

University of Groningen

Brainwaves and psyches

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Published in:
History of the Human Sciences

DOI:
[10.1177/0952695114566644](https://doi.org/10.1177/0952695114566644)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2015

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Brenninkmeijer, J. (2015). Brainwaves and psyches: A genealogy of an extended self. *History of the Human Sciences*, 28(3), 115-133. <https://doi.org/10.1177/0952695114566644>

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Brainwaves and psyches: A genealogy of an extended self

History of the Human Sciences

2015, Vol. 28(3) 115–133

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DOI: 10.1177/0952695114566644

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**Jonna Brenninkmeijer**University of Groningen, The Netherlands; Radboud University,
The Netherlands; University of Oxford, UK**Abstract**

This article presents an ethnographical and historical analysis of the mode of being that is constituted when people use neurofeedback (brainwave training) for self-improvement. I analyse how human brainwaves have been associated with the psyche since their first demonstration by the psychiatrist Hans Berger, how they were connected to personality types by the cybernetician Grey Walter, and made trainable by the psychologists Joe Kamiya and Barry Sterman. I compare these cases with the reports of contemporary neurofeedback practitioners and users, and demonstrate that working on the self by working on the brain constitutes a complicated relationship between the brain and the self. Moreover, I demonstrate that combinations of brains and selves, material and spiritual ideas, and biological and social explanations are not confusions due to the ignorance of neurofeedback users, but amalgamations that emerged in the work and ideas of early scientists.

Keywords

dualism, EEG, monism, neurofeedback, subjectivity

‘My thinking is not used to my brainwave activities, yet’

This somewhat confusing sentence is a citation from a woman (55) who did neurofeedback therapy to solve her anxiety and other problems. To do the neurofeedback she was ‘connected with electrodes on [her] head’, and ‘watched a screen on which pieces of

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puzzles appeared when [she] reacted calmly'. The therapy 'trained back' her disorders and helped her to go on with her life which was seriously problematized, among other causes being that her 'brainwaves were disturbed by [her] father who caused a lot of trouble'. Nowadays, she is very aware of her brainwave activities – although she is still not used to them.¹

In a neurofeedback therapy, a client is connected to an electroencephalograph (EEG) that visualizes his or her brainwaves. This brain activity is translated and real-time projected in understandable colours (e.g. green is good; blue is too low; red is too high) graphs or animations (e.g. happy or sad emoticon) by a computer. Watching their brainwave activity with an indication of its rightness or wrongness gives people the opportunity to start changing this activity – or at least that is the idea. *How* people should change this activity is not specified, and *if* it is possible to change one's own brain activity is also under debate (e.g. Arns *et al.*, 2009; Logemann *et al.*, 2010; Loo and Barkley, 2005; Vollebregt, van Dongen-Boomsma, Buitelaar and Slaats-Willemse, 2014). Moreover, there are many discussions about the assumed clinical successes and failures of neurofeedback, and the therapy is performed in many different ways by (educated or uneducated) therapists, who use various protocols and computer programs (Brenninkmeijer, 2013a, 2013b). That is, it is actually rather unclear what neurofeedback exactly does, but, as the introduction illustrates, at least it does something with people's experiences of themselves.

Neurofeedback is a clear example of a 'technology of the self' – a term Foucault used for techniques that 'permit individuals to effect by their own means or with the help of others a certain number of operations on their own bodies and souls, thoughts, conduct and way of being' (Foucault, 1997). Technologies of the self are always based on certain premises and ideas of self, and hence also enact certain ways of seeing and being oneself. And as ethnographic research among neurofeedback users and practitioners demonstrates, this mode of self can be rather specific (Brenninkmeijer, 2010, 2013b).²

Choosing neurofeedback to improve oneself suggests that users see themselves as their brain, or as part of their brain. However, when trying to change or control their brainwaves, they have to make a distinction between their selves and their brains. In interviews, users express this distinction with statements such as: 'at the moment you start focusing, your brain interrupts'. When explaining their problems, they often combine physiological theories with psychological explanations (the cause of my burn-out is 'definitely my brainwaves, but also my problem with saying no'). They regularly describe their healing process in computerized terms (a 'defragmentation of your computer'), and easily combine this 'materialistic' brainwave training with spiritual practices such as meditation or yoga (because these are supposed to change your brainwaves too). In other words, neurofeedback does not reduce the self to the brain, but extends the self with various psychological, physiological, material, spiritual and other entities.

This way of perceiving oneself does not fit into the current dominant view that we are our brain (Damasio, 1994; Swaab, 2014), nor into a 'traditional' dualistic (mind–body) idiom. As the philosopher Ian Hacking demonstrates, contemporary neuroscientists who try to reduce the mind to the body have actually extended the dualistic view with a brain (Hacking, 2005, 2007). However, the spiritual practices, the computerized terms, and the mixtures of psychological and physiological statements do not fit very well in a

‘trialistic’ (mind–body–brain) idiom either. Hence, I claimed that doing neurofeedback constitutes an extended self: a mode of being in which an assemblage of various neurological, psychological, biological, social, mechanical, spiritual and other entities are enacted (Brenninkmeijer, 2010, 2013a).

