systematic variations in the way that different entities fulfil their typical causal roles. Hence, the difference can be grasped in a functional description.
3) On the basis of those side-effects and their manifestation under critical conditions, functionally defined sub-concept of *F* can be build. All of those sub-concepts include the definition of *F* but are individuated by taking account in a functional way of the side-effects peculiar to each physical type. For any functional description *F* and any physical description P_1 of *F*, it is in principle possible to conceive a functional sub-concept F_1 of *F* that is co-extensional with description P_1.

Note that the procedure is repeatable. We can in principle construct functional sub-concept F_{1a} of functional sub-concept F_1 of *F* until our final sub-concepts are no longer multiply realizable.
In the three next sections, I will present guidelines for the application of this strategy. The goal is to show how to construct functionally defined sub-concepts F_1 and F_2 of a more general functional concept *F* in order to be able to distinguish between truthmakers of *F* that falls under different neuropsychological descriptions. In sections 3 and 4, I will introduce a very simple example in order to show clearly how to apply this model of reduction to the relation between functionalized folk psychology and neuropsychology. The section 5 will be concerned with the application of the sub-concepts strategy of reduction to an example of more complex neuropsychopathology.

3. Disconnection syndrome: split-brain patients

The concept "inter-hemispheric disconnection syndrome" picks out a set of behavioural abnormalities arising, from the neurological point of view, from injuries or from a total lack of corpus callosum. The corpus callosum is a large medullary strip linking both hemispheres of mammalians brain allowing information exchange between the two half-brains. It is composed of circa 200 to 800 millions of commissural fibers that can be tied up in three main classes (Kolb and Whishaw, 2003:428-30). Most of them are topographic in the sense that they connect nervous areas to their respective contralateral counterpart. A second group of connections goes to areas to which the homotopic area on the contralateral side projects. For example, area V1 of the right left visual cortex is connected both with right and left V2 and the same for area V1 of the left hemisphere. A last group of inter-hemispheric connections has diffuse terminal distributions.

Damages to the corpus callosum can accidentally occur, for example in the case of a tumour localized in the area of the central commissure. A lack, partial or total, of corpus callosum is due either to a congenital malformation, or to a surgical ablation. The therapeutic commissurotomy has been reintroduced in the early sixties by the surgeons Philip Vogel and Joseph Bogen as an elective treatment for severe cases of epilepsy. The motivation for such a heavy and irreversible surgery lays in the interpretation of hard epileptic crises as an electro-magnetic storm spreading itself trough all the brain from isolated sources of unrest (Purves et al., 2002). Removing the corpus callosum "*helps to confine the epileptic seizure to one side and tends to preserve consciousness during an attack* […] *and enables the patient to take precautionary or control measures at onset of a seizure*" (Sperry et al., 1969:274).

Behavioural issues of commissurotomy have been extensively studied in medicine as in neurosciences since the re-introduction of this surgery. The most surprising result is the apparent lack of change with respect to the daily life (Sperry, et al., 1969:275). One year is in general required for recovery of surgery but within two years, the patients are able to return to school or go to work. A conventional medical examination cannot reveal anything extraordinary in the behaviour of these patients (Kolb and Whishaw, 2003:433). One needs specific cognitive tests to detect from the behavioural point of view differences between split-brain patients and healthy subjects and to show that "*in the split-brain, each hemisphere can be shown to have its own sensations, percepts, thoughts, and memories that are not accessible to the other hemisphere*" (Kolb and Whishaw, 2003:433).

Standard tests allowing discriminating between split-brain and normal patients aim to determine if sensory information presented to only one hemisphere is at disposal of both or only one hemisphere. For example, a very simple test consists in asking an individual to touch an out-of-view object with the left hand and to find a similar object with the right hand. As the left hand is under the motor and somesthesic control of the lone right hemisphere and vice versa for the right hand, in the absence of inter-hemispheric communication, split-brain patients are unable to match the objects correctly. Many tests exist and are devoted to isolate the specific behaviour of split brain patients with respect to many motor tasks and sensory modalities. Although we are not interested in developing all these cases, let me enter the subject of split brain patients in more detail by briefly discussing the relevance of the perception and recognition of objects.

