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A CASE OF MIND/BRAIN IDENTITY: ONE SMALL BRIDGE FOR THE EXPLANATORY GAP

ABSTRACT. Based on the technique of pressure blinding of the eye, two types of after-image (AI) were identified. A physicalist or mind/brain identity explanation was established for a negative a AI produced by moderately intense stimuli. These AI's were shown to be located in the neurons of the retina. An illusory AI of double a grating's spatial frequency was also produced in the same structure and was both prevented from being established and abolished after establishment by pressure blinding, thus showing that the location was not more central. The illusory AI was predicted from the known non-linearity in the retina and this is the first case of a clear cut type-type identity of a sensation and a neural process. Some implications for the concepts of the explanatory gap between neurology and consciousness and multiple neural realizations of conscious states and topic neutrality are discussed.

Bechtel and Mundale (1999) have argued that the view that psychological states are multiply realizable has become orthodoxy in the philosophy of mind. This claim of multiple realizability is the claim that the same psychological state can be realized by different brain states, and thus that there could no identity relation between types of brain states and types of psychological states. Heil (1999) has argued that "Multiple realizability has been a central theme in anti-reductionist arguments designed to show that the mental is not reducible to the material" (p. 189). Block and Fodor (1980) emphasize this problem by arguing that "it is possible that the type-to-type correspondence required by behaviorism or by physicalism should turn out to obtain. The present point is that even if behavioral or physical states are in one-to-one correspondence with psychological states, we have no current evidence that this is so" (pp. 238–239). This has led to an enormous literature in which either functionalist token-token identity or non-reductive supervenience is proposed instead of type-type identity (Kim 1992; Macdonald 1992; Jackson and Pettit 1990). The aim of this paper is to suggest that despite these theories, a type-type identity relation can be given for some psychological states, as suggested by early identity theory. It is worth while examining the identity theory again, since Bechtel and Mundale (1999) conclude "that the claim that psychological states are in fact multiply realized is unjustified" (p. 177). Modern identity theory commenced because an Australian school of materialist philosophy was

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developed at Adelaide University, ironically, by two Englishmen (Place 1956; Smart 1959). The approach asserted an identity between mental processes and brain processes. Both Place and Smart confined their identity theory (IT) to sensations, but later Australian philosophers (Armstrong, 1968, 1980) extended the concept to all mental processes, such as thinking and feeling. This paper will confine itself to the case of sensations. Place (1956) argued that cognitive concepts such as knowing, believing, remembering and volitional concepts such as wanting and intending could be given a dispositional account. But he said "on the other hand, there would seem to be an intractable residue of concepts clustering about the notions of consciousness, experience, sensation and mental imagery, where some sort of inner process story is unavoidable" (p. 44). Place (1970) argues that "The thesis that consciousness is a process in the brain is put forward as a reasonable scientific hypothesis not to be dismissed on logical grounds alone" (p. 42).

Place (1956) points out that even famous physiologists, such as Sir Charles Sherrington concluded that an identity could not be found as there are "two continuous series of events, one physico-chemical, the other psychical, and at times interaction between them" (Sherrington 1947, pp. xx–xxi). Place argues that this is due to what he calls the 'phenomenological fallacy'. He says that "This logical mistake – is the mistake of supposing that when the subject describes his experience, when he describes how things look, sound, smell, taste, or feel to him, he is describing the literal properties of objects and events on a peculiar sort of internal cinema or television screen, usually referred to in modern psychological literature as the 'phenomenal field' " (p. 49).

Place concludes that the real situation is the reverse of this. "We learn to recognize the real properties of things in our environment. We learn to recognize them, of course, by their look, sound, smell, taste and feel – it is only after we have learned to describe things in our environment that we learn to describe our consciousness of them" (p. 49).

