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ORIGINAL ARTICLE

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# A short history of ideo-motor action

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**Abstract** The ideo-motor theory, which is currently receiving heightened interest in cognitive psychology, looks back on a long history. Essentially two historical roots can be presented. A British one, initiated by Laycock (1845) and Carpenter (1852), which was developed in order to explain ideo-motor phenomena by means of cerebral reflex actions. A second and older root is the German one by Herbart (1816, 1825), Lotze (1852), and Harless (1861), which considered the ideo-motor principle a fundamental mechanism of all intentional human behaviour. Both roots converged in James' (1890) *Principles of Psychology* before they fell into oblivion due to the dominance of behaviorism in the first half of the 20th century. The few empirical ideo-motor studies of the early 20th century are briefly described. Finally, similarities and differences in the history of the ideo-motor theory are delineated and a perspective is given covering research questions that could be examined in the future.

## Introduction

The impact of *action effects* that have been experienced on the control of voluntary behaviour is a topic of interest not only for this special issue of *Psychological Research* but also a current theme in the research surrounding *action control* currently being done in the field of cognitive psychology (e.g., Hoffmann, 1993; Hommel, 1998, 2003; Hommel, Müsseler, Aschersleben, Prinz 2001; Prinz 1990, 1997). Until now, the following major question has remained unanswered: How is the mind able to use the body to achieve its goals, without any notion of the anatomy and neurophysiology of its functioning. Theoretically, this research is guided by a relatively simple consideration, which states that human actions are initiated by nothing other than the idea of the *sensory consequences* that typically result from them. As a prerequisite for this causal relationship to take effect which effects originate from which actions must have previously been learned. Once this bidirectional connection between action and action consequence has been established, the movements of the body follow the notion of the movement's consequences in the mind "*unhesitatingly and immediately*," as James (1890, II, p. 522) expressed it, thus defining *ideo-motor action*.

Contemporarily, the concept of ideo-motor action is implemented in the description of sequential learning (e.g., Greenwald, 1970; Ziessler, 1998; Ziessler & Nattkemper, 2001; Hoffmann, Sebald, & Stöcker, 2001) as well as in the description of the acquisition of action competence (Hoffmann & Sebald, 2000a, 2000b; Stock & Hoffmann, 2002). For the explanation of their experimental results, all these studies used the major assumption of the ideo-motor principle, which states that an action is initiated by the anticipation of its effects. Furthermore, all of them agree that before this advanced action mechanism can be used, a learning phase has to take place, advising the actor about several actions and their specific effects.

Meanwhile, numerous experiments have been undertaken to empirically test this main assumption of the ideo-motor theory (e.g., Elsner & Hommel, 2001; Hommel, 1996; Kunde, 2001). Elsner and Hommel (2001), for example, could demonstrate that irrelevant but contingently experienced action effects became integrated into an ideo-motor action code. When these learned action effects were presented as imperative signals in a second task, they had an impact on the choice and execution of the following actions.

In addition, Kunde (2001) was able to show that even anticipated action effects have an impact on the free choice of an action and on its execution latency. Kunde's as well as Elsner and Hommel's results can be seen as evidence for the ideo-motor hypothesis. However, even after all the experimental successes in ideo-motor

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research, it is still an open question how exactly the idea of an action effect is constructed.

In order to evaluate today's application of the ideo-motor theory and to derive new ideas for future research, it seems in our view worthwhile to have a closer look at its history. The following historical overview will describe two historical roots, a British and a German one. Both roots developed almost independently of each other, focusing on the explanation of ideo-motor phenomena on the British side, and on the theoretical consideration about voluntary actions on the German side. Both the British and the German lines were considered by James (1890) in his *Principles of Psychology* before they fell into oblivion due to the dominance of behaviorism in the first half of the 20th century. The few empirical ideo-motor studies of the early 20th century are briefly described. Finally, a balance will be drawn up concerning which questions have been answered and which still need attention. As we will see, our retrospective view may in fact uncover a series of incitements for new theoretical and experimental considerations.

## The historical beginnings

James (1890) is often quoted with regard to the ideo-motor principle, but in fact he was not its author. He himself remarks in a footnote that the cleverly chosen term "ideo-motor," which "combined the driving force of a dominant *idea* with the resulting involuntary *motor* activity" (cf. Spitz, 1997), was originally coined by Carpenter.

William Benjamin Carpenter (1813–1885) was the intellectual leader of a small but agile research group[1] of physiologists and doctors, who were laying the groundwork for developing a physiological branch of psychology[2] in England between 1850 and 1875. In addition to Carpenter, one other member of this research group is of special interest. Thomas Laycock (1812–1876) was developing concepts about the reflex function of the brain as well as the automatic release of reflexes through ideas, which were essentially taken over by Carpenter.

Alongside Carpenter, James primarily refers to Lotze (1817–1881) and Harless (1820–1862). By doing so he mentions the German origin of the ideo-motor theory. Let us begin with the British root of the ideo-motor principle and focus primarily on Thomas Laycock, because as Tischner (1929, p. 76) wrote, Carpenter was "the creator of the term, but not the discoverer of the principle."

[1] According to Wozniak (1999) other members of this research group were: Benjamin Collins Brodie (1783–1862), Robert Dunn (1799–1877), Henry Holland (1788–1873), Thomas Laycock (1812–1876) John Daniel Morell (1816–1891), and Daniel Noble (1810–1885).

[2] In the history of psychology the conception of physiological psychology is usually ascribed to Wilhelm Wundt (1873/1874). This is not entirely correct when considering the work of the research-group around Carpenter.

## The British root of the ideo-motor principle

### Thomas Laycock and the reflex function of the brain

Thomas Laycock (1840, 1845) discovered the behaviour-initiating effect of ideas by taking a medical-physiological perspective. By observing patients with hydrophobia, or rabies as it is called today, he was able to demonstrate that the visible symptoms, such as "spasm of the respiratory muscles and gasping, convulsions of the face and occasionally of the trunk or limbs, and an extraordinary development of the instinct of conservation" (Laycock, 1845, p. 6), involuntarily occurred and could be characterized as reflexes. This reflex-like excito-motor behaviour could be triggered by a variety of stimuli, one of which was mere imagination:

> The acknowledged excito-motory phenomena of hydrophobia may be induced, firstly, through the sensual nerves of touch, as by the contact of water with the surface of the head, hands, chest, the lips and the pharynx; second, by a current of air impinging on the face or chest. In the majority of cases, the slightest breath of air will bring on gasping and convulsions. [...] But, thirdly, a bright surface, as a mirror; fourthly, the sight of water; or fifthly, the sound of water dropping; or sixthly, the *idea of* water, as when it is *suggested* to the patient that he shall drink; all most indubitably induce excito-motory phenomena. (Laycock, 1845 p. 6, italics added by the authors)