The visual system is crossed in a very specific manner. Roughly speaking, visual information of the left half visual field is computed by the right hemisphere and vice versa. Of course, since this crossing concerns the visual hemi-field and not the eyes themselves, the structure of the central visual pathway is quite sophisticated. Optical signals incoming from the left visual field are received by the right half part of the retina of each eyes. Both of them are connected to the right lateral geniculate nucleus through the optic nerve and the optic chiasm. From there, the information is forwarded by the optic radiations to the layer IV of the right visual cortex, namely the right striate cortex.

In the case of normal agents, information from a specific half visual field is available to both hemispheres. First of all, the corpus callosum connects both hemispheres together, tying up homologous areas of the left and the right hemispheres. In the case of visual information, area VI on the left is, as said, linked with V1 and V2 on the right. Secondly, eyes keep scanning micro-movements permanently. These unconscious micro-movements have the effect of distributing in both sides of the visual system a large part of the information that would be restricted, in the absence of those scanning micro-movements, to a specific side of the visual system before this information is forwarded trough the corpus callosum to the contralateral visual system side.

The existence of these scanning micro-movements explains why split-brain patients are able to live quite normally in spite of the lack of communication between both hemispheres. Scanning micro-movements provide a natural and very powerful mechanism of compensation that allows them to generate, for example, verbal reports about what stands on their left side even if the main language areas are localized in the left hemisphere. In the normal case, visual information is processed separately by each lateral visual pathway, as described earlier, up to the primary visual cortex, before being sent to the double visual pathways (Jeannerod and Jacob, 2005), which includes a temporal and a parietal stream of data. The left sided part of the former stream enables verbal reports of visual information by connecting the posterior speech zone with the left primary visual cortex and, in the case of a normal subject, with the right primary visual cortex through the corpus callosum (Kolb and Whishaw, 2003:440).

As said above, specific tests are required to discriminate between normal and split-brain agents from the behavioural point of view. In the case of visual perception, classical tests run as follows (Sperry, et al., 1969:275-77). The subject is seated at a table and faces an adjustable screen that prevents him to see his hands. Images are flashed on one or the other half of the screen whilst the subject is asked to fix a red dot in the central part of the screen. Images are flashed during circa 1/10 second to prevent eyes' scanning micro-movements of bringing information to both hemispheres. Visual material can that way be presented selectively to one specific or both hemispheres. Objects are placed on the table in the back of the screen in such a way that the experimenter can ask the subject to identify them just by touching them.

The commissurotomized patients appear to be essentially normal with respect to the right half visual field under these testing conditions. They can describe, read and use visual material as before the surgery. But if an image is flashed on the left side of the screen in a randomized sequence of stimulations, verbal reports of patients tend to show that they do not perceive the stimulus. However, if the time duration of the presentation of the stimulus is increased, patients are able to report what is presented in the left visual hemi-field. It should be emphasized that commissurotomized patients do not recover their pre-surgery abilities in the effectuation of such tasks. The behavioural consequences of commissurotomy appear to be definitive. Hence, a specific deficit in the information forwarding is hypothetisable.

Looking at behavioural effects of the commissurotomy, these results could also be taken as indicating a defect in the right visual system of those patients. But further tests exclude this possibility: when non verbal responses are employed to evaluate patients' perceptions, we can be sure that they understand the task and that they perceive and identify the stimulus. For example, if an image of an object is flashed on the left visual hemi-field, in spite of the pathological incapacity of verbally reporting the stimulus, patients are nonetheless able to pick out by touch with the left hand a corresponding object in a collection of other items. This demonstrates that right sided visual abilities of these patients are clearly unimpaired by the commissurotomy. A defect in verbal abilities is as well excluded since the subject can construct complex verbal reports about right-sided stimulations.