He then argues that once we rid ourselves of the phenomenal fallacy we realize that the problem of explaining introspective observations in terms of brain processes is far from insuperable. He then asserts a claim that was taken up by Smart (1959) that "when we describe an after-image as green, we are not saying that there is something, the after-image, which is green; we are saying that we are having the sort of experience which we normally have when, and which we have learned to describe as, looking at a green patch of light" (p. 49). It is interesting that this paper has been so influential, yet it nowhere discusses any evidence relating to how an identity would be realized or confirmed or even identified.

Smart (1959) extended and defended Place's position. In doing this Smart answered a number of objections to the proposed identity. Objection 3 stated that while it might be possible to get out of asserting the existence of irreducibly psychic processes, one could not get out of asserting the existence of irreducibly psychic properties. Smart's main reply to this was to expand Place's notion of not having an after-image but instead having an experience of an after-image. This reply introduced Smart's concept of topic neutrality. He says "when a person says 'I see a yellowish-orange after-image', he is saying something like this: '*There is something going on which is like what is going on when*' I have my eyes open, am awake, and there is an orange illuminated in good light in front of me, that is, when I really see an orange – notice that the italicised words, namely 'there is something going on which is like what is going on when' are all quasi-logical or topic-neutral words" (p. 149).

To objection 4 that an after-image is not in physical space, but a brain process is, so therefore the after-image cannot be a brain process; Smart replied as follows; "It is the *experience* which is reported in the introspective report – there is, in a sense, no such thing as an after-image or a sense-datum, though there is such a thing as the experience of having an image, and this experience is described indirectly in material object language, not in phenomenal language, for there is no such thing" (p. 150–151).

It is important to note that Smart like Place assumes that the thesis is a scientific hypothesis, although Smart concedes that no conceivable experiment could decide between materialism and epiphenomenalism. But also like Place, Smart does not examine any scientific evidence for the hypothesis or consider how it could be tested, he simply asserts that Occam's razor is sufficient. He says "If it be agreed that there are no cogent philosophical arguments which force us into accepting dualism, and if the brain-process theory and dualism are equally consistent with the facts, then the principles of parsimony and simplicity seem to me to decide overwhelmingly in favour of the brain-process theory" (p. 156).

In Borst (1970) are published a number of papers criticising Smart's position. Shaffer (1970) makes some important points about the criteria that are needed for mind/brain identity to be successful. He argues that there are three necessary conditions for this type of identity and the three conditions are jointly sufficient. The three conditions are that the two terms of an identity must (1) be located in the same place, (2) must occur at the same time and (3) the presence of one must be an (empirically) necessary condition for the presence of the other. Neither Smart or Place have considered these criteria. Rorty (1970) proposes even more stringent criteria

for identity. He asserts that "(1) that one-one or one-many correlations could be established between every type of sensation and some clearly demarcated kind(s) of brain processes; (2) that every known law which refers to sensations would be subsumed under laws about brain processes; (3) that new laws about sensations be discovered by deductions from laws about brain processes" (p. 190). Taylor (1970), in his attack on Smart's identity theory, takes a very pessimistic view about the possibility of such identities. He says that "Even granting that we may be able to account for behaviour by laws and conditions expressed exclusively in physiological terms, it does not follow that we can discover correlations between, say, after-images and brain states, or physical sensations and states of the body. For there is nothing that guarantees that a given after-image, judged the same on repeated occurrences in virtue of its phenomena properties, will always be accompanied by the same brain state, or even finite disjunction of brain states" (p. 235). It is proposed to cite evidence about after-images (AI's) that will meet these criteria for identity.

