Effect Anticipation and the Experience of Voluntary Action Control

Józef Bremer

Abstract This paper discusses the issues surrounding voluntary action control in terms of two models that have emerged in empirical research into how our human conscious capabilities govern and control voluntary motor actions. A characterization of two aspects of consciousness, phenomenal consciousness and access consciousness, enables us to ask whether effect anticipations need be accessible to consciousness, or whether they can also have an effect on conscious control at an unconscious stage. A review of empirical studies points to the fact that willed actions are influenced by effect anticipations both when they are conscious and when they remain inaccessible to the conscious mind. This suggests that the effects of conscious voluntary actions—in line with the ideomotor principle proposed by William James—are anticipated during the generation of responses. I propose that the integration of perceptual and motor codes arises during action planning. The features of anticipated effects appear to be optionally connected with the features of the actions selected to bring about these effects in the world.

Keywords action control; consciousness; ideomotor principle; neuroscience; Simon effect; Stroop effect; voluntary action control; voluntary motor actions

Introduction

Recent years have seen a rise in the amount of empirical research that aspires, on the one hand, to describe and explain how our human conscious capabilities govern and control voluntary motor actions and, on the other

✍ Józef Bremer, Jesuit University Ignatianum in Kraków, ul. Kopernika 26, 31-501 Kraków ✉ jozef.bremer@ignatianum.edu.pl

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hand, how these capabilities link these actions with their perceptual goals with a view to achieving the intended effects. A significant portion of this research has received confirmation from the ideomotor intellectual approach to action control. According to the ideomotor principle the person (the acting self, actor or agent) chooses, starts and performs a movement by activating anticipatory codes of the movement's perceptible effects.

Initially, I shall briefly characterize the two aspects of consciousness mentioned above, and then also the common-sense understanding of the self and its control-functions. Next, I shall review the empirical paradigms showing how the effects of conscious voluntary actions—in line with the ideomotor principle—are anticipated during the generation of a response. I suggest that the integration of perceptual and motor codes arises during action planning. The features of the anticipated effects are optionally connected with the features of the actions selected to bring about these effects in the world.

1. Consciousness: Two Different Aspects

In the literature pertaining to this subject we usually differentiate between two types of consciousness: phenomenal and access. The phenomenal properties of consciousness are of a different character to functional consciousness (i.e., to the intentional or psychological properties of consciousness). The phenomenal properties of consciousness are experiential, being categorized as including the experiential states we have when we see, hear, and have, for example, pains. "Phenomenal consciousness" is characterized in terms of "what it's like for the subject."[1] In contradistinction to this, functional or psychological phenomena like learning, reasoning, and remembering are linked to "access consciousness," and can be explained in terms of their fulfilment of some appropriate intentional role. For a state to belong to access conscious roughly means for it to be engaged in, or at least be prepared for being engaged in, exercising rational control over thought and behavior. For organisms that dispose of concepts and rules of language, access consciousness closely correlates with reportability: i.e. the ability to self-ascribe the state at will in language. For instance, if a system does the right thing, if it alters behavior appropriately in response to environmental stimulation, it counts as capable of learning. Specifying these functions tells us what learning is and allows us to see how brain processes could play this role.

One of the key questions that guide and organize research into human consciousness concerns just its functional nature: what is consciousness good for? A lot of answers to this question are possible, but the one that I shall be dealing with is particularly popular:

> Conscious control enables human decision makers to override routines, to exercise willpower, to find innovative solutions, to learn by instruction, to decide collectively, and to justify their choices.[2]

If appropriate, the implications of this specification are that decision-making and action control (i.e., voluntary actions) are exceptionally valuable from the point of view of human access consciousness, as they support and enhance the ways in which we address environmental challenges.

We should doubtless expect theoretical and empirical investigations of decision-making and action control to provide—amongst other things—an answer to the question of what the processes that engender our conscious, phenomenal experiences of authorship, and our voluntary, access-conscious control of our actions, are. How do we come to acquire the skills needed to control our own actions, together with the representational foundations of such control? Is it only conscious voluntary actions that are influenced by anticipation of the actions' effects? What about unconscious effect anticipation and its influence on voluntary action?[3]

In this article I will concentrate on the function of effect anticipation in action control. The anticipatory actions involved in acquiring action-effect relations reveal that the acquisition of action-effect relations depends on our ability to represent the forthcoming effects of our actions. My particular reflections center on the following problem: must these effect anticipations be accessible to consciousness, or can they also have an effect on

1. Cf. Ned Block, "On a Confusion about a Function of Consciousness," *Behavioral and Brain Sciences* 18, no. 2 (1995), doi:10.1017/S0140525X00038188.

2. Christoph Engel and Wolf Singer, ed., *Better Than Conscious? Decision Making, the Human Mind, and Implications for Institutions* (Cambridge, MA: MIT Press, 2008). Quotation from the blurb for the book.