A large variety of such visual tests confirm the conclusion that in the case of commissurotomized patients, things seen in the left and right halves of the visual field are processed separately in each hemisphere. Normal interaction between elements within each half-field is preserved, but split brain patients cannot integrate information of both halves of the visual field. However, basic mechanisms allow these patients to have a normal life, although their behaviour differs notably in many aspects once we use specific cognitive tests to complete our descriptions of their behaviour. Using such cases as example, the next section of this paper should make clear how the sub-concept strategy of reduction can be applied to the case of the relation between common-sense functionalism and neuropsychology.

4. *Application of the sub-type strategy to mind using split-brain example*

Let us begin with the following example. Take two individuals, Jack and John, watching TV and speaking about a movie running on the screen. Both can be described in psychological terms as *perceiving* the screen of the TV and common sense functionalism enables us to ascribe to each of them a mental state, namely a perceptual state that can be functionally defined as follows[1]:

> (A) A subject *S* visually perceives an object *x* if, when he looks conspicuously at *x* and when he desires to give a verbal description of *x*, *S* describes verbally successfully *x*.

A generic functional formulation of this descriptions can be given in the classical Ramsey-Lewis shape of theoretical concepts:

> (F) $(\exists x)(\exists y)(\exists z)(\exists w)(\exists u)((x$ is caused by environmental conditions c_1 v c_2 v … v c_n,) & (x tends to cause mental states y v z or x to occur) & (x tends to cause behavior b_1 v b_2 v … v b_n))

Let us introduce in our example the fact that John is a split-brain patient. We have here a perfect example of multiple realization: one and the same functional description is made true by two individuals falling under two distinct neuropsychological descriptions.

Because both individuals are neurophysiologically different, visual information is not processed by their respective brain in the same way. As the last section showed, those differences are detectable behaviourally in specific circumstances only. Suppose that the movie that Jack and John are currently watching together contains a set of very short and left-sided apparitions of the final monster that the heroes have to kill. If the apparitions do not excess 1/10 second, John will be unable to notice it and this can have some consequence for certain part of his behaviour, namely in the commentary he will give to Jack. Such differences in behaviour are nothing but the side-effects we mentioned in section 2 and that enable us to construct functional sub-concepts of the considered functional concept by accumulating behavioural observations in order to sharpen the grain of our psychological description.

[1] Of course there are many other cases of perception, as common sense ascribes this type of mental state in a lot of other scenarios. For example, verbal report is not a necessary condition for perception. But our purpose is here not to give an extensive functional description of perception.

> (A') A subject *S* visually perceives a movie if, when he looks conspicuously at the movie and when he desires to give a verbal description of it, *S* describes verbally successfully the movie *including a references to left-sided apparitions of less than 1/10 second.*
>
> (A'') A subject *S* visually perceives a movie if, when he looks conspicuously at the movie and when he desires to give a verbal description of it, *S* describes verbally successfully the movie *excluding left-sided apparitions of less than 1/10 second.*

(A) is a functional statement made true by both Jack and John. Our functional subtypes (A') and (A'') apply to just one of the two individuals, the former to Jack and the latter to John. In other words, adding specifications in our functional description reduces the extension of the statement. Of course, statement (A'') does not apply only to John or only to split-brain patients looking at the TV. There are several other explanations of the fact that John does not notice the brief apparitions of the monster. But we should be able to provide some further specifications to the functional description in order to delimit more finely its extension. For example, since split-brain patients have distinct memories and motor abilities (Kolb and Whishaw, 2003:433), John is able to draw the monster or to pick out a similar object in a collection of movie's tie-in product with the left hand, since this hand is under control of the right hemisphere, which is in possession of visual information concerning the monster. In that case, the new functionally defined sub-concept captures precisely the behavioural specificities of a split-brain patient, namely e.g. the inability to successfully match sensory information originating solely from one side of the body with similar information originating from the other side. That way, introducing functionally defined sub-concepts for both normal and split-brain patients of our over-simplified example enables us to reach the required condition for inter-theoric reduction, namely co-extensionality and bi-conditional bridging principles. Furthermore, neuroscience explains why the truthmaker of each functional sub-description produce a specific behaviour.