The various triggers can be condensed into three main classes: firstly, the *direct proximal-sensory stimuli* (e.g., the contact with water); secondly, the *indirect distal-sensory stimuli* (such as the contact of reflected light with the retina); thirdly, and this is the most important classification, *the indirect imagined-stimuli* (ideas), where the mere mental image causes the reflex (e.g., the mention of water in a conversation). As Laycock's observations show, this third class of stimuli implies that, at least with regard to hydrophobia, the mere idea of water and its connection with the idea of drinking lead to a compulsive necessity to execute an excito-motor program, as can been seen in his following examples: "On suggesting that he [the patient] should swallow a little water, he seemed to be frightened, and began to cry out," and: "On our proposing to him to drink, he started up and recovered his breath by a deep convulsive inspiration" (Laycock, 1845, p. 7), or: "Some ale was brought to Dr. Adam while he talked with the patient, the patient started up from the table at the sight of the mug, and ran away" (Laycock, 1845, p. 7).

Laycock attempted to determine a physiological explanation for the initiation of actions by ideas that would go beyond a phenomenological description. Therefore he postulated the existence of "ideagenic" and "kinetic substrates" in the encephalon. The ideagenic substrate can be activated when a patient imagines a cup

of tea, for example, upon which the connected ''kinetic substrate'' is compulsively activated and the typical symptoms of hydrophobia show. To the same extent, the ideagenic substrate can be activated by visual stimuli. In such a case:

> ...the spectrum of the cup of water will traverse the optic nerves, and enter the analogue of the posterior gray matter in the brain causing changes (ideagenous changes), corresponding to the idea of water; thence the series of excited changes will pass over to the analogue of the anterior gray matter exciting another series, (kinetic changes,) by which the necessary groups of muscles are combined in action. (Laycock, 1845, p. 8)

With the interaction of sensory (ideagenic) and motor (kinetic) substrates, Laycock (1845) anticipated a theoretical consideration that Harless, without knowledge of Laycock's work, published in a comparable form in 1861. Additionally, it is interesting that Laycock was convinced that this speculation was by no means new, tracing its origin back to the 17th and 18th century and to names such as Albrecht von Haller (1708–1777), Robert Hooke (1635–1703), and John Locke (1632–1704).

Due to the fact that Laycock reached his conclusions by observing hydrophobic patients, he considered the ideo-motor regulation of movement a cerebral reflex. Hydrophobic patients have no deliberate control over their own behaviour, even if their aggrieved nerves are only excited by ideational states. Laycock made no comments concerning the voluntary regulation of behaviour and a possible connection to his ideo-motor concept. This gap was closed by his scientific colleague, William Benjamin Carpenter.

## William B. Carpenter's ideo-motor reflection

While giving a Presentation at the Royal Institution of Great Britain on Friday the 12 March 1852 Carpenter coined the term ideo-motor in order to propose a scientific explanation for a series of en vogue parapsychological phenomena. At this time, occultism was widespread, and psychic séances were being held in the best of social circles (cf. Hyman, 1999). Table turning, the magical pendulum, mesmerism, and the divining rod are only a few examples of the phenomena that were believed to be driven by unknown powers.

Carpenter did not cast doubt on the observed mysterious phenomena. But he opposed the assumption that the cause of these phenomena can be found in unknown physical powers, spiritual influences or other supernatural sources. He wrote:

> ...from the account commonly given of these phenomena—to the effect that the *will* of the 'biologized' subject is entirely subjected to that of the operator—he [Carpenter] entirely dissented; and believed that he should be able to show that the state in question is one of *reverie*, in which the voluntary control over the current of thought is entirely suspended, the individual being for the time (so to speak) a mere *thinking automaton*, the whole course of whose ideas is determinable by suggestions operating from without. (Carpenter, 1852, p. 147)

The ''biologized states'' that were reached by the participants in such séances were subsumed by Carpenter as being like hypnotic states of mind, where the will of the hypnotized individual is turned off. In contrast to the hypnotic state, the peculiarities of the ''biologized states'' are that the people remain in a waking state. All senses are unaffected in their working and afterwards memory of what occurred and was experienced in the séance is generally complete.

Other renowned contemporary scientists such as Chevreul (1833) or Faraday (1853) were attempting to falsify the alleged paranormal causes of these occult visions in well-organized experiments and blind trials. Carpenter instead was postulating a psychological theory as an explanation for these phenomena:

> All the phenomena of the 'biologized' state, when attentively examined, will be found to consist in the occupation of the mind by the *ideas* which have been suggested to it, and in the influence which these ideas exert upon the actions of the body. Thus the operator asserts that the 'subject' cannot rise from his chair, or open his eyes, or continue to hold a stick; and the 'subject' thereby becomes completely possessed with the fixed belief of the impossibility of the act, that he is incapacitated from executing it, *not* because his will is controlled by that of another, but because his will is in abeyance, and his muscles are entirely under the guidance of his ideas. (Carpenter, 1852, p. 148)

Carpenter supported his psychological explanation of these phenomena with the physiological knowledge of his time. In this way he described reflex actions in a similar way to Laycock. Carpenter differentiated between *excito-motor reflexes*, like respiration and swallowing, and *sensory-motor reflexes* like surprise-reactions after a loud noise or the lid close reflex. Furthermore, he postulated as a third form of reflex actions the *ideo-motor reflexes*, the triggering of actions by ideas. Within this supposition he explicitly referred to Laycock as the first to extend the reflex doctrine from the spinal cord to the brain.[3]

In his reasoning (cf. Fig. 1), Carpenter imagined the processing of stimuli and the generation of action as a bottom-up path of information processing. In the normal course of processing external impressions evoke sensations, ideas, emotions, and intellectual processes that determine the will. Then the will initiates the actions to be executed. But if the path of processing is inter-

[3] Nevertheless, Carpenter denied that Laycock had already described the triggering of cerebral reflexes *by ideas* and presented these findings of Laycock as his own. This resulted in an ongoing dispute concerning authorship between the two (cf. Carpenter, 1871; Laycock, 1860, 1876).

