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## **Inhibition: Elusive or illusion?**

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‘... the arrest of the function of a structure or organ, by the action upon it of another, while the power to execute those functions is still retained, and can be manifested as soon as the restraining power is lifted’

(*Brunton 1883*)

What do we mean by ‘inhibition’ in the year 2007? Quite possibly, we mean very much what Brunton meant 124 years ago. When we discover that history already contains the current view, it is quite common to express disappointment that there has been no progress, but this is not at all a necessary conclusion. In fact, our understanding of the concept of inhibition has grown very considerably over the past century and a quarter, particularly in the realm of neuroscience, but also in the study of cognition. The interested reader should consult two excellent books on the history of the concept—Diamond *et al.* (1963) and Smith (1992).

### **Start vectors**

This brief chapter considers several issues critically connected to the concept of inhibition. To begin, however, it is important to indicate two ‘start vectors’. First, this chapter takes as absolute fact that there is inhibition at the level of the brain and nervous system, based on the vast neuroscientific literature that has developed since Sherrington (1906). It is also accepted that we can stop motor actions (see, for example, Logan and Cowan 1984), a phenomenon widely called inhibition, although the term has a different meaning there than its neuroscientific cognate, and a more neutral term such as ‘restraint’ or ‘(executive) control’ might be preferable. So the questions considered here relate to the concept of inhibition as invoked to explain memory at the psychological, cognitive or behavioral level—inhibition at the level of thought, not action (cf. Breese 1899).

A second start vector is also important to identify explicitly. No matter what one's position on the utility of the concept of inhibition in understanding cognition, it does not strengthen the argument to invoke the concept of neural inhibition. The two operate at fundamentally different levels of analysis. Nor is either a unitary entity: Cohen (1993), for example, identified four distinct subtypes of neural inhibition, each involving a variety of neural components. Certainly different ideas are conveyed by different uses of the term in the study of cognition. True, neural and behavioral inhibition both refer to a suppressed event, but that is where the analogy ends, and any kind of direct mapping seems very unlikely. Indeed, reserving 'inhibition' for the neural event and another term such as 'suppression' for the cognitive event, if it can be shown to occur, would be preferable. Put simply, a 'domain general' central concept does not seem plausible.

### **What might cognitive inhibition mean?**

According to the *Oxford English Dictionary*, there are four senses of *inhibition*. Two relate to societal or legal prohibition. Interestingly, the other two relate *separately* to the physiological and psychological senses of the term, consistent with the present claim that these two senses are distinct. The defining elements of cognitive inhibition appear to be two—mental withholding and reduced performance. The latter is directly measurable as reduced response likelihood or lengthened response latency, given a suitable neutral baseline or control condition against which to make the comparison. However, the former is an inference from performance. Inhibition is not an outcome; it is a theory about the cause of that outcome. Note that Brunton's emphasis on the function returning to 'full strength' once inhibition is lifted is only sometimes woven into the definition.

As argued elsewhere (MacLeod *et al.* 2003), even the measurement of reduced performance is not without considerable challenges. The choice of a neutral baseline is rarely straightforward or unanimously agreed upon. Great care must also be taken not to equate reduced performance reflexively with inhibition: inhibition is only one possible mechanism that might contribute to or cause that reduction. The crucial questions then become: How are we to determine whether inhibition was involved? What are the defining features of cognitive inhibition?

### **Defining criteria for cognitive inhibition**

Unfortunately, no 'litmus test' exists or is likely to appear, so we must rely on multiple co-occurring symptoms to support a diagnosis of cognitive inhibition. There are only two that have been proposed as specifically filling this role.

The first has been used in attention research but not yet in memory research. This is a kind of dissociation criterion wherein a pattern reverses from a benefit to a cost. [The cost/benefit terminology is borrowed (e.g. Jonides and Mack 1984) and is recommended as admirably agnostic with respect to process or mechanism.] Thus, in the phenomenon of inhibition of return, a cue appears at one of two spatial locations where a soon-to-follow target could appear. Although over trials the cue is not actually predictive of the location of the subsequent target, if the time between cue and target is brief, the cue provides a benefit in response time to a target at the same location. However, that benefit switches to a cost if the time between cue and target is lengthened. The received view is that when the delay is longer we inhibit the cued location, thereby slowing detection of the target should it appear there. The experimental conditions are unchanged except for the cue–target lag, so this reversal could serve as a marker for inhibition, although other explanations exist.