Although the AI has been extensively discussed in the philosophy literature (Armstrong and Malcolm 1984; Smart 1959, 1995; Boghossian and Velleman 1989; Bigelow et al. 1990), there has been little analysis of the relevant after-image literature. In an important study, Virsu and Laurinen (1977) have shown that there are two types of AI, each with a different location in the visual system. They employed the technique of reversible pressure blinding of the eye, which was applied during and after the adaptation producing negative AI's. This pressure blinding was achieved in less than 30 sec by pressing the lateral canthus by a finger supported against the zygomatic bone. There are two sources of blood supply to the eye (Brown 1968). The pressure blinding blocks the retinal blood supply but does not block the blood supply to the receptors, which arises from the choroid blood supply. (Brown 1968). Virsu and Laurinen (1977) found that pressure blinding did not effect long lasting negative AI's produced by intense stimuli, which also produced photochemical bleaching in the receptors. They called this AI the "bleaching image" and was thus identified as occurring in the receptors. However, when weaker, non-bleaching stimuli were used, then pressure blinding prevented any negative AI being produced. Thus this AI was occurring in the neural part of the retina, most likely in the ganglion cells, as these degenerate and disappear when the retinal blood supply is blocked (Brown 1968). They called this negative AI the "sensitivity image". When pressure blinding was applied after a negative AI was formed to a moderate stimulus, then all AI's were obliterated. This indicates that the negative AI was not present more centrally than retinal ganglion cells, as it would still have been seen against what

is called the subjective grey colour produced by pressure blinding (Virsu and Laurinen 1977). These results show that the neural mechanisms are the necessary and sufficient conditions for the moderate negative AI's and indicate that these AI's are identical to the brain processes. Such a result has not been shown for any other mental process, and is important as Lycan (1987) suggests that an AI is a paradigm case of a quale. In another very clever experiment, Virsu and Laurinen (1977) produced an illusory negative AI to sine-wave gratings, which could be explained by the non-linearity in the visual system. They adapted with a counterphase-modulated (i.e., each grating was 180° out of phase with the preceding grating) sine-wave grating of high contrast and moderate intensity. When they adapted with this grating unmodulated it produced a negative AI with the spatial frequency of the grating. When they adapted with the modulated grating then the AI had double the spatial frequency of the grating. During this counterphase adaptation, only the spatial frequency of the grating was observed. If the visual system was linear, then no AI would be produced by counterphase modulation because the 180° difference in phase would lead to a cancellation of the AI due to the lining up of the maximum and the minimum of the two presentations of the grating. (Figure 1) The non-linearity did not allow this cancellation and an illusory doubling of frequency was seen. This AI was also prevented from occurring and abolished after induction by pressure blinding so it also has a retinal neural origin. When intense stimuli, like those used by Craik (1940), were employed, then no illusory AI could be generated (Virsu and Laurinen 1977) suggesting that cancellation had occurred because of linearity that was present in the receptors. Thus, this illusory AI can also be regarded as identical with the neural processes as it is located in specific neural structures and depends on the non-linear properties of these structures. Virsu and Laurinen (1977) also showed that coloured negative AI's were prevented from occurring by pressure blinding, but they did not test for illusory coloured AI's. In some unpublished experiments, I was able to induce illusory, complementary coloured negative AI's. The combination of these two sets of results suggest the challenging conclusion that the colour mechanisms behind negative AI's induced by coloured sine-wave gratings are located in the retina This is challenging because it suggests that colour and orientation and spatial frequency mechanisms have got together in the retina without any of the complex cortical mechanisms that are said to be required for the binding of features of stimuli (Treisman 1996; Marlsburg 1995; Singer and Gray 1995).

Let us look at these data with regard to the criteria for identity outlined above. With regard to Shaffer's three criteria, the results are quite clear cut.