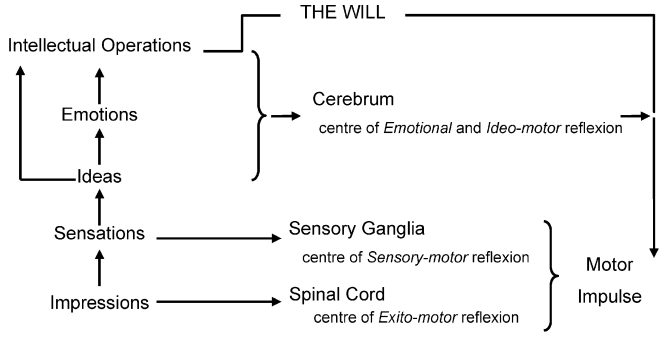


**Fig. 1** Internal processing of external impressions according to Carpenter (1852, 1874)

rupted at any point, Carpenter suggests that a reflex action occurs. On the lower levels we have excito-motor reflexes, which are controlled by the spinal cord. On the next highest level of processing, sensory-motor reflexes set in, controlled by the sensory ganglia. Finally, the ideo-motor reflexes occur, when the will, as the highest controlling instance, is turned off in some way. In this case ideas and emotions gain direct access to action execution through reflexes. Carpenter's model is depicted in Fig. 1.

The ideo-motor reflex action was introduced by Carpenter as the missing link in the chain of physiological explanations of action. This can be seen in his model:

> ...the *ideo-motor* principle of action finds its appropriate place in the physiological scale, which would, indeed, be incomplete without it. And, when it is once recognized, it may be applied to the explanation of numerous phenomena which have been a source of perplexity to many who have been convinced of their genuineness, and who could not see any mode of reconciling them with the known laws of nervous action. (Carpenter, 1852, p. 153)

By means of ideo-motor action, it was possible to explain a large number of occult phenomena without having to resort to new bioelectric powers. Carpenter supports that ideo-motor phenomena occur through a limited functioning of the will and additionally through a high level of expectant attention focused on the completion of the anticipated action effect (cf. Carpenter, 1852, p. 153).

To summarize, it can be emphasized that both Laycock and Carpenter described their theory of ideo-motor reflexes referring to cases where the will of the observed individuals was limited to a large extent by either sickness or occult settings. By mentioning ideo-motor actions with reference to these very specific cases, Laycock and Carpenter could have falsely classified them as being non-intentional.

Carpenter's conception of the ideo-motor principle in particular remains limited because it only refers to occult phenomena (cf. also Carus, 1988; Hyman, 1999; Spitz, 1997; Tischner, 1929). This was justly criticized by Prinz (1987):

> It is ironic that William B. Carpenter who [...] coined the term *ideo-motor action*, at the same time played an important part in discrediting the concept as well as the phenomena subsumed under it. [...] According to Carpenter, phenomena such as table turning, mind reading or Saint Vitus's Dance lose much of their disquieting and consternating character if interpreted as examples of ideo-motor action [...] Carpenter's examples placed the ideo-motor phenomena within the vicinity of the paranormal phenomena of the mind and thereby attached to them a certain odium which, to this day, has impeded their being taken as seriously as they perhaps should be. (Prinz, 1987, p. 47f.)

However, there was a flipside to this limitation. Due to the widespread fascination of occult phenomena that captivated Europe in the middle of the 19th century, it was only a matter of time before Carpenter's ideo-motor explanation for these phenomena became popular.

## The German root of ideo-motor action

The restricted classification of the ideo-motor principle as a cerebral reflex action, as we will see, was not of interest in the German root of this theory. While in Great Britain a medical-physiological view was taken, which led to the insight that ideas control action, and which was predominantly used to explain *ideo-motor phenomena*, the German scholars were more interested in developing an *ideo-motor theory of action control* in order to find an elegant solution to overcome the gap between mind and body—one of the major philosophical problems since Descartes (1596–1650). As Young (1990) explicated, the mind-body problem of interaction concerns a variety of questions such as "...how unconscious fantasies can cause psychosomatic illnesses [...]. How do material impacts cause thoughts, including the thoughts which lead from sensation to knowing," and last but not least, "...how thoughts can cause actions." The principle of ideo-motor action, proposed by the members of the German root, Herbart, Lotze, and Harless, is an attempt to dissolve the mind-body dichotomy.

### Johann F. Herbart's early conception of ideo-motor action

Herbart was convinced of the existence of a simple solution to the mind-body dichotomy. Contrary to many others in his time he did not attempt to disentangle the psychophysiology of the mind-body-problem. According to Herbart such an attempt would be doomed to failure, because, as he explicitly pointed out, the mind has no idea about the anatomy and physiology of the body. Instead, the solution for the mind-body problem must be found in the connecting function of sensations (cf. Stock, 2002). To get a better understanding of Herbart's work, let us take a closer look at his considerations.

As early as 1816 (in his *Textbook for Psychology*) and even more precisely in 1825 (in *Psychology as a Science*), Herbart described the main elements of the ideo-motor mechanism. With regard to the ideo-motor principle, he not only considered the action determining aspect of the theory, but also learning and developmental aspects in the construction of ideo-motor codes. These key developmental and learning elements had been more or less overlooked by Carpenter and Laycock. In this regard, Herbart was a great deal wiser and in 1825 he formulated the following supposition:

> Right after the birth of a human being or an animal, certain movements in the joints develop, for merely organic reasons and independently of the soul; and each of these movements elicits a certain feeling in the soul. In the same instance, the outside senses perceive what change has come about. [...] At a later time, a desire for the change observed before arises. Thus, the feeling associated with the observation reproduces itself. This feeling is a self-preservation (*Selbsterhaltung*) of the soul, which corresponds to all the inner and outer states in nerves and muscles through which the intended change in the sphere of sensual perception can be brought about. Hence, what has been desired actually happens; and the success is perceived. Through this, the association is reinforced: the action, once performed, makes the following one easier and so on. (Herbart, 1825, p. 464)

In this short passage Herbart describes the fundamental elements of the ideo-motor control of action. He identified this process as a two-step process. In the first phase, the soul observes from the body which movements are accompanied by which sensory effects. In the second phase, the soul is able to use this knowledge about actions and their effects in a purposeful manner in order to initiate actions by means of the anticipation of the action's sensory consequences.

Herbart contended that the formation of such relationships between actions and effects inevitably result because of the necessary role they play in the "self-preservation of the soul"—so that the soul is not brought out of balance. These relationships, generated and stabilized during the learning process, can subsequently be utilized by desires and wants through a bidirectional inversion. Again the fundamental necessity of the "self-preservation of the soul" is the reason why the idea of an action initiates the activation of nerves and muscles in such a manner that the actions leading to the desired effect are actually executed. All other movements would not serve the "self-preservation of the soul," since they would not be in agreement with the desired effect.