5. Critical conditions of manifestation and the quest for function localization

The approach presented above depends crucially on the possibility of finding adequate testing conditions that make salient the functional side-effects in order to be able to discriminate from a purely behavioural point of view the physically different truthmakers of a given mental description. The question remaining at this stage is whether it is possible to find such adequate conditions for every case of neuropathology, especially for complex pathologies that have diffuse behavioural effects. My claim is that finding such conditions is nothing but the daily practice of neuropsychologists. These scientists typically try to locate within the brain the structures processing different cognitive functions. Their experiments are designed to create a statistically significant contrast between control subjects and pathological or medicated patients precisely in order to show the causal impact of neural specificities on the production of behaviour.

The localization of cognitive functions has been conducted for a long time by comparing healthy brain and behaviour with pathological patient through post-mortem investigation of brain structure. History of neurosciences contains several examples, such as the double dissociation between lexical function of Wernicke's area and syntactical function of Broca's area. Damages to the Wernicke's area cause impairment in language understanding and in production of meaningful sequences of words. Damages to the Broca's area tend to cause impairments with respect to the syntax of speech and difficulties in the understanding of grammatically complex sentences. Such dissociations remain the basis for the localization of cognitive functions, even if the recent development of modern neuroimaging multiplies the possibilities of investigation. Neuroimaging enables to observe directly neural activity and, that way, to establish a correlation between a specific result in the execution of a behavioural task and a particular neural activation or lack of activation.

In order to establish such correlations, the key issue is to design an experimental set up that requires of the tested subjects to execute a task, which is as close as possible to the cerebral area's hypothesised cognitive function. The difficulty for neuroscientists consists therefore, firstly, in hypothesising an existing cognitive function, i.e. in developing a model of brain information computation using the right taxonomy of functions and mechanisms (Craver, 2007:128), and, secondly, finding an experimental protocol that requires of subjects ideally nothing but the execution of that very precise function. In such condition, neuroscientists are able to correlate behavioural results with patterns of neural activities.

Let me take as an example of complex neuropsychological pathology the recent developments in the identification of the neural mechanisms of recognition of self-generated actions and their pathological failure in the case of Schneiderian schizophrenia. From a cognitive point of view, the central monitoring hypothesis constitutes the current general framework for understanding the mechanism of recognition of self-generated actions. Roughly, the idea is that "*each time the motor centres generate an outflow signal for producing a movement, a copy of this command ("the efference copy") is retained. The reafferent inflow signals are compared with the copy. If a mismatch arise between the two types of signals, new commands are generated until the actual outcome of the movement corresponds to the desired movement*" (Jeannerod, 2003:8). Self generated actions recognition is in that framework based on the concordance between a desired action and its predicted sensory consequences.

Impairment of theses mechanisms leads to cognitive impairments characterizing Schneiderian schizophrenia, such as auditory hallucinations, thought insertion, feeling of other's influence on the patient's thoughts, actions and emotions (Farrer et al., 2004:31), but also such as altered perception, delusions and beliefs, which distort reality (Kolb and Whishaw, 2003). For example, auditory hallucination such as voices hearing are explained within the framework of the central monitoring hypothesis as a pathological incapacity of the patient to recognise his own inner speech as their own (Franck et al., 2001). The motor areas are engaged offline in order to generate an inner linguistic representation (the inner speech), but the auditory cortex interprets this activity as if it were produced by an external cause (Jeannerod, 2003:14). Schizophrenia appears that way as a pathology affecting the communication and the comparison of information between motors and sensory area.

In order to investigate the localization of the mechanisms of self-generated action recognition, many successive experimental designs have been set up (see Jeannerod, 2003 for a review). Farrer et al. (2004) designed an experiment whose central idea was to develop a task requiring of the subject to mobilise nothing but the execution of the investigated cognitive function, namely the comparison between a motor command and its intended result. The experimental set up used was then one in which both healthy subjects and pathological patients had to judge whether the images representing results of their respective actions on a screen were effects of their own manipulations of an out-of-vision joystick, or whether they were not. The experimenter was able to vary the degree of discrepancy between patient's inputs and visual output on the screen. Without entering in more details with respect to this experiment let us highlight the two following points.