3. This question has been addressed empirically. See Wilfried Kunde, "Response Priming by Supraliminal and Subliminal Action Effects," *Psychological Research* 68, no. 2–3 (2004), doi:10.1007/s00426-003-0147-4. "Thirdly, as the present study demonstrated, effect codes induce their associated motor patterns without conscious mediation, which points to a highly automatic spreading of activation from effect codes to motor codes" (ibid., 95). This suggests that awareness of effect codes is not a necessary precondition for such codes to govern action generation. Also, such action effects "without awareness", presented prior to action execution, induce a sense of agency. Cf. Katrin Linser and Thomas Goschke, "Unconscious Modulation of the Conscious Experience of Voluntary Control," *Cognition* 104, no. 3 (2007), doi:10.1016/j.cognition.2006.07.009. I owe this bibliographical suggestion to one of the anonymous blind reviewers of this paper.

conscious control at an unconscious stage? I will illustrate how empirical tests have shown that willed actions are influenced by effect anticipations both (a) when they are conscious and (b) when they remain inaccessible to the conscious mind.

2. A Common-Sense Understanding of the Self and its Control-Functions

A plausible research topic for psychology could be to understand how highly skilled professional performers, for example, gymnasts, are capable of apparently trouble-free and smooth performances of multi-layered bodily movements. The set of processes that enable gymnasts to move their bodies in the ways required of them are conceived under the term "motor control." Furthermore, gymnasts (or other very specialized persons or athletes) generally execute specific movements to achieve an intended effect, where this clearly elevates such movements to the status of voluntary actions. Consequently, motor control of such skilled movements can also be identified as voluntary action control. Within such a thesis, the term "action control" is used to underline intentional, goal-oriented behavioral processes oriented towards achieving anticipated effects. By way of contrast, the term "motor control" is primarily used to specify physiological configurations and control processes.

Taking as a basic point of reference our common experience as conscious agents, all of us would presumably accept that voluntary action is closely tied to shared intuitive conceptions of the selfhood of persons. The strongest common intuition in this regard pertains to the self conceived as a kind of "mechanism" that both controls our interaction with the environment and mediates between the stimulus input and the behavioral output.

What we expect here is that the self triggers intentions that take the form of conscious commands, and that it controls the effects of these commands.[4] The self transmits the intentions to the motor systems that will execute them, and in this way it causes consciously intentional actions to occur. The self understood in this way controls not only the actions but also the interactions of their effects with the world. Both of these functions are based on perception's being aimed at registering sensory events

4. Franz Brentano claimed that intentions and consciousness belong to the same kind of phenomena: consciousness is intentional: i.e. it is directed towards something (to an external or an internal object of thought). Cf. Franz Brentano, *Psychology from an Empirical Standpoint*, trans. Antos C. Rancurello, D. B. Terrell, and Linda L. McAlister, ed. Linda L. McAlister (London: Routledge, 1971), 88, 91.

in the environment as possible action effects. The interaction of goals with the world, then, takes the form not just of a movement aimed at executing an action, but also of perception's being aimed at registering sensory events in the environment as possible action effects.

What is the connection between control on the part of the self and the events caused by the self? We can answer this question by differentiating between two contrary situations with regard to self-caused events:

(i) if an event follows an action as its potential effect, and if this event has been correctly anticipated before the action, then this event will be experienced by the person as self-caused;
(ii) if an event does not follow an action as its potential effect, or if an erroneous instance of effect anticipation has occurred, then control on the side of the self will be attributed to an external cause instead of the self (or instead of the person).

According to Agnes Moors and Jan de Houwer, a person controls an act when he or she entertains a goal in connection with it, and when he or she achieves this goal. This definition of control contains three ingredients: (a) a goal pertaining to an act, (b) an effect (i.e., the state represented in the goal), and (c) the causal connection between the goal and the effect.[5]

This common-sense understanding of the role of the self has now come up against contemporary neuroscientific models of the connection between action and perception, and between an action and its effects. In opposition to this sort of commonly mentioned intuition about the acting self, the results of experimental studies in psychology and cognitive neuroscience have shown that the brain processes understood to form the basis of the control of voluntary actions operate mostly unconsciously.

Adopting a highly simplified brain-based model, our act of perception can be said to originate from environmental stimuli and to be an afferent (centripetal) process. Such stimuli produce patterns of stimulation in sense organs and give rise to sensory encoding in the brain. Movement, as an efferent process, originates in the motor codes of the brain. These motor codes represent certain patterns of activity and the relevant motor effectors set to work in order to carry an action into effect. The most rudimentary behavior is composed of all of the elements involved in such interactions at a given moment (no matter whether they are a function

5. Agnes Moors and Jan de Houwer, "Automaticity: A Theoretical and Conceptual Analysis," *Psychological Bulletin* 132, no. 2 (2006): 306, doi:10.1037/0033-2909.132.2.297.

of perception or of action). Because of this, the achievement of a goal depends above all on there being successful co-operation between perception and action.[6] I will try to describe such an achievement by analyzing the acquisition of action control as understood from the perspective of adherents of the ideomotor principle.