Herbart was the historical forerunner of both Laycock and Carpenter, and was admittedly ahead of them in theoretical analysis. He did not limit the principle of ideo-motor action to reflex-like behaviour. By that, Herbart anticipated the correspondent descriptions of Lotze (1852) and Harless (1861), and even James (1890). Approximately 70 years before James, Herbart supported the concept of the initiation of actions through ideas as a *basic principle* for the control of *intentional behaviour*.

Herbart's description of the ideo-motor principle is precise and comprehensive. In 1889, Külpe, from a more modern perspective, cast doubt on the principle of "self-preservation of the soul" as the underlying mechanism of action. However, in all other regards Herbart's considerations still apply today. His theoretical assumptions about the development of the relationship between movement and effect are still of relevance today. According to Herbart, all sensational effects resulting from a movement are automatically linked with this movement. The association developed from this gains in strength the more often it is experienced. Another assumption of Herbart, which states that the relationship between movement and effect can be used in the reverse direction in order to initiate movement, is still considered correct (e.g., Hoffmann, 1993; Hommel, 1996, 1998; Prinz, 1990, 1997).

However, Herbart's precise theoretical considerations did not generate empirical testing of the ideo-motor theory for a long time. One explanation of this can be seen in the fact that Herbart was not primarily interested in psychological experiments. In his *Textbook for Psychology* he wrote:

> Psychology must not experiment with the human being and artificial tools do not exist within its bounds. The more accurate the aid of calculations should be used. (Herbart, 1834/1965)

## Herman R. Lotze—Herbart's successor and critic

Herman Rudolph Lotze followed Herbart as the Chair of Philosophy at the University of Göttingen in 1840. The succession as Ordinarius of Philosophy not only provided a historically interesting constellation between these two scholars but also paved the way for a philosophical contention between Lotze and his predecessor. No other philosopher is given the same consideration in Lotze's work as Herbart is, but then again no other is as critically challenged either (cf. Nath, 1892; Wentscher, 1925; Pesters, 1997).

In the same year, 1852, when Carpenter coined the term "ideo-motor," Lotze published his *Medical Psychology and Physiology of the Soul*. In this book, Lotze agrees with Herbart's concept concerning the origin of movement. This concept contends that upon closer evaluation individuals in no way have a notion of the mediating processes in the nerves, tendons, and muscles that carry out movements. In Lotze's opinion, we should not be surprised by this insight; instead we should accept it as naturally as we accept the ignorance surrounding the mediating processes of sensory perception. Indeed, contrary to the passive perception of sensory

information, when referring to intentional actions, we must question how it can be that we continuously experience the precision of such a sophisticated mechanism while not having any notion of motor-mechanisms, even an approximate one.

> We accept that we can will action, but cannot accomplish it ourselves, that rather a natural course completely independent from our will has linked our will and other conditions of our soul with mechanical necessity to changes of our body, from which movements of the limbs in certain amplitudes and directions must result independently. All that is left to us is to create the psychic states that these physical processes originate from, and from which they unfold, in agreement with our aims, following rules and mediated by processes all of which elude our consciousness. (Lotze, 1852, p. 288)

This quotation contains an important statement as well as asking a crucial question, that regarding the form and specific features of those psychological states that provide the starting point for movements. Before considering Lotze's answer to the crucial question, his general statement should be discussed. In line with the reflex principles of Laycock and Carpenter, Lotze's concept about the movement of limbs supported the idea that there is a ''mechanical necessity'' to it. In his first large work from 1841, *Metaphysik*, Lotze had already emphasized ''the meaningfulness and indispensability of this mechanistic principle'' (cf. Wentscher, 1925) for the perception of sensations. Then in *Medical Psychology and Physiology of the Soul* (1852) he stated that said mechanistic principle is also important for movements.

In agreement with Herbart, Lotze comes to the conclusion that the aforementioned question can be answered by assuming a learning process that starts during the first weeks of an infant's life. Firstly, it is the body that teaches the soul, and then the soul learns to purposefully use the body. Lotze wrote:

> The soul would never guess that its limbs are meant for movement if it was not acquainted with the structure and the powers of its body. And it would never learn to move them, were there not independent motives to move in the body itself, the spontaneous effects of which teach both of the above to the soul. (Lotze, 1852, p. 289)

In the instructional phase of the body, the soul experiences movement-induced sensory consequences. By this the soul is able to draw connections between specific sensations and the movements causing them. After establishing this connection between actions and effects that has to be learned, whenever the soul has the desire to experience a certain sensory effect, the mere inner notion will automatically lead to the execution of the necessary body movements. Furthermore, this process is seemingly inevitable. We are able to do:

> ...nothing but at least in approximation reproduce the sensational state inside us that accompanied the occurring movement in the past and was caused by it. The interrelation between the condition of the soul and the movement must be arranged in such a way that the former cannot only be evoked by the latter, but also the latter by the former. (Lotze, 1852, p. 302)

This supposition about the bidirectional connection between sensation and action is not a novel concept. Herbart and Laycock had already mentioned it. Without any doubt, the bidirectional association between sensory-experience and motor-activity can be seen as a basic prerequisite for an ideo-motor theory explaining the control of human behaviour.

Lotze had also studied medicine and he thus speculated along the same lines as Laycock had in his *Physiology of the Substrates*. Laycock supposed that the bidirectional connections between sensations and movements are encoded in the ideagenic and kinetic substrates.

However, Lotze was skeptical of whether or not a mere idea or an affect of the mind could directly initiate movements. Instead he proposed that the idea of a successful movement or of a movement effect in a first step acts retrospectively on the ''sensitive central organs'' to activate the same sensations that would occur when an accordant effect influences the organism from an external sensory stimulus. Thus, the central motor organs must be closely bound to the sensory organs. Lotze did not find it logical to assume that one organ is responsible for all types of sensations, while another is responsible for all motor activity. He contended instead that only *sensory-motor organs* are responsible for various activation systems (cf. Lotze, 1852, p. 314).

Despite some minor differences, Lotze and Laycock agreed on the assumption that a bidirectional sensory-motor code that initiates and controls actions is available for various possible movement sequences. However, there is no known reference mentioning that Lotze had read any of Laycock's work.[4]

To sum up, in almost all of the essential theoretical issues surrounding the ideo-motor thought Lotze is in agreement with Herbart's suppositions. However, his theoretical considerations are often more detailed then Herbart's. Concurring with Laycock regarding the concept of bidirectional sensory-motor substrates, Lotze surpassed Herbart's considerations, giving way for Harless' (1861) to develop a model of bidirectional action codes.