First of all, neuroimaging study of healthy subject enables neuroscientists to correlate a task execution with a delimited pattern of neural activity. In the case of the studies of Farrer, a correlation has been reported between the degree of control by the subjects of the perceived movement on the screen and the activation of the right angular gyrus (Farrer et al., 2003, Farrer, et al., 2004:37), particularly of Brodman area 39 and 40 on the right side (reported in Jeannerod, 2003:9). Maximal activation occurred when the movements shown to the subject were unrelated to the subject's own movements.

But this correlation does not count in itself as a proof that the considered area is causally responsible for the correct task execution. It's only once one can compare, and that's our second point, the results obtained with healthy subjects with results of impaired patients that the relation between neural activity and behaviour takes the form of a counterfactual dependency that enables to consider the localized neural activity as a genuine cause for the observable behavioural specificity, what is in fact the result obtained by Farrer's research group. Schizophrenic patients perform very poorly the experimental task, showing that they encounter difficulties in discriminating self-generated movement of alien generated movement, while exhibiting an aberrant activity of the right angular gyrus in the very same experimental conditions (Farrer, et al., 2004:37, 42). This result confirms the hypothesis that the right angular gyrus is the locus of the comparison between efferent copy and reafferent signal (Jeannerod, 2003:9). Moreover, this result is consistent with the effects of severe lesions of the right parietal lobule. Patients suffering from such lesions also present cognitive impairment in discriminating the self from the world, manifesting the symptoms of the unilateral neglect syndrome. They frequently deny ownership of the left side of their body (Deprati et al., 2000) but also fail to recognise authorship of self-produced actions (Sirigu et al., 1999).

These results confirm the current explanation of the schizophrenia disease. Hallucinations and delusions are understood in terms of abnormal interactions between different cortical areas. This dysfunctional integration is explained at the cognitive level, in the framework of the central monitoring theory, as a failure to integrate perception and action and at the physiological level as a defect in connectivity (Farrer, et al., 2004:41). This abnormal connectivity "*disrupts the modulation by frontal region of those more posterior brain areas involved in the processing of the sensory consequences of an action*" (Farrer, et al., 2004:41), making difficult the identification of the source of the perception as internal or external. The incriminate absence of modulation then causes the primary sensory area relative to the perceptive modality in which the hallucination occurs to process the sensory consequence of action as if it would be the result of an external cause (Blackmore et al., 2000, Frith and Dolan, 1996).

Let's return to the functionally defined sub-concepts strategy. The example of such a complex neuropsychological pathology enables us to make the following remarks. First of all, such research proceeds from the possibility of finding test conditions that enable to investigate precisely our hypothesis with respect to the cognitive sub-functions that together compute the studied cognitive ability; here the ability of recognising self-generated actions. This possibility is open de facto in cases of schizophrenia and other neuropsychopathologies, since all of these concern cases where the impairment is observable from the behavioural point of view. However, the difficulty consists in setting up an experimental design that captures and tests precisely the incriminated part of the behaviour, in order to be in a position to correlate the behavioural results of the test with a very narrow cognitive sub-function, whose neural implementation is observable through imagery.

Secondly, comparison of the results obtained both behaviourally and through imagery with lesioned or pathological cases enables us to isolate the neural causes of the pathology. Neural pattern of activations observed within subjects performing specific tasks inform us about the locus of a given cognitive function execution just in case where the way of doing the task is correlated with a specific neural pattern of activation or structural specificity.

Thirdly, the cognitive tests used by neuropsychologists capture critical conditions that enable us to establish a contrast at the physiological level that mirror the contrasted results obtained at the behavioural level. These critical test conditions are precisely the salient conditions required in order to construct functionally defined sub-concepts for the Esfeld-Sachse strategy of reduction. In the case of schizophrenia, healthy and pathological subjects are clearly discriminable through their results in the test used in the experimentation of the Farrer research's group. Since the results of these tests are graspable from a behavioural point of view, they are usable in order to make precise our mental functional definitions, as explained in the case of split-brain patients. Of course, the detailed functional reports engaged in the case of such a complex pathology as schizophrenia will be much more complex.