3. Different Levels of Action Control

Living organisms have developed various forms of action control. Advances in this process of development are best described as a form of gradual progress with respect to behavioral adaptability: i.e. as regards the degree to which behavior can be selected independently of any momentarily present external conditions or some internal state.[7]

At the most basic stage, innate reflexes exemplify the least adaptable form of behavior. They are controlled by pre-established response programs which are automatically and necessarily triggered in a determinate fashion by specific external stimulus conditions. All reflexes, when reduced to their simplest level, are sensorimotor acts.[8] They require some kind of sensory (afferent) signal, and some kind of motor response.

Trigger stimuli are quite different from reflexes, being located in the environment and inside the organism and pertaining respectively to its current motivational state or state of need. Noises and visualia associated with chewing, tapping, and sniffling belong to the most common trigger stimuli. A current state of need of an organism—e.g. being thirsty—determines that a particular correlative response program—say, drinking—will be in a state of readiness. States of need do not directly trigger responses in a fixed way, but when appropriate trigger stimuli are available the behavior is performed.[9] States of need also determine the readiness of the need-correspondent action-program in humans. For instance, when

6. Cf. Claude-Alain Hauert, Pier-Giorgio Zanone, and Pierre Mounoud, "Development of Motor Control in the Child: Theoretical and Experimental Approaches," in *Relationship between Perception and Action: Current Approaches*, ed. Omar Neumann and Wolfgang Prinz (Berlin: Springer, 1990), 340.

7. Cf. Bernard Wallner, Ivo Machatschke, and Matin Fieder, "Occupational Ethology: A New Perspective in Occupational Stress Research," *Journal of Systemics, Cybernetics and Informatics. ISI Proceedings* (2008): 278.

8. For basic information about reflexes, see Masao Ito, *Cerebellum: The Brain for an Implicit Self* (Upper Sadle River, NJ: Pearson Education, 2012).

9. Cf. William McKinley Runyan, "Henry Alexander Murray," in *New Dictionary of Scientific Biography*, ed. Notretta Koertge (Detroit: Charles Scribner's Sons; Thomson Gale, 2008), 5:214–19.

actions are merely controlled by states of need, the desire for sugar leads an organism to consume chocolate as soon as it becomes available.

A somewhat increased degree of behavioral adaptability becomes evident in habitual responsive behavior of the kind furnished by procedural learning. Procedural learning enables organisms to modify or expand behavioral dispositions over the long term, in correlation with individual experience. Habitual behavior furnishes the basis for a large proportion of our daily activities. Because our motivational state defines the goals we should currently be pursuing, asking how motivation controls habitual action selection is tantamount to asking whether, and how, habitual behavior can be performed so as to achieve the relevant goals.

However, the formation of dispositions occurs only slowly, and once a habit has been formed, the possibilities for modification and adaptation are limited. Some forms of habitual behavior are learnt, and then become automatic, without the person involved being consciously aware of this happening.[10]

Let us now turn to the issue of voluntary action and the representation of its effects. In line with a broadly held view, we may say that voluntary action is closely tied to our ability to mentally, intentionally represent the future effects of our own, rule-based doings.[11] According to Thomas Goschke, what sets voluntary actions apart from involuntary behavior is not that they (voluntary actions) are independent of any causal determinants, but rather that they depend on evolved cognitive control competencies which enable us humans to select actions on the basis of our anticipation of future effects and to maintain long-term goals in the face of strong competing habitual or impulsive responses.[12]

Projected actions may be directly executed if an expected stimulus pattern signals an adequate action possibility (i.e., a start anticipation or action-cause condition). As sketched, effect anticipations play a key role when it comes to the initiation of voluntary actions. In addition to this, effect anticipations may also be used to control a continuous action.[13]

10. Cf. Wendy Wood, Jeffrey M. Quinn, and Deborah A. Kashy, "Habits in Everyday Life: Thought, Emotion and Action," *Journal of Personality and Social Psychology* 83, no. 6 (2002), doi:10.1037/0022-3514.83.6.1281.

11. Wilfrid Sellars distinguishes between intentionally and consciously "obeying a rule" and "merely conforming to a rule." Cf. Wilfrid Sellars, "Some Reflections on Language Games," in *Science, Perception, and Reality* (London: Routledge & Kegan Paul, 1963), 325–26.

12. Cf. Thomas Goschke, "Beyond Free Will: Towards a Cognitive Neuroscience of Decision-Making and Volitional Control," in *Intuition and Decision-Making*, ed. Fernando Lopes da Silva (São Mamede de Coronado: Fundação Bial, 2010), 58.