[4]But one could suppose that Lotze was confronted with the works of the anatomist Albrecht von Haller (1708–1777) during his medical studies. Professor von Haller held a position in the Department of Anatomy, Surgery, and Botany at the University of Göttingen from 1736 till 1753 (cf. Beug, 1977). As mentioned earlier, Laycock (1845) had also made reference to von Haller as a scholar who supported the substrate theory. Maybe von Haller is the connecting link between Laycock and Lotze.

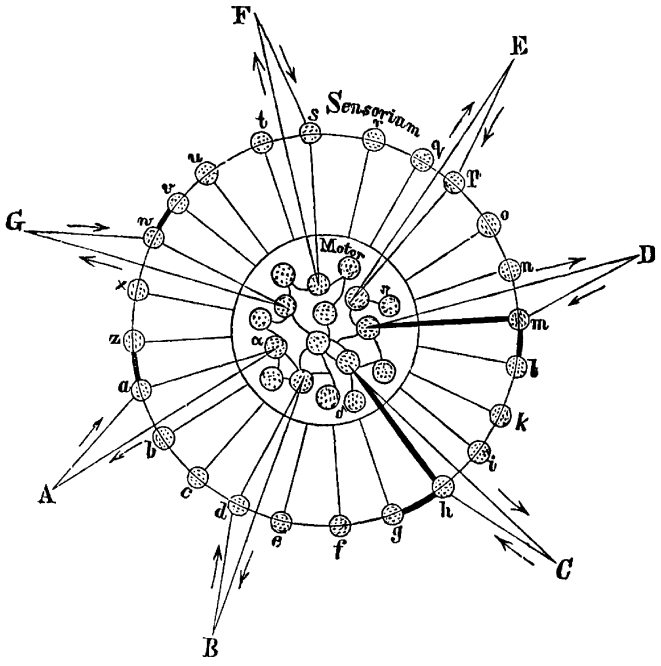


**Fig. 2** Harless' model demonstrating the development of sensory-motor codes of action determination (Harless, 1861, p. 62)

## Emil Harless and *The Apparatus of Will*

To further clarify the voluntary use of muscles and limbs, Harless proposed the following model (see Fig. 2), which schematically represents the structures involved. The model is based on the notion that was already popular at that time, which assumed that "the organic bases of sensation have functional coherence with the organic basis of movements" (Harless, 1861, p. 59).

A large number of motor elements (named e.g., $\alpha$, $\delta$, $\pi$) is positioned in the center of Harless' diagram. They are closely linked to one another and cannot initiate any sensations. The second circle contains peripheral sensory elements (named e.g., a, b, ..., z), which are connected with one another and also have contact with the inner motor elements through radii. The outside circle represents the "results of individual effectiveness" (points A–G), or, in other words, possible forms of movements.

Movements start at the center of the diagram and are activated by impulses of the will, which in turn lead to sensations on the sensory level. In Harless' opinion, this type of sensory-motor substrate is not found in a central position in the nervous system; instead, these substrates are numerously spread across the brain and spinal cord.

The development of movement competence begins sooner in Harless' theory than it does in Herbart's and Lotze's theories. Supplementary to both, Harless assumed that in the prenatal stage of human development interferences of the equilibrium (through outer or inner influences) already either lead to a direct activation of motor elements and by that to an action, or indirectly to an excitement of the sensory elements, which are linked to the motor elements. With increasing maturity, the soul gets into a position of influencing the motor elements in a playful manner, whereby voluntary but not purposeful actions result.

> Through the free play of the will on the motoric centers, a great variety of incidental movements results in the unborn and the newborn (e.g., A, B, C, D, etc.). Each of those movements causes a sensory image (effect image) of the movement (a d h m p s w). The excitation of a central motoric element produces, if it is weak, a very dull movement image through the connection between $\alpha$ and a or $\delta$ and d, etc. If it is stronger, weak movements, perhaps not even noticeable from the outside, result directly. The more often the same process is repeated [...], the wider and more passable the road between a and $\alpha$ becomes. (Harless, 1861, p. 66)

This practice-dependent consolidation between sensory and motor elements is represented in Fig. 2 by the thicker lines.

Now let us consider the functioning of the effect-image (a–z), shown in reference to voluntary action. The relationship (of voluntary action) is organized in the depiction in such a way that the sensation "a" is in connection with the movement form "A," initiated by the motoric element "$\alpha$." Harless contends that this operation does not occur with arbitrary ease. Instead, an initial amount of sensation strength must be present in "a," so that the process is carried out from $\alpha$ to A. However, if the connection between the elements has been made distinct through frequent repetition, a smaller amount of excitation of the sensory elements is necessary to trigger the associated movements. But the vividness of an effect image cannot be considered solely in classifying an action as completely voluntary.

> An intense sensation of the effect image is thus the primary and indispensable prerequisite for the execution of a voluntary movement, but it is not what completely effectuates the movement. (Harless, 1861, p. 67)

What must be added to this necessary but not yet sufficient impact of the effect image to finally execute the action? Harless illustrated this by using the idea of an alphabetical character. The effect image of a letter can be composed of the acoustic impression of the letter as well as the motor memory of the movements of the articulation apparatus during vocalization or according to the movements of the hand and fingers while writing the letter down. The more precise the effect-image becomes by means of attention the more we feel the drive to move the motor elements associated with it. This mutual stimulation between sensory and motor elements increases the explicitness of the effect image and enhances the certainty of choosing the correct motor elements. However, the execution of actions does not start until the soul wills it.

If Harless is critically assessed, the conclusion can be drawn that his work did not essentially introduce any new material. He was in agreement with almost all aspects of the ideo-motor concepts that Herbart and Lotze had already presented years before. With respect to the propositions concerning the acquisition of movement competencies, which Herbart and Lotze placed in early infancy, Harless expanded their applicability to the prenatal development.

## The integration of both roots in James' *Principles*

Up to this point, our description of the ideo-motor principle has shown two clear roots: one British, dealing primarily with the explanation of ideo-motor phenomena, and the other German, using the ideo-motor principle to explain human voluntary behaviour. Both lines of work are partially contained in James' *Principles of Psychology* from 1890. Therefore, if a genealogical tree for the ideo-motor principle during the 19th century had to be proposed, it could be constructed as shown in Fig. 3.