The second criterion, in contrast, is unique to the memory literature, and has been championed by Anderson and Green (2001). The logic is that if a memory is truly inhibited by some operation on a representation, then other operations on that same representation should also reveal evidence of that inhibition. Anderson and Green had people try not to think of a previously studied word when provided with a cue that had been studied with that word. They found that this led to poorer recall of the target word than was the case without having tried not to recall it. This outcome could be seen as suggesting inhibition—but in fact does not rule out simple interference. However, the target word was also harder to recall to a (related) cue that had not been studied, suggesting that the target word itself, not just the particular studied association, was suppressed by the act of not thinking about it. Anderson and colleagues have cited this pattern as strong evidence for inhibition in memory (although its replicability has been questioned, see Bulevich *et al.* 2006).

These two are worthy efforts in terms of trying to diagnose true instances of inhibition, but more criteria are needed. (Of course, inhibition is not alone in this predicament; other cognitive mechanisms certainly warrant greater definition.) To differentiate inhibition-based from non-inhibition based memory situations will require considerably more work and ingenuity. In so doing, the hope must be that the coherence of the concept will be considered as well, given that at present inhibition can mean quite different things to different memory researchers.

## Plausible alternatives to inhibition

What process(es) might cause a cognitive task to slow down or to become more error prone? Inhibition of a component of the response, such as the

representation upon which it relies, is certainly a candidate. However, discriminating inhibition from interference will continue to be a most difficult problem. So interference—being drawn to an alternative other than the nominally correct alternative—is also a candidate. The term ‘interference’ is also problematic, though, sometimes being used to refer to an observed phenomenon and sometimes to a possible explanation of the phenomenon. The crux of the problem was well laid out by Klein and Taylor (1994, p. 146) who said:

Unlike in the neural sciences, however, where inhibitory mechanisms can be observed in the hardware, in cognitive models inhibition must be inferred on the basis of overt behavior. As such, there is a danger of circularity whereby investigators attribute interference effects to inhibition and subsequently define inhibition on the basis of behavioral interference. For this reason, the terms inhibition and interference are often confused.

In any given situation where inhibition is proposed as a possible account, other possible accounts are certainly available. These other possibilities vary, so a proponent of the idea of cognitive inhibition might argue that one of its virtues is its breadth. However, a critic could just as readily maintain that because inhibition means quite different things to different researchers, the apparent ‘value added’ of breadth is illusory and actually has considerable potential to create confusion. If those favoring inhibition accounts had to divide inhibition into subtypes, it might actually be better to abandon the umbrella term altogether, focusing instead on these subtypes as distinct processes.

MacLeod *et al.* (2003) argued, following several other investigators, that a viable alternative account to widespread inhibition in cognition could actually be more directly memory-based. Under this account, it is routine, even automatic, to retrieve continuously from memory information relevant to the present situation. Ordinarily, such retrieval is advantageous—a benefit—helping to narrow options and speed the decision regarding what to do. However, sometimes, retrieved information will conflict with the present situation, slowing processing and producing a cost. Although such costs could be seen as inhibition, they need not be: they are instead the joint product of automatic memory retrieval and consequent conflict resolution. Such an account works well in many situations that otherwise might seem to demand an inhibitory explanation.

## Conclusion

The position put forth here is that we do not have strong evidence of inhibition in memory. There may be inhibitory processes in memory, but we simply do not know yet, and better indices are required. The existence of neural inhibition is seen as a different phenomenon. In the nervous system, it is the balance of

excitation and inhibition that determines neural computation and ultimately behavior. It is therefore most likely that even if we can identify true cognitive inhibition, such inhibition will also rely on the balance of neural inhibition and excitation, and will not be uniquely related to neural inhibition. Under this view, the existence of inhibition in the nervous system in no way speaks to the likelihood or character of inhibition in behavior, any more than the existence of neural excitation necessitates a counterpart in cognition.