In other words, anticipated action effects may be linked to a perceived course of action (or its effects), and divergences can be corrected when necessary. Regarding start anticipation, it appears evident that a mere quick visual identification of, for example, the intended action of a partner or opponent might allow a person (or a skilled craftsman, like the above-mentioned gymnast) to initiate a motor action on schedule. Obviously, the rules governing action-generation and action-perception are closely intertwined. The most recent views to emerge concerning voluntary actions and the experience of the authorship of thoughts and sensory representations have tended to suggest that such mental representations or anticipations of future effects also play a decisive role in the creation of the conscious experience of voluntary control.

4. The Acquisition of Action Control

In general terms, two models of how perception and action are represented in the brain so that they can interact functionally have been proposed—both of them pretty familiar by now.

(M1) Sensory information arising from movement generation is used to control the movement. In other words, sensory feedback is used—if required—to compare the intended movement stage with the actual movement stage and to correct movement errors (i.e., a divergence between intended and actual movement stages).

(M2) Sensory information (sensory feedback) is not required for goal-oriented movement generation but may function as a trigger stimulus for the next contraction as and when the movement is completed.

4.1. Perception and Action: The Separate Coding and Control Model

Firstly, there is the model according to which perception and action are separately coded. It could be said that the author of model M1 was Descartes, who assumed that there were separate pathways and different processing principles for perception and action (i.e., separate coding models). He described the human sensory-motor system in terms of mechanics and hydraulics. In his theory of action the pineal gland represented an instance of an executive control center for the co-ordination of sensory input and

13. The ideas of "start anticipation" and "effect anticipation" have been extensively modeled in Joachim Hoffmann, *Vorhersage und Erkenntnis. Die Funktion von Antizipationen in der menschlichen Verhaltenssteuerung und Wahrnehmung* (Göttingen; Bern; Toronto; Seattle: Hogrefe, 1993), 46, 246.

anticipated motor output. Afferent conduction (perception) was described mechanically: sensory input "plucked" at specific nerve fibers, which ended in the pineal gland. The pineal gland was conceived as a "translator" of afferent input—via "nerve-fluid"—into the efferent system. Descartes assumed that the "translation" caused hydraulic pressure to be exerted on the corresponding motor effectors, ultimately eliciting the execution of movement.[14]

According to the current state of neurological research, the pineal gland produces melatonin, while also being involved in the control of circadian and seasonal rhythms: e.g. pertaining to sleep. Since Descartes, models of perceptual-motoric interaction have traditionally subscribed to the view that perception and action are separate in terms of both their representational status and their underlying control processes.

The idea that perception and action control rely on distinct functional principles has, however, been challenged by various empirical findings—for example, research into how subliminally presented priming stimuli influence target processing on the part of participants, when the latter entertain (anticipatory) intentional attitudes towards processes involving these stimuli and are, moreover, expecting these stimuli in the current task context.[15] In addition to this, there is also the observation that the presentation of stimuli (sharing certain characteristics with the actions to be performed) can conflict with the execution of those actions.

As regards the last of the above-mentioned neurological results, we may state that (a) they invoke an understanding of the human sensory-motor system that finds itself in tension with traditional Cartesian models of separate perceptual, motoric, and controlling processing, and (b) they imply an essential correlation between the functional mechanisms of perception and action, and between ways in which they are represented in structures encountered within the brain.

4.2. Perception and Action: A Jointly Coded Model?

Secondly, there is the model according to which perception, action, and intended action-results are jointly coded. The essential hypothesis behind this conception is that perceptual and behavioral interaction in humans

14. Cf. Gunther S. Stent, "Epistemic Dualism," in *The Mind as a Scientific Object: Between Brain and Culture*, ed. Christina E. Erneling and David M. Johnson (Oxford: Oxford University Press, 2005), 150.

15. Cf. Andrea Kiesel, "Unbewußte Wahrnehmung. Handlungsdeterminierende Reizerwartungen bestimmen die Wirksamkeit subliminaler Reize," *Psychologische Rundschau* 60, no. 4 (2009), 217–20, doi:10.1026/0033-3042.60.4.215.

is based on a single common law of nature governing the coding they involve (i.e., perception and action make use of one common representational domain, and action representations may become activated when one observes an action that one is able to perform).[16]

As a consequence of the high level of similarity exhibited by the functional mechanisms that form the basis of perception and action, perceptual events—which share specific characteristics with the actions assigned to them—will be encoded in a common representational domain. This provides direct continuity at the point of interconnection between perception and action: a sensory event which activates a perceptual pattern in the brain automatically co-arouses the related motor pattern, as both are encoded inside the same representational domain.