In this article, I describe how this ‘extended self’ was historically constituted. I explore the academic work, diary notes and media appearances of 4 scientists who are often mentioned in histories of clinical EEG and neurofeedback (e.g. Robbins, 2000; Budzynski, 1999; Demos, 2005; Niedermeyer and Lopes da Silva, 2005). I analyse how human brainwaves have been associated with something like the self, or the psyche, since their first demonstration by the German psychiatrist Hans Berger (1873–1941). How they were connected to personality types by the British neurophysiologist and cybernetician Grey Walter (1910–77), and made trainable by the American psychologists Joe Kamiya (1925–) and Barry Stermann (1935–). I compare these cases with the reports of contemporary neurofeedback practitioners, who can be seen as the active promoters and facilitators of these technologies, and with the explanations of contemporary users who constitute this mode of self. My analysis will demonstrate that the (increasingly) complicated relationship between the brain and the self, the machine-like version of the self, the combinations of materialistic philosophies with spiritual ideas, and biological theories with social explanations are not confusions due to the ignorance of contemporary neurofeedback users, but amalgamations that emerged in the work and ideas of early brainwave scientists.

Berger’s ungraspable psyche

The discovery of the human electroencephalogram was not a matter of course. In fact, it took a frustrating 30-year-long struggle before the German psychiatrist and psychophysiological Hans Berger (1873–1941) dared to publish the sentence which would make him famous: ‘I therefore, indeed, believe that I have discovered the electroencephalogram of man and that I have published it here for the first time’ (Gloor, 1969: 70).³ During his entire career Berger struggled with a personal mission: he wanted to prove the existence of psychical energy. This mission was not a result of his neurophysiological findings, but preceded his scientific career. According to one of his most prominent biographers, Berger was already ‘absorbed by the mind–body problem’ in his teenage years (Gloor, 1994: 253). One important episode for his devotion was ‘a case of spontaneous telepathy’ that Berger retrospectively described in his last published document, named *Psyche*:

As a 19 year old student, I had a serious accident during a military exercise . . . In the evening of the same day, I received a telegram from my father who enquired about my well being . . . This is a case of spontaneous telepathy in which at a time of mortal danger, and as I contemplated certain death, I transmitted my thoughts, while my sister, who was particularly close to me, acted as the receiver. (Berger, 1940: 5, 6; translated by Gloor, 1969: 2, 3)

Shortly after this episode, Berger changed his studies from astronomy to medicine, and for his entire career – from his doctoral degree in 1897 until his retirement in 1938 – he worked at Jena Psychiatric University Clinic. The first few years he did some

work in neuroanatomy, but his drive to find a connection between mental and physical events soon emerged in his research. In 1901 he published his first psychophysiological experiments about the blood volume changes in the brain of a trepanned patient, and in the same period he made the first attempts to record electric brain activity in animals and later in humans. For many years, however, these recordings did not reveal any clear results, and Berger expressed his frustration about the ungraspable human brain recordings in his diaries:⁴

Of nine experiments, one success and even this one rather doubtful ... One can therefore not say that I gave this thing up lightly. Eight years! Trying always, time and again. (Gloor, 1969: 5)

Despite these disappointments, Berger did not set aside his mission, but accentuated it: 'Psychical Energy is the major challenge! Especially assigned to me' (translated from Borck, 2005a: 76). Apparently, Berger was so eager to solve this personal assignment that he did not involve any colleagues in his work but carried out his experiments solely after working hours, as if he had a secret mission (Ginzberg, 1949). However, the many failed experiments, perhaps combined with the fact that Berger worked completely on his own, made him somewhat uncertain about the few results he did find. His first successful EEG recording from a non-trepanated skull was made in 1924 of his son Klaus, but Berger made many more EEGs before he was convinced that the measured activity was really brain activity rather than artefacts from the machine or muscle movements (Spear, 2004). It took Berger 5 more years before he dared to publish his results about the 'writings of the human brain', which he called electroencephalograms, in analogy to the human electrocardiogram (Gloor, 1969; Borck, 2001). Moreover, even for this report, which would be followed up by 13 more, Berger had decided 'not to go into hypothetical matters with the publication on the EEG, but only communicate purely concrete facts and findings!' (Millett, 2001: 537, 538).

The next step was to reveal the meaning of these recordings. One of the first things Berger noticed was a difference in the EEG when people opened or closed their eyes, as well as between subjects doing nothing or performing mental tasks. These changes appeared in specific wave patterns that intensified or reduced. The first pattern Berger determined he called the alpha rhythm, also described by him as 'the physical concomitants of conscious phenomena' (Millett, 2001: 539) and as corresponding with 'fluctuations of attention' (Gloor, 1969: 79). Berger further connected these brain fluctuations with the subject's mental condition by demonstrating that anxiety or attention can change the EEG, and by comparing EEGs with people's intelligence. In his 14th report Berger, for example, reported:

[M]ental defectives in general exhibit better resting E.E.G. curves than intelligent persons. When I wanted to demonstrate beautiful E.E.G.s to colleagues who were interested in such recordings, I particularly liked to use a certain imbecile. (Gloor, 1969: 315, 316)

Berger visualized alpha and beta waves and he made a connection between these waves and mental activity. As a result of his findings, Berger is nowadays often

mentioned as an important neuroscientist and a monistic thinker (Gloor, 1994; Millett, 2001). In his diary Berger indeed refers to the monistic philosopher Spinoza, and in several publications he emphasizes the homogeneity of psychophysiological activity. In his 6th, 11th and 14th reports, for example, he writes that psychophysiological activity in the cortex acts as *'ein einheitliches Ganzes'*, which can be translated as a 'uniform', or 'homogeneous', whole. And in his inaugural lecture 'Brain and Soul' (1919),⁵ delivered on the occasion of his appointment as director of the psychiatric clinic, Berger explains:

