The after-effect of Adolf Wohlgemuth’s seen motion

Gustav Adolf Wohlgemuth (1868–1942, figure 1) provided a singular service to visual science with his monograph on the aftereffect of seen motion (Wohlgemuth, 1911). In it he reviewed 19th-century studies of the motion aftereffect (MAE) in what remains the most comprehensive single article on the phenomenon. According to John Carl Flügel (1954), it was “the most thorough of all investigations on this subject” (page 25), and that opinion remains to this day. The monograph was the first Supplement published by the British Psychological Society, and it was essentially his thesis for a Doctor of Science at the University of London. He commenced his research “on the advice and kind assistance of Mr William McDougall”, who also acted as a subject in some of the experiments, as did Charles Spearman, Carveth Read, James Sully, and Flügel.

One of the virtues of Wohlgemuth’s thesis is his thorough review of the earlier German literature. In the preface to his published account in 1911 he remarked: “The compilation of the Historical Survey was very protracted work owing to the literature being scattered in many places other than the ordinary psychological sources.” The survey was chronological, and he repeated many of the previous studies before reporting 34 experiments of his own.

Figure 1. Detail of a photograph of Gustav Adolf Wohlgemuth probably taken in the late 1920s (kindly supplied by Winifred Carey, Wohlgemuth’s daughter-in-law).
He confirmed aspects of previous experiments showing that: motion over the retina is necessary to generate an MAE; the strength of the MAE is more marked with fixation; the MAE is restricted to the retinal area stimulated by prior motion; it immediately follows adapting motion and its visibility improves with practice; an MAE can be produced in each eye independently, and what is seen with two eyes is a combination of the two monocular adaptations; adaptation of one eye transfers to the other; MAEs can be produced by a wide range of speeds, and by stroboscopic as well as real motion; following adaptation motion can be seen with the eyes closed. This last distinction was referred to as the MAE in the subjective field (with the eyes closed or viewing a homogenous surface) as opposed to the objective field (when viewing a stationary test pattern). The aftereffect in the subjective field was of shorter duration, and it was phenomenally different from that in the objective field: “At no time does there appear to be such a rapid or tumultuous streaming in the objective field as in the subjective” (page 31). As such, it is closely linked to the ‘streaming phenomenon’ that can be seen during or after fixation on geometrically repetitive patterns.

Wohlgemuth drew attention to the paradoxical feature of MAEs:

“I hold that in an objective movement we have two factors, viz. (a) the experience of movement proper, similar to the after-effect, and (b) the change of position in space …. The after-effect is different from the experience of seeing an objective movement, in that the latter contains two components (a) and (b), as described above, whereas the after-effect contains (a) alone” (pages 108–109).

This characteristic of MAEs has created problems with regard to its measurement, since it cannot be readily cancelled by real motion. On the other hand, the possibility exists that it might provide a means of measuring a pure motion system in vision. Indeed, this was appreciated early on by Henry Bowditch and G Stanley Hall (1881): “We cannot resist raising the question whether we may not be here very near the quale of real, pure sensation” (pages 300–301).

Three of Wohlgemuth’s experiments deserve particular attention in that they predate later research, but too often this has not been acknowledged. His first experiment demonstrated that the MAE is more readily visible in the objective than in the subjective field and, after its dissipation, it can be revived briefly by blinking. Moreover, if the eyes remained closed for a period longer than the MAE would normally last, then it was still seen on opening the eyes. This is now called storage of the MAE. Storage was rediscovered by Irwin M Spigel (1960), although he made no mention of Wohlgemuth’s work. Experiment 15 in the monograph describes what we would now call a ‘velocity aftereffect’—that adaptation of motion in one direction generally slows subsequently seen motion in the same direction. No lesser figure than James Gibson (1937) ‘rediscovered’ this effect, and though he did acknowledge that the MAE had been “rather thoroughly investigated” by Wohlgemuth, he made no mention of Wohlgemuth’s experiment 15. Experiment 30 reports that the movement aftereffect occurs whether or not the mind is attending to the motion. He notes that this result concurs with the earlier work by Adolf von Szily (1905), who “concluded that the after-effect of motion is brought about without the mediation of consciousness” (Wohlgemuth, 1911, page 22). Whether the MAE is influenced by attention has attracted a good deal of interest in recent years (Morgan, 2011). Avi Chaudhuri (1990) was the first of a spate of claims that attention does affect the MAE; but again, although he cited Wohlgemuth as a general reference to the ‘much studied and well-documented phenomenon’, he failed to note that the very experiment that he reported had already been described in Wohlgemuth’s monograph, albeit with a very different result.

Wohlgemuth also found that the MAE is more marked with a well-illuminated stimulus; it occurs with indistinct moving contours; its strength increases with spatiotemporal frequency and is related to the velocity of the adapting motion; a stronger MAE is seen with square-wave
than with rectangular-wave gratings; the MAE can be added to real motion; its initial velocity is comparable with that of the adapting motion; it occurs with both light-adapted or dark-adapted eyes; it has different characteristics in central and peripheral retina; an MAE is not seen if adapting motion involves the whole visual field, but it does occur with motion over very small visual angles; following opposite simultaneous or successive motions over the same retinal area, the motion observed is the resultant of the component MAEs; MAEs are restricted to the orientation of lateral motion; it does not require attention; and it does not occur for touch.

Previous interpretations were classified as physical, psychical, and physiological. His model for MAEs (figure 2) was greatly influenced by William McDougall, who was in turn in thrall of Charles Sherrington’s theory of integration within the nervous system. Sigmund Exner (1894) was also the source of inspiration. A similar, but more generally stated, analysis of motion was presented by Pleikart Stumpf (see Todorovic, 1996). Both Wohlgemuth and Stumpf presented precursors of Reichardt detectors, although Wohlgemuth formalised the model more fully.