The co-aroused motor code can, working in reverse, trigger the performance of the corresponding response. Under joint (i.e., common) coding conditions, any "translation" or other kind of "mediation" at the point of the perception-action interface (as is indeed required in the case of model M1, outlined above) becomes untenable. Furthermore, joint coding is not confined to sensory events perceived in an actually present environment. Rather, as has been disclosed in a study by Bernhard Hommel, common coding also encompasses sensory events associated with certain actions as anticipated (in other words intended) effects or goals of planned actions.[17]

> [C]ognitive and neuroscientific research on action control has accumulated much evidence that conceptual action knowledge used to organize goal-directed movements becomes an integral part of these motor representations.[18]

In sum, cognitive research into the perception–action relationship and affective research into the evaluation–behavior link reveal a reciprocal connection between both stimulus processing and action preparation.

16. Cf. Robrecht van der Wel, Natalie Sebanz, and Günther Knoblich, "Action Perception from a Common Coding Perspective," accessed 3 November 2016, https://somby.ceu.edu/sites/somby.ceu.edu/files/attachment/basicpage/6/inpressrobchapter.pdf.

17. Bernhard Hommel, "The Prepared Reflex: Automaticity and Control in Stimulus-Response Translation," in *Control of Cognitive Processes: Attention and Performance XVIII*, ed. Stephen Monsell and Jon Driver (Cambridge, MA: MIT Press, 2000), 247–73.

18. Andreas B. Eder and Karl Christoph Klauer, "A Common-Coding Account of the Bidirectional Evaluation-Behavior Link," *Journal of Experimental Psychology* 138, no. 2 (2009): 230, doi:10.1037/a0015220.

5. Thinking is Doing: The Ideomotor Principle

In the nineteenth century, William Carpenter and William James proposed the notion of "ideomotor action" (the ideomotor principle): the thought here is that merely thinking about doing something automatically makes it more likely that we will perform the action in question. In other words, mental representations of willed actions and their effects can actually generate those actions which, as we have already learnt, produce the movements and effects in question.[19]

According to James, this principle means that

> every representation of a movement awakens in some degree the actual movement which is its object.[20]

Voluntary action relies on the anticipation of movements' sensible effects, be they proximal or distal, or even remote.[21] James likewise emphasized the passive nature of the effect: he argued that an act of will was not necessary for the action impulse abetted by the thought to emerge in actual behavior. An important element in James's understanding of the cognitive guidelines pertaining to "will" is the proposal that action control is based on the above-mentioned ideomotor principle. Corresponding to this principle, two processes are involved in the acquisition of controlled action:

Action control according to the ideomotor principle

(P1) Action $\xleftrightarrow{\text{Bidirectional attachment}}$ Effect

(P2) Effect $\xleftrightarrow{\text{Automatic activation}}$ Action

(P1) Primarily, actions which are incidentally created produce particular changes in the surroundings. The motor structure of that action is then attached to that effect in a bidirectional way. Once action–effect attachments are obtained, action control happens.

(P2) Connection between effect and action occurs based on actions' being automatically triggered by the anticipation of their consequences.[22]

19. Cf. Ap Dijksterhuis, "Automatic Social Influence: The Perception-Behavior Links as an Explanatory Mechanism for Behavior Matching," in *Social Influence: Direct and Indirect Processes*, ed. Joseph P. Forgas and Kipling D. Williams (Philadelphia, PA: Psychology Press, 2001), 102.

20. William James, *Principles of Psychology* (New York: Holt, 1890), 396.

The claim that the acquisition of a competency with respect to voluntary action occurs on the basis of a two-stage learning process has, more than anything else, helped to determine the direction pursued by current theories of voluntary action.[23] Carpenter claimed that the very idea of an action can trigger the associated motor activity. Ideomotor movements are, for him, reflex-like and non-intentional. With reference to this, James went on to consider our conceptions of voluntary action control.

The M1 mechanism proposed above, for instance, requires that a visual image or representation of visual feedback from performance (developed during observation) be present following the response in order to act as a standard for comparison with the feedback from the response itself. The ideomotor theory regards the anticipated feedback as more important (meaning that feedback from the final or goal response is not so important). The ideomotor mechanism requires that the image be present prior to the response, so as to be active in an instance of response selection. Although these two mechanisms seem rather incompatible, it may be that the image in the ideomotor mechanism is similar to the memory trace in the M1) model, as the memory trace is supposedly involved in the response selection.

6. A "Dual Route" Model versus a "Prepared Reflex" Model

Pace what developmental nativists have suggested, in accordance with this proposal reflecting the ideomotor principle action purposes are not given at birth: instead, they emerge through sensorimotor experience.[24] Conscious experience would then be connected with the implementation of a specific purpose, which again would be coded in terms of the intended and expected action-outcomes, the sensorily disclosed action consequences. The question "Why would that be the case?" then brings with it the question "What, in that case, is consciousness?"

21. J. Scott Jordan, "Intentionality, Perception, and Autocatalytic Closure: A Potential Means of Repaying Psychology's Conceptual Debts," in *System Theories and A Priori Aspects of Perception*, ed. J. Scott Jordan (Amsterdam: Elsevier, 1998), 189.

22. "According to James's (1890) notion of ideomotor action, a representation of an act discharges itself directly in the initiation of the act, unless representations of other acts prevent it." Moors and de Houwer, "Automaticity," 306.