I openly declare that I do not hold the popular parallel principle as the solution, but instead I accept an interaction between mental and bodily processes and embrace an energetic perspective, against which all possible objections can be raised, like any other assumption. (Millett, 2001: 533)

In this quotation, Berger seems to oppose dualism, but one can wonder if an interaction between mind and body should be considered as a monistic statement. In his final work *Psyche*, Berger expresses this duality of an interacting oneness:

This psychical energy . . . fundamentally distinguishes itself from all other kinds of energies, but can interact with, or rather arise from, and retransform into these. One can rightly argue against this assumption that it maintains the old Dualism of material and psychical processes, only in a somewhat concealed form. This can be admitted easily and does the view no harm. (Translated from Berger, 1940: 24)

Berger used 'the law of the conservation of energy'⁶ to connect physical energy with psychical phenomena, but, as he states himself, this does not make him a confirmed monistic thinker. Moreover, the German historian Cornelius Borck even argues: 'He was a dualist, and he sought to fight materialism with its own weapons' (Borck, 2005b: 83). This struggle between monistic and dualistic ideas can also be traced in statements and acts of contemporary neurofeedback users who on the one hand try to explain themselves and their problems in brain terms, but on the other hand simultaneously distinguish themselves from their brains by trying to intervene in the brain's working process, and by combining biological and material or mechanical explanations with psychological or spiritual statements. Apparently, the line between monism and dualism is not as clear as it is often claimed.

It is unclear whether Berger should be considered as a monistic, a dualistic, or maybe even a holistic thinker (see also Borck, 2001), but what can be concluded is that the connection between mind and body started as Berger's mission, turned into his frustration, and resulted in a feeling of failure. In his final work *Psyche* Berger revealed his (somewhat spiritual) ideas about psychical energy and telepathy, and he also declared that 'It is absolutely sure that it will never be completely revealed how material processes of the cerebral cortex and the corresponding psychical processes will be related in the end' (Berger, 1940: 16).

Hans Berger visualized human brainwaves, connected these to psychological states, got confused by the complicated interaction, and tried to integrate his spiritual ideas on telepathy in his scientific work. To his own frustration there was almost no

acknowledgement for his scientific work during his life, and the attention for his work predominantly occurred after his suicide in 1941. However, there was some limited popular uptake immediately following Berger's first EEG publication in 1929. Berger's 'brain mirror' gained attention by German newspapers, which described the invention as producing the 'zig-zag line of the human soul' and the 'Electric script of thinking' (Borck, 2001). According to the German press, the EEG was not only a recording, but also a deciphering of the language of the operating brain, and they made Berger the inventor who taught the brain 'to write in black on white' (ibid.: 584), by publishing his picture besides samples of his recordings. While it is difficult to trace the precise impact of such articles, it is presumable that people's first confrontation with a brain script that is translated as the visualization of the human soul had some impact on people's understanding of their selves.

Walter's brain country

One of Berger's followers, who was actually not particularly flattering about his predecessor, was the British neurophysiologist and cyberneticist William Grey Walter (1910–77). In his popular book *The Living Brain* (first published in 1953) Walter described Berger as 'a surprisingly unscientific scientist', with the 'reputation of a crank' being 'completely ignorant of the technical and physical basis of his method'. To Berger's recordings he referred as: 'wobbly line[s]' that 'did not convince us or anybody else at that time' (Walter, 1957: 29–30). However, at the insistence of his laboratory director at the Maudsley Mental Hospital in London, the psychiatrist Frederic Golla, Walter did get involved in EEG practices in 1934 (Hayward, 2001; Pickering, 2010). First at the Maudsley Mental Hospital and from 1939 at the Burden Neurological Institute in Bristol, Walter and Golla performed many EEG experiments together. They confirmed Berger's alpha and beta waves and soon traced a new rhythm, which they named delta, because of its association with 'disease, degeneration and death' (Walter, 1957: 53). The delta wave appeared to be usable for the detection of cerebral brain tumours and epilepsy, and, shortly after its detection, Walter used the EEG in the defence of a man who murdered a schoolgirl, by 'showing' that the defendant was an epileptic who had attacked the girl during a seizure. This story attracted attention in the British press and gave the EEG the status of some kind of 'truth machine or electric confessional that would reveal the occult working of the human mind' (Hayward, 2001: 620).

Walter's detection of the delta wave made the EEG an important diagnostic tool in medical sciences, and his later detections of the theta wave and the contingent negative variation (CNV) gave him an important role in science (Hayward, 2001; Holland, 2003). His experiments with the alpha wave, however, led to interesting speculations about brains and personality types. When performing his EEG experiments, Walter had soon found out that not every brain produced the same patterns of alpha. His own brain, for example, did not produce any alpha, other brains produced the rhythm all the time, while most brains produced alpha only with closed eyes and 'a blank mind'. Walter concluded that different alpha activities should correspond to different ways of thinking, and thus to different personalities. He developed a theory of three different alpha types. The M type stood for minus, no alpha, and this person was an image-based thinker like himself. The

P type (Persistence alpha), was an abstract thinker, and the R type (Regular alpha) could switch between abstract and image-based thinking (Walter, 1969a).