The requirements for the functionally defined sub-concepts are thus met. First, the possibility of constructing sub-concepts is open for complex neuropathology with the result that the co-extensionality between fine-grained psychological descriptions and neurological descriptions is obtainable in general. Second, neuroscience progresses currently in order to produce reductive explanations of the neural causes of pathology such as schizophrenia. The possibility of such an explicative account is the shared criterion for both Kim's and Esfeld-Sachse's strategies.

At this point, it should be clear that there is no objection in principle as to why the procedure should not be applicable to each pathology within neuropsychology, i.e. to pathologies, whose effects are observable from the behavioural point of view. Hence, it is in principle possible to introduce a functionally defined sub-concept of a mental concept for each type of neuropsychological realizer, i.e. for normal individuals in contrast to split-brain or schizophrenian patients, but also for neglect patients, blind-sighted patients, and so on. What is required is just to sharpen in the following way the functional reports, using the behavioural testing tools of neuropsychology:

> (F) $(\exists x)(\exists y)(\exists z)(\exists w)(\exists u)((x$ is caused by environmental conditions $c_1 \vee c_2 \vee \ldots \vee c_n)$ & (x tends to cause mental states $y \vee z$ or x to occur) & (x tends to cause behavior $b_1 \vee b_2 \vee \ldots \vee b_n$)) + further descriptions of actual causes + further descriptions of mental states implicated + further descriptions of actual behavioral effects of x.

This is possible because all neurological pathologies induce specific behavioural effects that neuro-sciences use to build a global theory of the production of behaviour by the brain. But we should be able to go further by applying our procedure to distinguish between strictly normal realizations as well. Since, as outlined in section 2, composition and structure differences imply causal differences, we should be able to find critical situations where differentiations in the structure of normal brains are linked with specific cognitive abilities and, hence, that are themselves observable in the behaviour. These behavioural differences can then be used to construct more finely grained sub-types of our traditional functional descriptions. The procedure is in principle reproducible down to the physical description of the brain. Of course, functional descriptions matching physical specificities have to be extremely detailed, but that's a practical problem, the abstract possibility remaining open.

6. Conclusions

According to our argument, guidelines for applying the Esfeld-Sachse model of reduction by means of functional sub-types to mental states should be the followings. First of all, ordinary psychology has to be arranged in accordance with the standard functionalist interpretation of special sciences, using common-sense functionalism or scientific functionalism. Mental property tokens are thus identified through their characteristic causal role, although being ontologically identical with physical properties. Second, neuropsychology explains how a specific brain produces certain behaviour and why neural specificities lead to variations in the way of producing the behaviour. Third, we can construct functionally defined sub-concepts of mental descriptions using standard cognitive tests in order to hit co-extensionality between sub-concepts, whose description is couched in the vocabulary of common-sense functionalism, and the corresponding neuropsychological descriptions. Those cognitive tests are designed to grasp functional side-effects produced by specific neuropsychological realizations of mental states. Ultimately, since any compositional differences imply causal differences, it should be possible to replicate this procedure to reduce neuropsychological descriptions to some more fine-grained neuroscientific descriptions, and, in the last resort, to a physical description of the brain.

The present paper focuses on the relation between ordinary psychology and neuropsychology, two kinds of descriptions that make reference to observable behaviour. However, since the main target of such an account is to escape the anti-reductionist consequence of MR, it is desirable to apply the strategy down to physical level of description, since the neuropsychological types used here are themselves multiply realizable. The main difficulty arising here is to make sure that every variation in the realization will lead to observable differences in the behaviour within critical condition, even if the precision of neurobiological descriptions is required in order to distinguish between realizers from the point of view of the lower level of description. In other words, if this paper opens the way in order to produce mental functional description fine-grained enough to match the precision of neuropsychology, a theory about how to pursue the same strategy with respect to the relation between neuropsychology and neurobiology is still to be worked out.

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