23. Tobias Melcher, Maaike Weidema, Rena M. Eenshuistra, Bernhard Hommel, and Oliver Gruber, "The Neural Substrate of the Ideomotor Principle: An Event-Related fMRI Analysis," *NeuroImage* 39 (2008), doi:10.1016/j.neuroimage.2007.09.049.

24. Bernhard Hommel, "Consciousness and Action Control," in *The Wiley Handbook of Cognitive Control*, ed. Tobias Egner (Chichester: John Wiley & Sons, 2017), 111–23.

It has been proposed that access consciousness is associated, perhaps even limited to, the consolidation of knowledge. If so, consciousness would be more probably linked with processes and functions that take into account multiple origins of information. Coding and implementing a goal presumably meet this standard. However, the primary role of access consciousness in action control seems to be, essentially, that of exchanging information with other persons. A window onto different moments of action control furnished by access-consciousness will (a) permit a person to express what he / she is doing and why he / she is doing it, and (b) deliver an opportunity to communicate to other persons information about policies regarding how to perform and control the activity in question. Such interactional information would / could also be used for self-control.

Action consequences are often highly context-dependent, as practically the same movement can lead to many different sensory consequences in different situations—just consider pushing a key to create a letter on a monitor, switching on a light, or beginning a theater performance. In effect this means that identifying the action-cause most appropriate for serving the goal of the moment—or, if the goal does not extend past the generation of that action effect, that pleases moment-to-moment goal constraints—necessitates the integration of quite a number of informational sources.

Once a suitable action–effect code has been chosen, the associated motor exemplar could be more or less automatically primed and the action performed without any broader considerations pertaining to context. If so, the hypothesized link between consciousness and integration of the information would, though, indicate that consciousness is more oriented to the choice of action–effect codes and its control than to the activation of motor-exemplars.[25] The potentiality for conscious experience to be cou-

25. Bernhard Hommel, Stephen B. R. E. Brown, and Dieter Nattkemper, *Human Action Control: From Intentions to Movements* (Berlin: Springer, 2016), 87–8. It might be important to reflect on what an "effect" actually is. It could be one of two things: (a) a specific perceptual end-state which actors sometimes aim at (the room light being switched on), or (b) a change of stimulation from current to intended stimulation (an increase of brightness). There are both theoretical reasons and empirical evidence to support the idea that changes of stimulation rather than end-states of stimulation govern action control. Cf. Wladimir Kirsch, Oliver Herbort, Benjamin Ullrich, and Wilfried Kunde, "On the Origin of Body-Related Influences on Visual Perception," *Journal of Experimental Psychology: Human Perception and Performance* 43, no. 6 (2017), doi:10.1037/xhp0000358. Among other things, assuming that motor codes are linked to specific transitions of stimulation solves the problem of the context-dependency of action outcomes. I owe this bibliographical suggestion to an anonymous blind reviewer of this paper.

pled with the execution of action-goals rather than their online control is also consistent with our (more or less) everyday experiences.

Let us assume, as illustrative, some case of accelerated manual reaction to the onset of a visual stimulus. Still, before the stimulus appeared, we had as early as possible set ourselves into some type of condition that assured that the response would be performed forcefully, and as requested. Causing such a condition is a voluntary, attention-control-demanding act, but as soon as the condition is prepared, the response is indeed a case of involuntary, or at the very least automatic, habitual responsive behavior—given that no additional exertion of will-power is required to convert the stimulus into the action. Is it really plausible that conventional reaction-time analyses would leave room for the thought that there could be a further engaging of executive control (i.e., as something more or less like a sequel to the processes triggered earlier by the will itself)? To put it another way, what most psychological experiments are picking up on here might be regarded as a case of willfully created habitual responsive behavior.[26]

Our conscious activity was principally addressed to setting up a particular task and preparing ourselves for carrying it out. Once that has been done, an external stimulus is sufficient to trigger the further execution of the task without much conscious reflection. Hence, a performance (implementation) of an action goal could be considered as turning the cognitive system into a "prepared reflex."[27] Following the ideomotor principle of action, it is possible to propose that a person can prepare a reaction by transforming an ideomotor EFFECT ⟶ ACTION configuration into a (reactive) STIMULUS ⟶ RESPONSE one. The resulting configuration will conform to a prepared reflex. A prepared reflex is a very special kind of reflex or trigger-anticipation. It is more like the formation of an intentional attitude, having the form of a rule: "If I am confronted with situation S, then I will realize goal-directed action A; but if I am

26. Cf. Bernhard Hommel, "Action Control According to TEC (Theory of Event Coding)," *Psychological Research* 73, no. 4 (2009), doi:10.1007/s00426-009-0234-2.