To identify someone's alpha type one could measure the subject's brainwaves, or give a mental exercise in which a painted cube should be halved several times. After getting the puzzle, the subject was questioned about the colours and structure of the cube. During a lecture Walter declaimed:

How many of you, I wonder, saw not merely a color but the grain of the wood, perhaps the knife or saw-blade or sawdust? These I would hail as my brain-brothers. I would expect that to some extent they have followed my arguments, shared my images, even if they have not agreed with me. Those who saw nothing . . . the ones who computed without form or color, I salute as distinguished strangers in my brain country, I fear they may have found my examples trivial and my arguments tedious even if they do agree with me. (Walter, 1969a: 23)

Walter categorized people in M, P and R types, and talked about brain brothers who would understand each other and brain strangers who might think and communicate differently. In other texts, he claimed that differences in alpha waves could not only cause miscommunications between people, but also bring about serious problems in marriages, science, society, and the world in general:

Their mental accents, so to say, separate them as surely as verbal accents in a class-conscious society. Of course, it is not only among scientists that such discrepancies can cause irrational rupture of communication . . . Some current conflicts that threaten to tear our world asunder may be no more serious in origin than an argument about whether the cube was 'really' red or blue. Perhaps a diplomat should have his alpha-type endorsed on his passport. (Walter, 1968: 184)

By categorizing people in different alpha types Walter presumed that people have a 'fixed' brain state, or brain personality. He referred to EEGs as 'brainprints', in analogy to fingerprints, and he claimed that although the EEG changes continually its trends are very individual and identifiable (Walter, 1957: 136).

These brain-type theories, however, contradict Walter's explanations of another wave he detected – the theta wave. Walter associated theta, a rhythm dominant in infants, with pleasure and pain and when prominent in (bad-tempered) adults, with 'childish' behaviour like intolerance, selfishness, impatience and suspicion (Walter, 1957: 140, 144). Being able to control these theta waves, on the other hand, he associated with self-control, personality and maturity. In several texts (Walter, 1952, 1957, 1960) Walter described experiments in which subjects were stimulated with flickering lights of theta frequency. This stimulus provoked theta waves in the brain, as Walter illustrated with an EEG, and was supposed to arouse an annoying feeling. However, according to Walter people were not 'at the mercy of' their theta rhythms (Walter, 1957: 146). Subjects who produced theta and who were confronted with a bad or annoying feeling, would consequently 'or if they were told to' try to suppress this feeling, and because of their successfully repressing this emotion, their theta waves would decrease. In Walter's words: 'If he [the subject] gives way to his feelings, the theta pattern will increase, but if he tries to

keep his temper, the pattern fades away, and so does the feeling of annoyance' (Walter, 1952: 62). That is to say, in Walter's explanation a distinction between the subject 'or the self' and the brain can be traced which resonates with statements of contemporary neurofeedback users, who, for example, explain: 'It seems that at the moment you start focusing, your brain interrupts with "Hey, I don't want this signal to be changed."'

Walter realized that his work contained some distinctions between the brain and the self, but according to him such dichotomies could only be linguistic. He explained: 'I suppose it is always possible to define one's observations in such a way as to permit a dichotomy, and this may be operationally useful as long as one remembers that it is a descriptive device not an explanation' (Walter, 1972: 44–5). In a number of texts he claimed physiological unity (Walter, 1953) and he called himself a 'thorough-going materialist' (Walter, 1972: 48). He furthermore claimed he was completely uninterested in notions of autonomy or identity (Walter, 1957) and he explained the relation between mind and brain as velocity versus the engine (Hayward, 2001; Walter, 1957). Instead of working with the concept of mind, he preferred using the word 'mentality', as being a brain function.

However, Walter had no problems combining these strictly materialistic ideas with spiritual phenomena. *The Living Brain* (1957[1953]) on the one hand is a 'down-to-earth, materialist and evolutionary story of how the brain functions' and on the other hand a book full of references to 'dreams, visions, ESP [extrasensory perception], nirvana and the magical powers of the Eastern yogi' (Pickering, 2008: 1). Walter thought of such phenomena as 'physiological curiosities' (1957: 175) that were perhaps hard to explain in biological terms, but nevertheless attracted his attention. For him, the brain was an uncontrollable system, and the answer to study such a system – and perhaps in the future also the solution to solving the (linguistic) mind–body distinctions – was cybernetics (Walter, 1956: 53, 1972). Adherents of this approach studied the communication and control between 'systems', with which they could refer to the human or animal brain, as well as to a computer or machine (Pickering, 2010). In Walter's vision the brain was an organ that adapted to its environment, just like other systems did. To demonstrate the equivalence between systems like brains and machines, he developed robotic tortoises that performed 'human' behaviour. These tortoises had photoelectric cells that responded to light and electrical contacts that made them reactive to touch. The photoelectric cells made the tortoises move to light, but because these cells were placed on a rotating motor the tortoises could move only in arcs. Whenever the tortoises touched an object their electrical contacts made them move back again (Hayward, 2001: 623). The result of these constructions was a tortoise that could dance on its own in front of a mirror, or have a 'somewhat flirty' dance with another tortoise. According to Walter, his tortoises had 'free-will', 'recognised their selves' in a mirror, and organized their behaviour in a social way (Walter, 1960).