Figure 2. Wohlgemuth’s (1911) model of motion detection: “Let \(a_1, a_2\) and \(b_1, b_2\) be connected retinal elements in a straight line and adjacent or nearly so. These elements are connected with series of neurones, as indicated by the dotted lines, giving off collaterals to the various centres of brightness, of colour, perhaps of ‘local sign’, etc. Also a branch, as indicated by the drawn outline, towards a ‘subcortical centre of movement’, consisting of summation-cells \(A_1, A_2, B_1\) and \(B_2\), etc., that pass their excitations on to the cortex, the organ of consciousness. Now, if a physical stimulus passes across the retina in such a direction that the stimulation takes place in the direction \(a_1, a_2\), etc., \(a_1\) becomes first stimulated. The excitation passes on to \(A_1\) and also to the ‘Schaltzelle’, \(S_1\). From \(S_1\) two paths are open to the innervation, viz. towards \(A_1\) and \(A_2\). But the resistance at the synapse \(S_1-A_1\) has been lowered owing to the direct excitation of \(A_1\) from \(a_1\), so by far the greater part of the excitation from \(S_1\) will pass on to \(A_1\) and comparatively little to \(A_2\). Then \(a_2\) is stimulated and the excitation passes on towards \(A_2\) and \(S_1\). Here, however, the resistance at the synapse \(S_1\) is lower than at the synapse \(A_2\), hence most of the excitation from \(a_1\) passes on to \(S_1\), and thence, for the same reason, to \(A_1\). In other words, by the successive stimulation of \(a_1\) and \(a_2\), \(A_1\) becomes more strongly excited than \(A_2\) . . . . If now the movement stops suddenly, then there is no difference in the excitations reaching \(A_1-A_2, B_1-B_2\), but \(A_1\) and \(B_1\), being more fatigued than \(A_2\) and \(B_2\), owing to the previous excessive stimulation, send off less innervations to the cortex than these, and my theory is then that this fact of \(A_2\) and \(B_2\) having now more tonus than \(A_1\) and \(B_1\) constitutes the subcortical condition of an apparent movement in the opposite direction” (pages 99–100).
Thus, Wohlgemuth adopted a physiological interpretation of MAEs, despite the fact that relatively little was known about visual neurophysiology at that time. Nonetheless, he appreciated that naturally occurring neurological conditions could cast light on his interpretation and also that the MAE could prove useful for neurology. He argued that “if there is a lesion in this theoretical ‘centre of movement’, the after-effect ought to be impaired under some conditions, possibly intensified under others. For this purpose it would be necessary to examine a great number of cases, especially those where there is a lesion affecting the optic tract” (1911, page 115). He started collecting cases, with the assistance of Victor Horsley, but he could not pursue them to his satisfaction. His final statement was “If it is possible to prove this theory conclusively, it is evident that an abnormal increase or decrease in the intensity of the after-effect may afford some valuable aid in diagnosis” (page 115).

Wohlgemuth did not continue with research on vision, although he remained at University College, where he was noted for his skill in the construction of experimental apparatus and as an authority on experimental design. Despite being a prominent figure in the psychological laboratory, he never occupied a position as a member of staff (Flügel, 1954). His interests turned to memory and imagery, and he published articles on these topics (Wohlgemuth, 1913, 1915, 1916, 1919) which influenced Bertrand Russell, with whom he corresponded (Pincock, 2007). Wohlgemuth (1923) is perhaps best known for his critical assessment of the scientific basis for psychoanalysis. A flavour of his scorn is evident in this statement: “The psychologist aims, as it were, at an aseptic treatment, whilst the psycho-analyist indulges in deliberate infection” (page 245)!

But what of Wohlgemuth, the man? He was born in Berlin and moved to London as a young man. Little seems to be known about his life in Germany or when he moved to London. His name appears in the London census of 1891, and he was naturalised as a British subject in 1897. His business imported and exported sausage casings (figure 3); it is listed in 1903, and he retained the business throughout his life. Wohlgemuth embarked upon a degree in psychology at University College in 1902 and was awarded a third-class science degree.
by the University of London in 1905; he commenced experiments for his doctorate in the Psychological Laboratory immediately thereafter. He was described as ‘a brilliant research student’ and completed his research in 1909, with the award of his Doctor of Science in the following year.

His private life was not without complications (see Valentine, 2008). Two years after publication of his monograph on seen movement, he married a French widow (Clemence Morrelet), but the union was neither fruitful nor happy. Wohlgemuth had formed a close friendship with a fellow research student, Nellie Carey (1886–1960), who worked on colour vision and imagery in children. On 6 June 1918 Adolf was shot in the back by his jealous wife. In the initial report of the crime, published in The Times on 8 June 1918, Adolf is reported to have stated to the policeman at the scene of the crime: “She shot me in the back like a damned Frenchwoman would do.” The trial at the Old Bailey was delayed until 12 September 1918 due to the recovery of Adolf from the gunshot wounds; Clemence was found innocent of attempted murder but sentenced to six months imprisonment for unlawful wounding. Nellie Carey changed her name to Wohlgemuth, and she bore a daughter in 1921 and a son in 1929. Adolf and Nellie, who are shown in figure 4, finally married in 1936, after the death of Clemence.

It is a pity that we know so little about a visual scientist whose life was so moving and colourful.

Figure 4. Detail of a photograph of Nellie and Adolf Wohlgemuth taken in the late 1930s (kindly supplied by Winifred Carey).
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