From the British root, James adopted Carpenter's extremely suitable term "ideo-motor," but did not agree with him with regard to the opinion that ideo-motor phenomena can only be applied to elucidate occult curiosities. Instead, James proposed that all everyday actions have to be seen as ideo-motor actions. Interestingly, James may not have been aware of Thomas Laycock's previous work, because he did not mention it in his *Principles*.

Influenced by the German root, James adopted the ideo-motor idea in its entirety. He explicitly referred to Lotze (1852), whom he very much respected, and to Harless (1861), whose physiological considerations anticipated many of the aspects that James reported in his *Principles*. Astonishingly, James did not mention Herbart in the context of the ideo-motor principle, although he was obviously familiar with Herbart's publications, since James had cited him in several other places in the *Principles*. James may have restricted himself to Lotze's and Harless' publications under the assumption that these included Herbart's thinking as well.

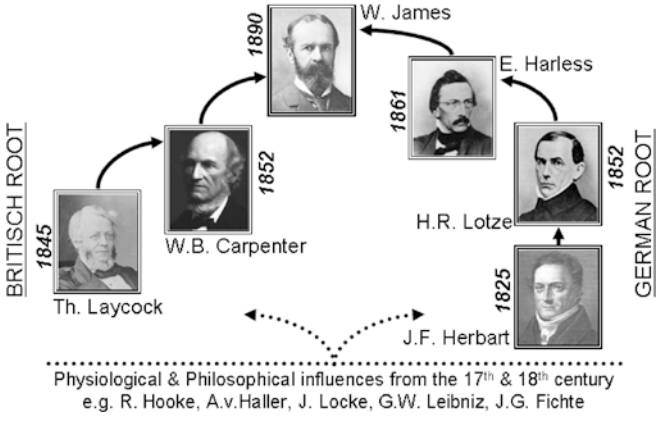


**Fig. 3** Genealogical tree of the ideo-motor principle in the 19th century

The impact of James' *Principles* on the ideo-motor concept is not to be seen in a theoretical or empirical expansion. Instead, his major contribution was the inclusion of the concept in his *Principles*, a standard textbook for psychology, thus ensuring its widespread popularity.

## Edward L. Thorndike and the upcoming behavioristic criticism

Thorndike (1913) resolutely attacked the ideo-motor theory. In the publication of his APA conference speech from 1912, he banded the ideo-motor principle together with belief in magic. He thought he could demonstrate that the ideo-motor idea was so absurd that the following question had to be raised:

> Why [...] did the theory ever gain credence, and why is it still cherished? The answer to these questions, which I shall try to justify, furnish my last and perhaps strongest reason why it should be cherished no longer. My answers are that the ideo-motor theory originated some fifty thousand years ago in the form of the primitive doctrine of imitative magic, and is still cherished because psychology is still, here and there, enthralled by cravings for magical teleological power in ideas beyond what the physiological mechanisms of instinct and habit allow. (Thorndike, 1913, p. 101)

Obviously Thorndike meant business with his campaign against the ideo-motor idea, otherwise he would not have expressed himself so provocatively, especially doing so in his function as president of the American Psychological Association. However, if we examine his arguments more closely, there are in fact only two that he cites as having influenced his beliefs.

The first argument is well known. It is the objection that an idea must not provoke an action, even if this idea is very intense. James anticipated possible objections, such as the one Thorndike made, and had already tried to explain why ideas did not inevitably have movements as a consequence. In James' thinking, different inhibitory ideas prevent each other from being executed. Even before James, Carpenter (1852) and Harless (1861) suggested a control function of the will to refute this objection.

Furthermore, Thorndike claimed that even in those cases where an idea has a movement as its consequence, in the majority of situations this could be explained by assuming that this connection (between the idea of a movement and the real movement) is in fact triggered by the frequent execution of a situation-adequate behaviour and its positive reward. What is essentially learned is the connection between a situation and behaviour—nothing else. According to Thorndike, *the idea of behaviour* has no impact at all.

Needless to say, James considered this argument as well, and wrote that there are many cases in which it is difficult to decide whether the idea of a movement or the extremely suitable situation actually initiated the action.

> I sit at table after dinner and find myself from time to time taking nuts or raisins out of the dish and eating them. My dinner properly is over, and in the heat of the conversation I am hardly aware of what I do, but the perception of the fruit and the fleeting notion that I may eat it seem fatally to bring the act about. There is certainly no express fiat here; any more than there is in all those habitual goings and comings and rearrangements of ourselves which fill every hour of the day, and which incoming sensations instigate so immediately that it is often difficult to decide whether not to call them reflex rather than voluntary acts. (James, 1890, II, p. 522f.)

In comparison to his first objection, Thorndike's second argument appears to be more worthwhile considering because it refers to empirical data. At the APA congress in 1911, Thorndike invited a number of participants to judge four to ten statements in order of truth about the theoretical contents of the ideo-motor principle. Among the original forty items, there were some original quotations from James *Principles*, e.g.: "We may then lay it down for certain that every representation of a movement awakens in some degree the actual movement which is its object," as well as some constructed, artificial items of different plausibility, like: "To make your spear fly straight and pierce the breast of your enemy, it is useful to think hard of the visual, tactile and kinesthetic sensations originally produced by the performance of the movement itself," or superstitious items like: "To make your spear fly straight and pierce the breast of your enemy it is useful to make a wax image of your enemy with a spear stuck through his breast" (cf. Thorndike, 1913, p. 98ff.).

Thorndike arranged the ratings on a "scale of truth," where the difference between individual items corresponded to their difference in truthfulness. The results showed that some of the items representing theoretical beliefs of the ideo-motor principle were placed near items representing mere superstition.

> The most approved statements of the ideo-motor theory are by their own advocates confessed to be only a little more truthful or less false than the rankest magical nonsense. (Thorndike, 1913, p. 103)

The judgments of those items, which were formulated in accordance with the ideo-motor theory, underlined the remaining criticism that it is not definitely clear what should be understood as the action initiating content of ideas or imaginations. With regard to this lack of clarity, Thorndike criticized the following:

> You vote overwhelmingly that a mere picture of the spear striking the enemy is more likely to produce the proper cast of the spear than a full and exact representation of the movement itself. You vote that 'any idea tends to produce that act which it resembles' but you vote that the more it resembles it the less it tends to produce it! (Thorndike, 1913, p. 100)

Even if Thorndike's method of scientific argument was not able to reduce the ideo-motor thesis to an absurdity, it does, however distastefully presented, rightly allude to weaknesses and a lack of precision in the theory's formulation. Naturally, Thorndike's conclusion is considerably more critical.