With his book *The Living Brain* (1957[1953]), as well as with performances and illustrations in newspapers and magazines, Walter demonstrated to a broad public that the brain was an entity that could act upon the person. That is to say, he created a 'performative brain' (Pickering, 2010). This brain could define someone's personality type (M, P, R), could influence success in marriage, struggles with colleagues, and even world peace ('Electronic Patterns of the Brain', 1956; Walter, 1957, 1968), and it could take

over someone's responsibility, as in the case of the epileptic murderer (Hayward, 2001). Furthermore, where Berger had detected alpha and beta waves, Walter identified theta and delta waves, and the first struggles between subjects and brainwaves appeared in Walter's publications. The connection, and with this the entanglement, between human and machine that was made by Walter, can also be found in the statements of contemporary neurofeedback users. Phrases like a 'defragmentation of your computer', 'a computer wiring me', 'my system is unstable' strongly resemble Walter's claim that: 'The brain has a capacity for resetting itself, for setting up its own wiring' (Walter, 1953: 141).

Moreover, Walter taught people that they – themselves – could act upon their brain. With *The Living Brain*, he informed a broad audience about the possibility of provoking visions, hallucinations, or 'waking dreams' by gazing into a stroboscope with alpha frequency. This inspired several artists and researchers to build their own brain-manipulating flicker machines (Geiger, 2003). That is to say, Walter introduced technologies that would work, or experiment, on the brain, and with this on the self. The promises of these technologies were not as extensive as those of the neurofeedback devices people use nowadays, but Walter definitely paved the way for some first steps into brain work.

Kamiya's desirable alpha

Berger and Walter are important figures in the history of the EEG (e.g. Niedermeyer and Lopes da Silva, 2005), but contemporary neurofeedback practitioners (e.g. Robbins, 2000; Budzynski, 1999; Demos, 2005) usually identify two other pioneers of their discipline. One of them is the psychologist Joe Kamiya (1925–) who taught his human subjects to recognize and manipulate their own brain states. Another frequently mentioned experiment is that of 'the cats' that were trained to produce a specific brain rhythm by the neuropsychologist Barry Sterman (1935–). Sterman's and Kamiya's claims were significant. They argued that brainwaves interacted with the subject's will-power, personality and consciousness.

Joe Kamiya was a medical psychologist of the Langley Porter Neuropsychiatry Institute in San Francisco, and in contrast to most of his contemporaries – including Grey Walter – Kamiya claimed to be really interested in subjective experiences (Kamiya, 2011). In a recent article, Kamiya reflects on the 1950s and 1960s, when he performed several EEG-biofeedback experiments with human subjects, and explains:

For me, such elements of private experience as feelings, images, thoughts, and hopes were a fundamental feature of human life . . . The apparent denial of their relevance for understanding behavior for the sake of scientific rigor seemed self-defeating. (Kamiya, 2011: 65)

This intention to pay attention to private experiences, hopes and feelings, however, was put into practice in a way that was shaped by the behaviourist tradition of the 1950s.⁷ Kamiya attached subjects to an EEG device and frequently asked them to identify, at the sign of a ringing bell, whether they thought they were in brain state 'A' (alpha) or 'B' (no alpha), whereupon he told them whether they were correct. In this way, Kamiya claimed, his subjects were trained to recognize their own brain state (A or B). Furthermore, he

trained his subjects to try to suppress and enhance this alpha state, with apparent success (Kamiya, 1968, 1969, 1971).

According to Kamiya, his test-subjects ‘had learned to read [their] own brain, or [their] mind’ (Kamiya, 1971: 282). He quoted his subjects while being in alpha state with positive phrases like ‘pleasantness’, ‘some kind of relaxation’, ‘a general calming-down of the mind’ (ibid.: 287; see also 1968). According to Kamiya, psychotherapists and other people who ‘are good at intuitively sensing the way you feel’ are good alpha controllers, and Kamiya furthermore reported that he ‘generally tend[s] to have more positive liking for the individual who subsequently turns out to learn alpha control more readily’ (1971: 287, 288). Kamiya described the alpha state as a ‘desirable thing’ (ibid.: 288) and he connected this desirable state to something spiritual by doing experiments on practised Zen meditators, and by reporting that subjects who were good at controlling their alpha were mostly also interested in meditative or introspective practices (1968, 1971).

As he explained himself, Kamiya did not publish much of his work in scientific journals, but he gave many presentations to scientific and ‘civic’ groups (Kamiya, 2011). Furthermore, he published his findings in the popular magazine *Psychology Today* (Kamiya, 1968). In this way, Kamiya showed members of a broad public how they could influence their own brainwaves and which pleasurable or spiritual effects this might have. Hence, his alpha-trainings became very popular: ‘I have a list a mile long from various people who call me on the telephone or write me from New York, and other places all over the country to ask if they can come over and serve as subjects!’ (Kamiya, 1971: 288).

Kamiya’s experiments became famous, especially in spiritual circles, and his name can still be found in some yoga and meditation books. The connection between brain activity and spirituality was not new in this area of study: Berger was inspired by his telepathic event, Walter was not surprised by all kinds of spiritual effects of the brain, and even Kamiya’s contemporary Sterman would admit that ‘there is usually a general response to biofeedback training which resembles some aspects of meditational and Yoga experiences’ (Sterman, 1981: 405). However, Kamiya’s simple experiments inspired members of a general public to try to reach the ‘desirable’ alpha state by themselves.

Kamiya was the first researcher in the history of neurofeedback who seriously tried to pay attention to the feelings and reports of his subjects. He called it ‘self-defeating’ to deny the experiences of subjects and he gave some control back to the self, by informing a broad audience about the possibilities to recognize, change, or enhance the brain state. The self that he restored, however, was not only a mechanical self that could be trained by a ringing bell, but also a spiritual self that could try to change its brain state to a more meditative one.