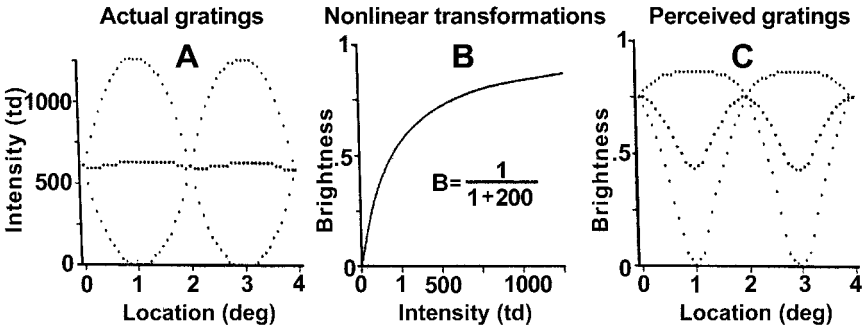

Figure 1. A: The actual counterphase sine-wave grating as a function of intensity leads to a cancellation effect; B: the non-linear transformation employed; C: the perceived gratings showing the effects of the non-linearity in which there is no cancellation but a doubling of the spatial frequency. (reprinted from Virsu and Laurinen, 1977), with permission from Elsevier Science).

The AI occurs at the same time as the neural process. It also occurs in the same place and the presence of one, the neural processes, are an (empirically) necessary conditions for the presence of the other, as no illusory AI is found with intense stimuli. Thus it is essential that the conditions of moderate stimuli, counterphasing and non-linearity are present to achieve the illusory AI. Also, the abolition of the AI after induction indicates that some neural conditions are necessary for the AI.

Even Rorty's more stringent criteria appear to be partly met. There is (1) a one-one correlation between types of sensation (e.g., the three types of AI: illusory, "sensitivity" to moderate intensity stimuli and "bleaching" to intense stimuli) and some clearly demarcated kinds of brain processes; (2) while not every known law which refers to sensation can be subsumed under laws about these brain processes, some generalizations about the particular AI could be generated, e.g., the location, the timing and the nature of both the illusory AI and the standard AI to moderate stimuli can be predicted from the neural properties; (3) a new law about sensations can be generated by the new prediction of an illusory AI, which was not known about before these experiments. Also, an objective measure of an AI can be produced for the first time. Virsu and Laurinen (1977) using a computer method were able to measure the spatial frequency of the negative AI's, thus giving a third person measure of a sensation. In some unpublished experiments, I have been able to replicate their results and measure the spatial frequency of these "Sensitivity" and illusory AI's . Thus, for the first time, it is possible to give a third person account of sensations. Identity theorists have been challenged to account for the asymmetry between first- and third-person access to mental states (Braddon-Mitchell and Jackson

1996). The work discussed here shows for the first time for sensations or qualia that they can be identified with brain processes and also shown to be third person accessible. That is, the same sensation is measured across subjects as they all show the doubling of grating spatial frequency.

With regard to Taylor's pessimistic predictions, these also appear to be met. Taylor said that "nothing guarantees that a given after-image, judged the same on repeated occurrences – will always be accompanied by the same brain state – whenever it occurs in the biography of one person, let alone in all human beings" (p. 235). Instead, we find that the same brain state accompanies these moderate AI's, both illusory and non-illusory. Also we can show objectively that the same AI or sensation occurs in all subjects. It should be stressed again that this is the first case of a clear cut identity between a mental state or sensation and a sharply localized brain process. The pressure blinding has allowed us to reversibly manipulate a specific brain area and specific cells to produce predicted changes in sensations. As Craik and Vernon (1941) have pointed out this reversibility is important as it "furnishes a convenient 'tap' between eye and brain which can be turned on and off at will" (p. 70). We can thus show that a neural retinal process is both a necessary and a sufficient condition for the illusory AI and this can be repeated both within the same subject and across different subjects. This type of manipulation has not been possible using other types of interventions. For example, studies of blindsight (Weiskrantz 1986) have shown that visual cortex VI is part of a pathway involved with visual consciousness, but it does not show that the sensations are generated there. In the case of the AI, the fact that all AI's can be abolished after their generation shows that the site of generation is not more central than the retina and it is not a case of a simple blocking of impulses to other areas where the AI is being produced. It is not possible to show this with either lesion studies or blindsight studies as the changes cannot be reversed. Even modern imaging studies using positron emission tomography (PET) and functional magnetic resonance (fMRI) scans can show only a correlation and at best a sufficient condition for any sensation. In fact, recent analyses of these techniques (Van Orden and Paap 1999; Stuffelbeam and Bechtel 1999) have suggested that "imaging studies do not reliably converge on the same brain regions, and cognitive studies do not discover the same components across tasks. No cognitive variable shows its effects identically in different task contexts. Instead, every cognitive variable that might indicate a cognitive component reliably interacts with other variables, and the patterns of interaction change across tasks – perhaps this is why no single cognitive component has yet been discovered for which there is general agreement among investigators" (Van Orden and Paap 1999, p. S90). This