> Shocking as it may seem, it can be shown that the orthodox belief of modern psychologists, that an idea of a movement tends to produce the movement which is like it, is a true child of primitive man's belief that if you sprinkle water in a proper way your mimicry tends to produce rain. (Thorndike, 1913, p. 101)

As Prinz (1990) emphasized, Thorndike's harsh bottom line was obviously motivated "...by the idea of promoting contiguity and reinforcement as the principles that govern the forming of associative connections and of ousting from this position the principle of similarity as inherent in the idea of ideo-motor action." Thorndike's attack against the ideo-motor principle, formulated while having the authority of acting president of the APA, certainly contributed to pushing the ideo-motor idea into the background of new research, at least in the USA.

Fortunately, the ideo-motor idea was not lost completely and from today's standpoint, Thorndike's "blow below the belt" to the ideo-motor theory was nothing more than any other cheap attack: A lot of hot air with little constructive criticism behind it.

## The ideo-motor principle up to the middle of the 20th century

In spite of the predominance of behaviorist thinking, isolated theoretical and empirical works dealt with the ideo-motor principle up to the 1950s. Of particular importance were the works of Moede (1920), Allers and Scheminzky (1926), and Richter (1954, 1957).

Walter Moede (1920) was among the first to record movement-induced ideo-motor behaviour within the framework of experimental settings. For this the experimenter, for example, moved his arm up and down in front of the participants. The ideo-motor hand movements of the participant thereby induced were registered with high accuracy by the aid of a "Sommer apparatus" (Sommer, 1898). In these experiments, Moede made the following observation. When participants were instructed to attend exclusively to the downward movement of the experimenter's arm, the inductions focused on (downward) movement could be differentiated from unattended (upward) movement inductions, because unattended movements provoked more co-movements

in the participants than attended movements. The attended movements led either to co-movements or to counter movements.

Moede interpreted the co-movements of the participants during the upward arm-movement of the experimenter completely in terms of James' proposition. Both stated that in the case of an unattended movement induction no central inhibitions are activated, whereas on the downward movement there is a different interaction. Because of the participants' manipulated attention to this kind of movement, a permanent innervation of the arm and hand musculature is caused.

As a consequence, the participants responded before, synchronously, and after the downward arm movement of the experimenter with a compensating countermovement. Those participants who executed countermovements rather then co-movements conveyed in a post-experiment interview that they in fact experienced a tendency for co-movement but did not want to comply. Or even that they developed the strong counter-intention to not move the arm at all. Naturally, several participants also executed ideo-motor co-movements, occurring either synchronously or delayed (with latency up to 2.5 s) with the downward movement presented.

In addition to Moede's investigations into co-movement-inductions by *real movements* that were observed, several studies on the ideo-motor effect of *imagined movements* were even carried out. Allers and Scheminzky (1926) were among the first to attempt to prove the ideo-motor effect by using the physiological method of deriving muscle-action potentials. For instance, they instructed their participants to imagine making a fist with their right hand, or to loudly say: "Now I will ball my fist." In about 80% of the participants given this instruction, Allers und Scheminzky (1926) could demonstrate a muscle potential in the ideo-motorically addressed hand.

The most extensive experiments on the ideo-motor principle were conducted in the middle of the 20th century by Richter (1954, 1957). He extended Moede's mechanical measurement of hand movements with an extensive apparatus that was able to register the movements of several limbs simultaneously.

Taking up Allers' and Schminzky's (1926) results, Richter differentiated within the ideo-motor phenomena between:

1. Those movements activated by seen movements to produce imitations (perceptual ideo-motorics or echokinesis)
2. Those initiated by an idea, which he called "Vorstellungs-ideomotorik" (Richter, 1957, p. 229)

In this context, Richter had formulated two essential basic questions that applied to all ideo-motor phenomena. The first is the question of the correspondence between the perceived action effect and the idea of the action in the mind. The possible contents of such an idea of movement effects could be sensory and motor movement imaginations, distal effect perceptions, as well as intentions. The second question concerns the specificity of ideo-motor effects. It is conceivable that the twitch of the hand caused, for example, by the idea of grasping, is only a part of an arousal of the whole body that is not otherwise registered.

Richter's suggested answer to the first question is that at least the idea of an action and its effects is necessary to initiate the corresponding movements. In many experiments, Richter instructed his participants to imagine as intensely as possible making a fist with their right or left hand. With this instruction, focusing on the idea of the movement, Richter found considerable ideo-motor effects in the right or left hand addressed. But at the same time he was able to register a significant amount of kinetic effects in the contralateral hand and in both feet. In response to his second question, Richter pointed out that the ideo-motor effect is not specific to the hand addressed, as his findings show.

In order to strengthen or lessen these unspecific kinetic effects, Richter applied external stimuli (e.g., a little clamp or a color mark) to the ideo-motorically addressed hand or to the contralateral hand in further experiments. By using this experimental variation Richter got results that showed that external stimulation was able to influence the kinetic reactions of the participants. If the stimulus is applied to the ideo-motorically addressed hand, it strengthens the ideo-motor effect, and it lessens the unspecific kinetic effects in the other limbs. But if the stimulus is instead applied to the contralateral hand, it is even able to reduce the ideo-motor effect and to strengthen the unspecific kinetic movements.

Since Richter's experimental results are not completely compatible with the ideo-motor theory he concluded that the idea of an action is necessary but not sufficient to initiate the ideo-motor effect. According to Richter, an additional intention is required. Ideas as well as intentions can only be prevented from execution by an inhibitory force. This interplay of initiating ideas and inhibiting factors led to an unspecific arousal of the whole body. By means of external stimuli this arousal could be directed to specific effectors (for a comprehensive description of Richter's extensive experiments and results see Stock, 2002).

This short description of Richter's work concludes our historical overview of the ideo-motor principle. An impression of the contemporary impact of action effects on action initiation can be found in this special issue. However, a moment should be taken to have a look at those aspects of the ideo-motor hypothesis that will most probably need future investigation.