Sterman’s voluntary brain control

According to Kamiya, his alpha experiments not only encouraged people to serve as subjects, but also inspired several important scientists (Kamiya, 2011). Apart from the famous behavioural psychologist B. F. Skinner, Kamiya reports a visit of Barry Sterman, now a professor emeritus of the University of California, Los Angeles (UCLA). Sterman completed his PhD in neurology and psychology and started to work as a sleep researcher

in the 1960s. Inspired by Pavlov's conditioning experiments with dogs, Sterman put cats in boxes and conditioned them to press a lever for food, after a bell rang. The cats were connected to EEG devices and in this way Sterman observed that, when the cats sat still while waiting for the right moment (3 seconds after the bell) to press a lever for food, they produced a brain rhythm of 12–16 Hz on the sensorimotor cortex. Probably encouraged by Kamiya's experiments, Sterman thereupon started to train his cats to produce this so-called sensorimotor rhythm (SMR) 'at will' by rewarding the cats with food whenever they showed the brain pattern. After Sterman stopped rewarding his cats they continued producing SMR more than average. Furthermore, Sterman noticed that the sleep EEGs of the cats were altered, and that they slept more soundly and woke up less (Robbins, 2000; Sterman and Egner, 2006; Sterman and Wyrwicka, 1967).

Around the same time, Sterman was asked by the National Aeronautics and Space Administration (NASA) to examine the toxic effects of rocket fuel. He injected 50 cats with the toxicant which promptly evoked epileptic seizures in most of them. Seven cats, however, resisted the seizures somewhat longer, and three of them were not harmed at all. Sterman did not understand what the difference was between the cats, and it took him several years to realize that the seizure-resistant cats were the ones he had trained to produce the SMR-rhythms (Robbins, 2000).

Shortly after this finding, Sterman tried his SMR-remedy on a secretary: Mary, 'a 23-year-old white female with a history of convulsive disorder'. Sterman trained her for 4 months and her seizures reduced from an average of 2 per month (varied from 0 to 3) to only 1 seizure that appeared after 3 seizure-free months – this apart from a double seizure 6 days after the first session (Sterman and Friar, 1972). Apart from these results, Sterman noticed that the subject showed changes in her sleep and personality:

Having previously been a quiet and unobtrusive individual, she progressively became more outgoing, showing increased personal confidence and an enhanced interest in her appearance. She also spontaneously reported experiencing a shorter latency to sleep onset, a more restful sleep, as indicated by a reduction of her normal physical re-orientation in bed through a night, and a more rapid awakening in the morning. None of the latter changes could be documented objectively, but they were particularly interesting in terms of the similar, quantified findings obtained with SMR in the cat. (Sterman and Friar, 1972: 91)

Sterman did not only develop theories about sleep and epilepsy. His observation of behavioural changes in the secretary and the cats is important to understand how contemporary neurofeedback users constitute themselves. Where Berger visualized the 'writings' of the human brain, Walter turned this brain into a living or performative brain that could act upon the self, Kamiya introduced a self that could act upon the brain, and Sterman elaborated on this controlling self by claiming that the subject's personality (as well as the sleeping patterns and epileptic fits) could be altered through conditioning. He described his method in terms of 'voluntary control', 'voluntary therapy', and stated: '[T]he method of biofeedback requires that the subject assumes personal responsibility for any beneficial effect to be had and provides the basis for a new level of self-awareness' (Sterman, 1981). With this, he makes clear that the self can and should control its brain and actions.⁸

In media interviews and articles, on the other hand, Sterman makes several comments in which the self is completely controlled by the brain. In a popular book on neurofeedback, for example, he is quoted as saying:

I can tell from an EEG whether someone's paying attention, and if they are, if they are paying attention to me or to what they did last night. You can tell whether someone is mildly retarded from an EEG. Or whether someone is hyperaroused and can't relax . . . Everything depends on the topographical distribution. (Robbins, 2000: 34)

Together with a colleague, Sterman nowadays runs a company for 'Evidenced Based Neurotherapy', and their website contains phrases like 'bad brain habits' and 'neuromodulations for each disorder'.⁹ They visualize these disorders as brain states with colourful pictures and enumerate the disorders they can modulate, varying from 'brain injury' and 'emotional disturbances', to 'efficacy', 'social functions' and 'love'.¹⁰ That is, Sterman's ideas about the brain and the self are actually rather complex since they include two actors; the brain works upon the self, and the self works upon the brain.

The struggle between the brain and the self was made clear in American newspaper articles commenting on Sterman's intervention in the appeal case of a convicted murderer, Terry Clark who had been sentenced to death for the killing of a 9-year-old girl in New Mexico in 1986. Based on a brain scan made by a colleague, Sterman declared: 'It's a disability, not a bad person' and 'I don't think you want someone with his frontal lobe disturbance out in society' (Bresenham, 2001; Herrera, 2001a). However, the defendant himself claimed that 'These reports about me having brain damage are false' and 'I have a personal, moral and social obligation to take responsibility for what I did' (Herrera, 2001b; 'New Mexico: Death-row inmate says he's not brain-damaged', 2001).¹¹ A few months after, Clark, who had voluntarily stopped his appeals procedure, was executed with a lethal injection. That is, in contrast to Walter, who had successfully defended a murderer by showing with an EEG that the defendant had had an epileptic seizure, Sterman encountered a defendant who resisted his brain diagnosis because he wanted to take responsibility for his own actions.