is not meant by me to disparage the possible use of these methods, but it does suggest in our particular case we have a unique situation in the identity literature, in that we can specify the specific neural structures and their properties and relate them to specific cognitive or sensation properties in a reversible manner.

The illusory AI has very important implications for the concept of an explanatory gap in the explanation of consciousness by brain processes (Levine 1983, 1994). Using pain and C-fibres firing as an identity example, Levine (1983) argues that this identity has an explanatory gap as it does not say why pain should feel the way it does. Levine argues that there is a deep problem about how we can explain the distinctive features of mental states in terms of their physical properties. For example he asks why a surface with a particular spectral surface should look blue. Levine wants to argue that no matter how much we know about neural mechanisms we will never know why we have the phenomenal properties we do have. He says "For a physicalist theory to be successful, it is not only necessary that it provide a physical description for mental states and properties, but also that it provide an *explanation* of these states and properties. In particular, we want an explanation of why when we occupy certain physico-functional states we experience qualitative character of the sort we do – why it is like what it is like to see red or feel pain" (Levine 1994, p. 128). These are important considerations, but the illusory AI appears to be the first neural case which does not have such a gap. The neural explanation tells us what the AI should look like i.e., double the spatial frequency of the sine-wave grating. Unfortunately, there does appear to be a gap with other phenomenal features, particularly colours. However, the illusory AI appears to refute Nagel's (1998) claim that "I believe that the explanatory gap in its present form cannot be closed – that so long as we work with our present mental and physical concepts no transparently necessary connection will ever be revealed between physically described brain processes and sensory experience" (p. 344).

The results have also some implications for a current important theory about consciousness which is largely based on an explanatory gap (Chalmers 1996). Chalmers says that "no matter what functional account of cognition one gives, it seems logically possible that that account could be instantiated without any accompanying consciousness – consciousness may in fact *arise* from that functional organization in the actual world – but the important thing is that the notion is logically coherent. If this is indeed logically possible, then any functional and indeed any physical account of mental phenomena will be fundamentally incomplete. To use a phrase coined by Levine (1983), there is an *explanatory gap* between

such accounts and consciousness itself. Even if the appropriate functional organization always gives rise to consciousness in practice, the question of *why* it gives rise to consciousness remains unanswered" (p. 47). At least in the case of the illusory AI, we can give an answer to Chalmers's "*why*". In this one case, we can say why consciousness (the spatial frequency) looks the way it does. A large part of the strength of Chalmers's argument has come from our inability to give one case that appears to explain consciousness in neurological terms. If other cases could be found, then a reductive account of consciousness might be achieved instead of Chalmers's proposal "that materialism is false and that a form of dualism is true" (Chalmers 1996, p. XV).