27. "It is trivial to demonstrate that humans can quickly learn to associate a motor response to a given sensory stimulus. The phenomenon, which occurs both in everyday life, in educational settings, and in countless laboratory experiments, is often instantiated by a simple instruction, such as 'press the square button when the light is green' or 'turn the knob when you hear a click.' The learning process for such associations is often quick and effortless. This striking ability to link stimuli to responses ('S-R links,' for short) has been a primary object of study in the history of psychology." Pin-Wei Chen, Tiffany K. Jantz, and Ezequiel Morsella, "The Prepared Reflex: Behavioral and Subjective Flanker Interference Effects," *International Journal of Psychological Studies* 6, no. 4 (2014), doi:10.5539/ijps.v6n4p1.

confronted with situation T, then I will realize goal-directed action B."[28] The above-mentioned "habitual responsive behavior" and its formation can be treated as a sovereign form of control arrangement. That arrangement trades off cognitive diversity and flexibility of goal-directedness for speed of implementation and works by developing persistent neural connections correlated with "prepared reflexes."

Next, more systematic experimental research has supported the idea that realizing a goal and a related action-plan delegates control to internal and external stimuli which may operate outside of consciousness.[29] Among other things, such a point of view tends to undermine the so-called "dual-route" (or dual-process) models. They can be found in almost all psychological and cognitive-neuroscientific research areas and even in the theoretical foundations and everyday practices of modern law. For instance, in their action-control model, Donald A. Norman and Tim Shallice[30] distinguish between habitual, stimulus-driven actions on the one hand and actions that are assumed to be under "deliberate conscious control" on the other hand. It is interesting to note that this terminology implies (for no given reason) that unconscious deliberate control is inconceivable.

7. Experiments: The Stroop and Simon Effects

In the following section we shall investigate how the "dual route" and "prepared reflex" model of conscious action can explain two well-known phenomena: the so called Stroop and Simon effects.[31]

28. The mentioned rule corresponds to Sellars' behavioral "rules of action" ("ought to do's"): "When one is in circumstances C, one ought to do A." Cf. Józef Bremer, *Rekategorisierung statt Reduktion. Zu Wilfrid Sellars' Philosophie des Geistes* (Göttingen: Vandenhoeck & Ruprecht, 1997), 82. "To say that a man is a rational animal, is to say that man is a creature not of habits but of rules." Wilfrid Sellars, "Language, Rules and Behaviour," in *Pure Pragmatics and Possible Worlds: The Early Essays of W. Sellars*, ed. Jeffrey F. Sicha (Atascadero, CA: Ridgeview Publishing Company, 1980), 138.

29. Cf. Gabriele Oettingen and Peter M. Gollwitzer, "Strategies of Setting and Implementing Goals," in *Social-Psychological Foundations of Clinical Psychology*, ed. James E. Maddux and June Price Tangney (New York; London: The Guilford Press, 2010), 122–23.

30. Donald A. Norman and Tim Shallice, "Attention to Action: Willed and Automatic Control of Behavior," in *Consciousness and Self-Regulation*, vol. 4, *Advances in Research and Theory*, ed. Richard J. Davidson, Gary E. Schwartz, and David Shapiro (New York: Plenum, 1986), 1–18, doi:10.1007/978-1-4757-0629-1_1.

31. Bernhard Hommel, "Intentional Control of Automatic Stimulus-Response Translation," in *Beyond Dissociation: Interaction between Dissociated Implicit and Explicit Processing*, ed. Yves Rossetti and Antti Revonsuo (Amsterdam: John Benjamins, 2000), 221–43.

The Stroop effect consists in the demonstration that naming the color of a word is slower and less accurate if this word refers to an incongruent color (e.g., the word "RED" written in blue ink) than if it refers to a congruent color (the word "GREEN" written in green ink).[32] Dual-route models attribute this effect to a competition between the intentional route, which is responsible for translating word color into a corresponding naming response, and an automatic, habitual route, which in this case represents the previously acquired reading skill. As the automatic route is not under intentional control, the cognitive system needs to counteract the automatic activation of the reading response in incongruent trials, which takes time and effort—as reflected in delayed reaction time and reduced accuracy.

While the resulting conflict scenario as just depicted may be correct, the prepared-reflex view would suggest that the reading response is a result of the task goal: namely, to utter color words in response to color stimuli. This would fit with the observation that the Stroop effect is very small (less than 10% of its original size) or absent in task versions in which the verbal naming response is replaced by key pressing responses.[33] The small differentials dissolve completely when covert naming responses are prevented through concurrent articulation. According to Wilhelm R. Glaser (and others), reaction-time tasks with key-pressing responses supply a strong argument for there being a dominant pathway from the nonverbal component of a Stroop-like stimulus to the non-verbal response that is practically unaffected by the stimulus word.[34] Applying word / color stimuli, it was found that the mean difference in reaction times of an incongruent and a congruent stimulus (the so-called Stroop impact) was reduced from 86 ms with verbal color naming to 39 ms with key pressing. "The speed of response is, therefore, essentially determined by the motor execution of the responses."[35]

32. The psychological occurrence we now call "the Stroop effect" was first described in 1935 by John Ridley Stroop. See J. Ridley Stroop, "Studies of Interference in Serial Verbal Reactions," *Journal of Experimental Psychology* 18 (1935), doi:10.1037/h0054651. Why has the Stroop effect continued to fascinate psychologists? Part of the answer is that it appears to tap into the essential operations of cognition, thereby offering clues to fundamental cognitive processes.