Perhaps this anecdote is telling for Sterman's somewhat ambiguous position regarding the steering brain and the modulating self. Neuromodulation is a 'voluntary therapy' that provides self-awareness, and requires that the subject takes responsibility. On the other hand, Sterman categorizes phenomena like murder, social functioning and love under brain-based behaviour. This appears to be contradictory, and can perhaps best be understood by returning to Walter who claimed that his robotic tortoises were also capable of human and social behaviour, such as self-recognition and acting out of free will. That is to say, Walter and Sterman both invented a determining brain, but combined their ideas about brain brothers and brain habits, with a certain form of free will.

The mind–body web

EEG biofeedback appeared to be a temporal phenomenon that largely disappeared from the psychological stage.¹² However, over the past few years, this technique has made its comeback in the form of neurofeedback. Practitioners offering this technique do not only

promote and explain their therapies, they also spread the message that people can work on their selves by training their brains, and make their clients familiar with their (problematic) brainwaves, brain maps and potential personality changes.

One aspect that can be traced in the stories of neurofeedback ‘pioneers’ as well as in those of the current promoters is the ambivalent relation between the brain and the self. Berger tried to grasp the psyche by visualizing brain activity, but he became more and more frustrated about the complex ‘interaction’ between the two. Walter tried to liberate the controllable brain from the intangible self with his cybernetic theories, but his brain type theories were endangered by his theta experiments. Kamiya intended to pay attention to subjective experiences (feelings, hopes) by teaching people to train their own brain states, which resulted in a trend of people’s each trying to change her or his own brain state to reach a more spiritual self. And in Sterman’s work the brain is controlled by the self, but the self is also controlled by the brain. In all these cases the brain and the self do not simply coincide, but seem to struggle for control.

This complicated relationship between the brain and the self can also be retrieved in the acts and statements of contemporary practitioners. Although ‘the mind is the brain’ is a generally recurring phrase among practitioners, this statement is also most easily abandoned, for example, by stressing that someone should not be ‘entirely in the hands of his central nervous system’, or by emphasizing the importance of the client’s cooperation. When being directly confronted with questions concerning the mind–body relation practitioners occasionally avoid the question, or they become confused. One practitioner tries to explain the difference between brain behaviour and cognitive behaviour:

It is not only that you are angry because of your brain behaviour, your brain behaviour will also . . . Well, yes, what am I saying . . . ? Of course cognitive behaviour is brain behaviour too. Yes, now it becomes really . . . Before you notice you are in the neuro-philosophical corner, which is very interesting, but it is not about feedback.

It is not surprising that practitioners use this kind of confusing language when being confronted with mind–body issues. As I earlier demonstrated, even ‘thorough-going materialists’ like Walter can get caught in the web of mind–body interactions. Moreover, as the philosopher Ian Hacking concludes: ‘Neuroscience is not so monistic as it so confidently asserts’ (Hacking, 2007: 101) since contemporary neuroscientists keep dividing people into beings with mind, brain and body qualities, like emotions, thoughts and physical sensations (Hacking, 2004, 2005). Aside from these puzzling statements, neurofeedback practitioners also use language that comes close to the terminology of Grey Walter, when he divided people into personalities according to their brain types. One of the supervisors of a neurofeedback course that I attended, for example, clarifies the difference between two levels of dopamine by stating: ‘You can see low levels walking into your door [acts lethargic] and you can see high levels [acts hyperactive].’ During the same course, several other connections between someone’s brain and personality are made and put forward in stereotypes. Alcoholics are called ‘alphaholics’; brainwaves are personalized by calling them nice, beautiful, or very reactive; and when one of the supervisors uses a metaphor, his colleague explains: ‘He is very good at metaphors, he has a good parietal lobe.’

Other practitioners explain how they increasingly learned to connect brain activity to behaviour during their careers. Someone says in an interview: ‘You started looking at people and thought: “This person needs somewhat more beta”, or “that person needs SMR”.’ Another practitioner explains how he recognizes people with high frequencies in their brains: ‘You notice they breathe very high . . . and you notice they sit like this [hunches his shoulders, shrinks his body].’ His colleague speaks of persons with low alpha waves as ‘low voltage-persons’, which comes close to Walter’s M (minus) alpha type.

Another recurring theme that started with Berger’s interest in telepathy and can be traced in the work of all cited scientists, is the connection between this materialistic point of view and a spiritual way of thinking. Many neurofeedback users also practise yoga or meditation, some practitioners use neurofeedback to meditate or to hypnotize themselves, and others learnt about the therapy by reading spiritual magazines or books. People who try to work on their brains to enhance themselves often use reductionist language (the mind is the brain), but they easily connect this way of thinking with a holistic view.¹³ That is to say, believing that the self is a total functioning organism (holism), or reducing it to the brain (monism), apparently have the same consequences: people start working on their brains, to change themselves.

Genealogy of the extended self

Using a device to visualize, control, enhance, or cure the brain changes people’s understanding of their selves. This is not only the case in the practices described in this article. Several scholars have analysed how brain knowledge turned us, for example, into ‘neurochemical selves’ (Rose, 2003), or objective or pharmaceutical selves (Dumit, 2003, 2004), or changed personhood into brainhood (Vidal, 2009). Other scholars, however, nuance this impact of the brain and emphasize that people who are confronted with their neurological constitution do not simply become neurologic subjects but use heterogeneous language of psychological and physiological statements (Bröer and Heerings, 2013; Choudhury, McKinney and Merten, 2012; Martin, 2010; Pickersgill, Cunningham-Burley and Martin, 2011). Users of neurofeedback do both: they strongly identify their selves with their brains and also use heterogeneous language of physical and psychological statements. Moreover, the combination of material and spiritual ideas, the computer metaphors, and the brainwave activities that are all enacted in this way of being oneself is typical for neurofeedback users.