The illusory negative AI also suggests that the problem of multiple realizabilty need not be a general one. Fodor (1997) argues that it is general and says that "I am strongly inclined to think that psychological states are multiply realized and that this fact refutes psychophysical reductionism once and for all" (p. 149). It is possible to argue that these experiments have shown that AI's are multiply realized. What has been shown is that there are two types of AI (to either intense or to moderate stimuli), which are located in different structures and thus each is singly realized. The fact that the negative AI to moderate stimuli can be prevented from occurring by blocking activity in one area and it can be abolished after it is induced clearly indicates that it is realized in the one place. It should be stressed that both the "sensitivity" and the "bleaching" types of AI's are long lasting (e.g., 1–3 minutes after the primary stimulus is removed), so their abolition indicates that this long process is not occurring more centrally than retinal ganglion cells or in any other location. Both the standard AI and the illusory one to moderate stimuli are clearly not cases of multiple realization. The concept of multiple realization was first put forward by Putnam (1980). He based his argument on pain as instantiated in mammals, reptiles and mollusca and suggested that these organisms would not be likely to be in the same brain state when they experience pain. Putnam (1980) asserts even more strongly that "if we can find even one psychological predicate which can clearly be applied to both a mammal and an octopus (say "hungry"), but whose physical-chemical "correlate" is different in the two cases, the brain-state theory has collapsed. It seems to me overwhelmingly probable that we can do this" (p. 228). While it does seem likely that across species comparisons will not support an identity claim, Bechtel and Mundale (1999) claim to have shown that scepticism about neurosciences role in understanding cognition or sensation is misguided and that the apparent success of multiple realizability is based on methodological error. This error is based on a mismatching of a broad-

grained criterion for psychological states with a fine-grained criterion for brain states. They claim that if the grain is made equal then multiple realizability is not so prevalent either across species or in the one species. In the situation discussed in this paper, we have two clear cases of single realizability in humans, clear cases of type-type identity. It would seem to us that it is the lack of other reversible methods like pressure blinding to manipulate specific brain structures that is holding back physicalist or identity explanations.

Finally, we should say something about Smart's concept of topic neutrality. The topic-neutral approach has been heavily criticized by a number of philosophers (Bradley 1964; Jackson 1977; Rosenthal 1976). Rosenthal (1976) argues that the topic neutral translation of Smart and Armstrong has tried to address what he calls the 'irreducibly psychic properties' (IPP) objection to materialism. Rosenthal claims that their approach is one of semantic translation of predicates. When a theoretical reduction translation based on neural laws is needed. Rosenthal (1976) asserts that "It is reasonably clear and uncontroversial what empirical results would show that mental events are neural events; temporal and causal correlations, and the ability to explain and predict events by appeal to those correlations, should suffice" (p. 396). These points are very similar to the criteria for identity mentioned above. However, there has been no systematic attempt in either the philosophy or the physiology literature to see whether visual science supports a reductive approach to such mental properties. While the above findings on the AI support the reductive concept, some other studies of the AI also give direct support to the concept that something is going on with the AI that normally goes on when an object is before one. Anstis et al. (1978) showed that AI's could act like external colours and produce simultaneous colour contrast effects. Day and Webster (1989) also showed that AI's could act like external stimuli. Day and Webster (1989) used an coloured AI combined with an external stimulus (a black and white grating) to produce a coloured McCollough after-effect. A uniform red stimulus was presented followed by a vertical black and white grating, so that a green AI was present with the grating. This was followed by a green stimulus followed by a horizontal black and white grating. Thus a red AI was present with this grating. After a long sequence of these combinations presented in alternation, a coloured red after-effect was produced on the vertical black and white grating and a green after-effect was on the horizontal grating. This McCollough after-effect is not an AI (Day and Webster 1989) and its colours are the opposite of what would be produced if real colours had overlaid the gratings. These results indicate that the mechanism underlying the AI can act like a real colour mechanism and get hooked

up with an external stimulus to produce an after-effect. This suggests that Smart could be correct in proposing the translation that something is going on with an AI which is like what goes on when an external coloured object is present.

In conclusion, the studies of the AI discussed here show that a mind/brain identity explanation can be given for some mental/sensation processes. It indicates that materialism is not necessarily false, as suggested by Chalmers (1996). It is suggested that if other techniques, with the selective and reversible control of pressure blinding, (perhaps other 'taps' (Craik and Vernon 1941)) could be found and employed, then a more general identity theory could be established incorporating other mental processes.

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