## General discussion and future prospects of ideo-motor action

We have considered the approximately 125-year history of ideo-motor action and it makes sense to work out

which assumptions, questions, and problems were repeatedly raised, and accordingly, which aspects were overlooked and should be considered in the future:

1. All representatives of the ideo-motor hypothesis shared the belief that the execution of an action after its initiation by an idea takes place with mechanical necessity. Therefore, Laycock and Carpenter presumably described the ideo-motor action as a cerebral reflex action. Primarily, they assumed that ideo-motor (reflex) actions appear only in cases of illness or limited function of the free will.
   Herbart, Lotze, Harless, and particularly James emphasized instead that the ideo-motor hypothesis is a fundamental principle of movement determination. James explicitly pointed out that automatic, everyday actions in particular have a reflex-like character. The border between voluntary action and reflexive action becomes indistinct here.
   Astonishingly similar is the concept, found by the varying authors, that ideo-motor actions easily take place when "the transition from the idea to the movement" simply happens, as Lotze wrote in 1852, or, as Carpenter expressed it, when the movement occurs in a trance-like state. Furthermore, Moede (1920) as well as Richter (1954, 1957) pointed out that a relaxed mental attitude facilitates the measurement of ideo-motor effects.
   All in all this points to an ideo-motor responsibility for the more automatic everyday actions, and for those actions that have typically been described as unconscious and involuntary
2. A further question concerns the contents of the ideas that instigate the motor activity. Margarate Floy Washburn once assumed: "A movement idea is the revival, through central excitation, of the sensations, visual, tactile, kinesthetic, originally produced by the performance of the movement itself. And when such an idea is attended to, when, in popular language, we think hard enough of how the movement would 'feel' and look if it were performed, then, so close is the connection between sensory and motor processes, the movement is instituted afresh." (cited according to Thorndike, 1913, p. 93)
   Is it really the case that all action effects are stored in the idea of a movement, or are only the attended ones stored? And what about the question of the loading and the importance with which the action effects are memorized? Is it the case that mere motor effects, i.e., the proprioceptive sensations, have a greater importance? Or do the intentionally aimed changes in the environment determine the idea of a movement? Basically all representatives of the ideo-motor hypothesis expressed themselves rather unspecifically on the contents of the idea of a movement. In this regard no clear answer is given and it is not surprising—as Thorndike (1913) could demonstrate in his criticism—that across the different theoretical concepts no correspondence exists concerning the content of movement ideas. Many of the questions mentioned here remain open, although we do now have experimental evidence of at least the integration of remote effects into movement ideas (e.g., Hommel, 1996; Elsner & Hommel, 2001; Kunde, 2001)
3. Regarding the question of action competence acquisition, Laycock, from a physiological point of view, spoke about the construction of ideagenic and kinetic codes in terms of his substrate theory. Harless and James speculated in a similar manner. From the perspective of the psychology of learning, the assumptions of Herbart, Lotze, and Harless are of importance, because they focus on the question of how the body reveals its movement possibilities to the soul, and then how the soul takes over the intentional control of actions. All three agree that in an early period of life (Herbart and Lotze) or even prenatally (Harless) the body moves for merely organic and other basic reasons, and that those original movements are accompanied by sensory movement effects. In this early stage, the links between movements and movement effects are stored in the memory, so that if the desire for a specific action effect arises the corresponding action can be addressed.
   Although the acquisition of behavioral competence by our body mainly takes place in early childhood this does not exclude that the learning mechanisms mentioned still function in the same way later on. Nevertheless, the hypothesis is conceivable that in the first years of our life each action effect is inevitably integrated into a sensory-motor action code. However, in later stages of development this encoding must no longer occur in an automatic manner. Instead it can be presumed that intended action effects are preferably integrated, whereas unintended action effects may require a much stronger saliency for their integration into an action code. This consideration seems to make sense if we accept that it is advantageous to acquire as much competence as possible in early childhood. However, in later developmental stages it is more useful to consider only intended action effects in order to specialize actions to the highest degree and to increase the efficiency of (behavioral) learning. Thus, future experiments should pursue these developmental aspects of the ideo-motor hypothesis
4. Another issue that needs attention is the question concerning the release of action. The ideo-motor principle was often criticized in that the mere idea of an action, even if it is very intense and characterized by motor as well as proximal and distal sensory effects, does not inevitably lead to the execution of said action. The usual counter-argument to this criticism was, for example, James' reply, which stated that a second, competing idea of an action effect coincidently exists in all those cases and blocks the execution. There are many indications that ideo-motor actions take place particularly easily if we give ourselves up to the movement idea and ignore all

competing and distracting ideas. James described the example of imagining crossing our fingers. We could have this imagination without anything happening, but as soon as we give ourselves up to the movement, the fingers are crossed: ''Drop *this* Idea, think of the movement purely and simply, with all brakes off; and presto! it takes place with no effort at all'' (James, 1890, II, p. 527).

Obviously the key point here is the mentioning of ''releasing all brakes'' which allows the movement ideas to have their effect. Exactly this happens in innumerable everyday actions, e.g., when we are driving a car or riding a bike. Due to this process we gain the freedom of addressing our attention to other things. The historical context presented here shows a broad consensus on the assumption that everyday behaviour runs according to the ideo-motor principle. Besides the everyday automatisms, other actions exist that need some kind of release signal or a conscious decision permitting their instant execution. This type of action especially occurs in cases when various well-known single parts of actions are merged into an unfamiliar chain of actions. Then, at each junction between actions a decision has to be made to begin the following segment of action. The decision to choose a proper action and then to initiate it is of course not explained by the ideo-motor principle. For the explicit choice between actions, we need either a psychology of the will, as Carpenter and Harless discussed, or we need to apply a theory of intentional, ideo-motor actions, as Stock (2002) proposed. With the addition of a theory of intention, the ideo-motor principle would be embedded in a more extensive action-psychological context (cf. also Hoffmann & Stock, 2000)

5. As a last point it should be discussed that all of the representatives of the ideo-motor hypothesis mentioned here disregarded the role of situational conditions in human actions. On the one hand, behaviorism was justly blamed for ascribing—in the triad of stimulus, response, and effect—too much importance to the relationship between stimulus and response. On the other hand, and with the same authority, the representatives of ideo-motor action could be justly blamed for focusing too much on the connection between response and effect

It took a long time before the examination of animal learning provided results that could unerringly prove that animal behaviour can be controlled by the situation—as well as by the anticipated action effect (cf. e.g., Bolles, 1972; Colwill & Rescorla, 1990; Rescorla, 1990a, 1990b, 1991a, 1991b). The first attempts at exploring this have only begun with reference to human learning (Hoffmann, 1993; Hoffmann & Sebald, 2000a, 2000b; Stock & Hoffmann, 2002). The growing interest in the ideo-motor hypothesis in recent years has provided a chance to integrate—as a necessary advancement of the fundamental idea—situational dependencies into the effect-controlled intentional behaviour of the ideo-motor idea.

This last point brings our historical overview of the development of the ideo-motor principle to an end. We will shape its future in the present. But, in doing so, we should not forget to learn from its past.

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