This ‘new’ mode of self is not fixed or universal, but its characteristics can be traced in the ideas of early scientists. Hans Berger tried to grasp psychical energy and in his devotion he created a brain that could give signals on paper. Grey Walter claimed not to be interested in concepts like the mind and introduced a performative brain that appeared to be able to control the self. Joe Kamiya constituted a brain that could be trained by the self in order to help this self becoming more spiritual, Barry Sterman designed a brain that could control, and could be controlled by, the self, whereas contemporary practitioners promote a brain that should be worked on and taken care of by the self, since it otherwise can cause serious harm. In this development, all kind of brain-related entities (alpha, beta, theta, SMR) have been distinguished, and started to have effects on the self. Connections

and entanglements between human and machine emerged, mind–body problems enlarged and struggles between brains and selves appeared.

The result of these developments is a self that is extended with all kind of entities that exchange and control each other continuously. Contemporary users, for example, talk about their ‘bad beta’ or their self-resetting system. They state that they use their ‘will-power’ to control their brainwaves, explain that they give their brain ‘an assignment’, or explicitly try not to ‘pay attention’ to its actions. The recurring frustration concerning the mind–brain relation is also revealed in the statements of contemporary neurofeedback users. For example, they say: ‘I had always thought that I was controlled by myself [instead of by neurons], or ‘There is also one part of me that doesn’t want to see it at all in that way’ (Brenninkmeijer, 2010, 2013b).

Doing neurofeedback creates new ways of perceiving oneself, and with this new ways of acting and being oneself. This self is not universal or fixed, but analogies between users’ statements can be traced. Neurofeedback users split their selves from their brains, refer to various brain (map) entities, compare themselves with machines, and maintain a commitment to the traditional souls, minds and psyches. Analysing the work and lives of important figures in the history of neurofeedback showed that the drive to understand the self by the brain is not particularly new or modern, and the resulting struggle between the self and the brain is not that new either. The blend of psychological, physiological, mechanical and spiritual explanations brought up by contemporary neurofeedback users when describing themselves, does not signify confusions due to a new (‘modern’) scientific way of thinking, but is a result of the quest to grasp the (spiritual) self with a brain device.

Notes

Part of the research for this article was conducted with a short visit grant from the European Neuroscience and Society Network (ENSN). I would like to thank Maarten Derksen and Trudy Dehue for their helpful comments on earlier versions of this article.

1. All ethnographic material in this article was collected for my PhD research ‘Brain Technologies of the Self’ (Brenninkmeijer, 2013b).
2. With ‘user’ I refer to the person using neurofeedback as a technology of the self, with ‘practitioner’ I mean the person who gives the therapy. Most practitioners I interviewed are psychologists in the Netherlands and the UK, and they often work in a neurofeedback clinic.
3. Gloor (1969) translated and published all 14 reports: ‘Über das elektroencephalogramm des menschen’ of Hans Berger.
4. Of what is saved of Berger’s diaries, most is published by Jung (1963) and Jung and Berger (1979). Gloor (1969), Borck (2001, 2005a, 2005b) Millett (2001) and others also cited and translated parts of Berger’s diaries.
5. Berger (1919) *Hirn und Seele* [Brain and Soul] (Jena: Fischer). Unfortunately, I had no access to the document.
6. See Sourkes (2006) for more information about the consequences of the law of conservation of energy for psychological theories.
7. That is, Kamiya used operant conditioning procedures, but explains that he was also inspired by cognitive psychologists (Kamiya, 2011).
8. However, Serman also writes that some patients are unable to benefit from this voluntary therapy, probably due to motivational factors (1981).
9. Accessed on 14 June 2012, @: www.skiltopo.com/index.php

10. An article by Sterman's colleague David Kaiser clarifies: 'Love is the primary source of neuroplasticity', and neuromodulation is a form of 'guided neuroplasticity'.
11. Clark does not directly respond to Sterman with this citation. Several other experts claimed that Clark had brain damage.
12. EEG-biofeedback never entirely disappeared. In the United States, several other figures were important in the establishment (or continuation) of neurofeedback. An assistant of Sterman, Margaret Ayers, noticed that after doing neurofeedback, 'these epileptic individuals were happier, smiling, they were talking about things' (Robbins, 2000). She started one of the first neurofeedback clinics in the USA. One of her clients was the son of 'The Othmers' who became prominent neurofeedback promoters after their son had benefited from Ayer's training in the 1980s. According to one of my interviewees, the Othmers and Sterman together gave a neurofeedback course in the 1990s in which some Dutch psychologists took part, who thereupon started their own practices and also developed a European course. The American psychologist Joel Lubar is also important in the history of neurofeedback because of his EEG-biofeedback research on hyperactive children (Lubar and Shouse, 1976).
13. Holism understands systems or organisms as a whole, instead of a sum of elements. Physiological processes are seen in terms of their roles in the total functioning of the organism, and mind and body are not ontologically different. For holistic thinkers, the mind is in the body, and the body is reanimated with a mind (Harrington, 1999).

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