33. Hommel, "Consciousness and Action Control," 114; James R. Schmidt and Derek Besner, "The Stroop Effect: Why Proportion Congruent Has Nothing to do with Congruency and Everything to do with Contingency," *Journal of Experimental Psychology* 34, no. 3 (2008): 519, doi:10.1037/0278-7393.34.3.514.

34. Wilhelm R. Glaser, Margit I. Glaser, "Colors as Properties: Stroop-Like Effects between Objects and Their Colors," in *The Cognitive Psychology of Knowledge*, ed. Gerhard Strube and Karl F. Wender (Amsterdam: Elsevier, 1993), 5.

35. Ibid.

This provides a person with sufficient time to come up with strategies for stimulus encoding and a responsive selection which are neither observed nor controlled by the experimenter.

Comparable results follow from the Simon effect, which is based on stimulus-response compatibility. The effect can be observed without difficulty. It occurs when there is a proper (coherent) relation between what we observe and how we have to respond to it. The Simon effect shows that spatially defined responses, such as pressing a left versus right key, are delayed and less accurate if the stimulus appears at a location that corresponds to an improper response.[36] Dual-route models ascribe this result—as with their interpretation of the Stroop effect—to competition between the intentional route, responsible for translating the appropriate stimulus property (e.g., shape) into the correct response, and the automatic route that unintentionally translates stimulus location into response location.

In contrast to this, the prepared-reflex model proposes another solution: preparing for a spatially defined response requests an emphasis on (i.e., a stronger evaluation of) location properties, with the ancillary effect that the nominally irrelevant stimulus location now attracts attention. If that is the case, the Simon effect would be a necessary, but in a sense artificial, consequence of preparing for a task with spatially specified responses. It has been shown that behavioral and electrophysiological indicators of stimulus-induced response activation in a Simon task are obtained if the relevant stimulus-response mapping occurs before the stimulus (with the result that the goal could be implemented ahead of the stimulus), but disappear if the mapping occurs after the stimulus.

8. Conclusion

The ideomotor principle can be considered a key theme in cognitive psychology, and has been adapted to suit recent theoretical frameworks of action control. Indeed, the core aspects of the Carpenter–James version of the principle still apply today. On the one hand, an action generates effects, but on the other hand, anticipating an effect also activates a corresponding action.

The above-mentioned observations, along with others, allow for the possibility that experience of the kind connected with access consciousness is associated with those cognitive functions responsible for the realization of goals and the execution of related action-plans as well as their

36. Hommel, "Consciousness and Action Control," 114–15.

effects. The possibility that conscious experience is linked with the realization of action-goals rather than with their online control is also consistent with everyday observations. More methodical research has underpinned the idea that the realization of a goal and a related action plan assigns control—in the sense of a "prepared reflex"—to internal and external stimuli. These stimuli themselves may act without consciousness.

The above-mentioned cognitive functions are probably capable of affecting both "intentional" activities anticipated in the planning process and the "automatic" activities that emerge as a collateral product of such planning. While preparation can be thought of as inverting the role of the cognitive access system into that of a kind of prepared reflex, all processes following on in the wake of planning and its contexts (whether intended or a by-product) are likely to possess some or all of the features of "automaticity."

Taken together, these and other observations give rise to the possibility that conscious experience could be associated with cognitive functions responsible for the implementation of goals, as well as the preparation of related action-plans and effects. For this reason, the involvement of consciousness in action control does not seem to be suitably captured *by* the idea that perception and action control rely on distinct functional principles, that there is a chain of the kind

PERCEIVING ⟶ INTENTIONAL THINKING ⟶ ACTING.

Contrary to this, and also more likely, there is a chain of the sort

INTENTIONAL THINKING ⟶ (ACTING ⟶ PERCEIVING).

Despite the fact that consciousness does not seem to be causally involved in progressive action control, its primary purpose is presumably to supply the foundation for interpersonal and verbal information exchange.

It should also be observed that the prepared-reflex operationalization of action effects differs in critical respects from such anticipated action effects as innate reflexes or trigger stimuli. The ideomotor approach thus provides a positive foundation for determining the neurophysiological basis of action control through sensory anticipations. The latter basis, however, can only be grasped through a clearer understanding of the brain's interactions in action control, alongside the neurophysiological dynamics of ideomotor processes. The result will be a conclusive incorporation of ideomotor theory as a serious psychological concept, along with classical neurophysiological models of action control.

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