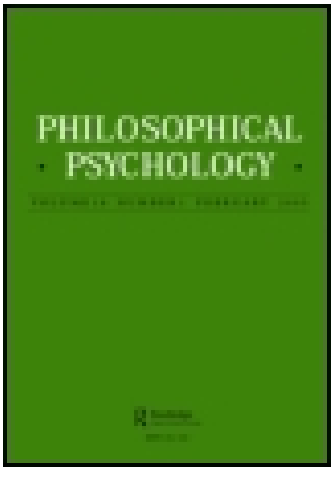

Philosophical Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cphp20

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Published online: 05 Sep 2014.

To cite this article: Eric Mandelbaum (2014): The automatic and the ballistic: Modularity beyond perceptual processes, Philosophical Psychology, DOI: 10.1080/09515089.2014.950217

To link to this article: http://dx.doi.org/10.1080/09515089.2014.950217

Philosophical Psychology, 2014
http://dx.doi.org/10.1080/09515089.2014.950217

Routledge
Taylor & Francis Group

The automatic and the ballistic: Modularity beyond perceptual processes

Eric Mandelbaum

Perceptual processes, in particular modular processes, have long been understood as being mandatory. But exactly what mandatoriness amounts to is left to intuition. This paper identifies a crucial ambiguity in the notion of mandatoriness. Discussions of mandatory processes have run together notions of automaticity and ballisticity. Teasing apart these notions creates an important tool for the modularist's toolbox. Different putatively modular processes appear to differ in their kinds of mandatoriness. Separating out the automatic from the ballistic can help the modularist diagnose and explain away some putative counterexamples to multimodal and central modules, thereby helping us to better evaluate the evidentiary status of modularity theory.

Keywords: Automaticity; Cheater Detection; Cognitive Penetration; Modularity; Multi-Modal Perception

1. The Putative Autonomy of Perceptual (and Perhaps Other) Mental Processes

One of the most fraught debates in philosophy of mind and cognitive science concerns whether perceptual processes are modular. In philosophy the debate connects to foundational issues in the philosophy of science and epistemology, as well as to those regarding perception. For instance, one may be interested in how the theories one holds affect one's perceptions (Churchland, 1988; Fodor, 1988) or in how top-down penetration would affect justification by perception (Siegel, 2012). Investigations of the theory-neutrality of perception generally take a stand on the question of how modular perceptual processes are. If you claim, as Siegel (2010) does, that knowing that you are seeing an elm and not just a tree can change the phenomenology of your percept, you are—prima facie, at least—committed to a claim about how cognition can interact with our perceptual faculties.[1] Indeed, modularity is at heart

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a claim about how little interaction there is between our conceptual stores and our perceptual apparatuses.

Modules are posited as mental processes that are fast, domain specific, informationally encapsulated, and mandatory (Carruthers, 2006; Fodor, 1983; Mandelbaum, 2013). Modules are also thought to be innate (though Karmiloff-Smith, 1995 challenges this criterion), to have regularized and predictable development, and to exhibit characteristic breakdowns.[2] In his original presentation, Fodor (1983) hypothesized that the perceptual processing underwriting the five basic senses, in addition to language processing, were modular. Since then, the number of proposed modules has ballooned to include non-peripheral elements of the mind, such as a number module, a letter-recognition module, a visual-postural module, and a cheater detection module. Some supporters of evolutionary psychology (e.g., Barrett & Kurzban, 2006; Carruthers, 2006; Pinker, 1997; Tooby & Cosmides, 1992) have tried to push the notion even further, arguing that every mental process is in fact modular. In the hands of these theorists, unimodal perceptual processing, linguistic parsing, and cheater detection constitute their own single natural kind, in that they are all equally modular.

In what follows, I remain agnostic as to whether certain multimodal and central processes are indeed modular. Instead, I want to focus on an ambiguity in the notion of "mandatoriness" and how it affects debates of modularity for non-unimodal perceptual processes. Disambiguating the different senses of mandatoriness allows the modularist to respond to some influential objections to multimodal and central modular models. Doing so won't just help clarify debates over whether some aspects of perception and cognition are really modular; it will also help us understand the different ways in which mental processes can be reflexive.

2. The Ambiguities of Mandatory Processing: The Automatic and the Ballistic

Roughly, one can understand mandatoriness in two ways, which I label *automatic* and *ballistic*.[3] A mandatory process is *automatic* if, when a module encounters a stimulus that is in its proper domain, the module *must* process the stimulus, regardless of what else is occurring in one's mind (e.g., regardless of the allocation of other mental processes). In essence, automaticity says that all it takes to start a perceptual process is the mere presence of the domain-specific input.

In contrast, a mandatory process is *ballistic* if, when the processor starts, it cannot be stopped by any endogenous means. The proper input is not necessarily processed every time the input reaches the module, but once the processing starts, one cannot stunt it, either through top-down effort or via other roughly psychological means.[4] Identifying something as a purely ballistic process does not explain how the processing is initiated. It simply describes how the processing unfolds, namely, in an uninterruptable fashion.

The contrast can be summed up thusly: automatic processing can't help but start whenever the proper stimulus is encountered, whereas in ballistic processing, the mere

contiguity of the stimulus with the processor isn't necessarily enough to set off the module. Likewise, an automatic but not ballistic process would be one where processing begins anytime a proper stimulus is encountered but may be stopped short by any number factors after the onset of the processing.

To illustrate, suppose that attention can affect modular processes. If a modular process is automatic, then reallocations of attention couldn't stop the module's processing from starting once it has encountered its domain-specific stimuli, but reallocations of attention *could* stop the processing from completing its route after the module has been triggered. However, if a modular process is ballistic, reallocations of attention (inter alia) could block the module from starting its processing, but once the processing has begun, the processing would have to continue to completion.

In principle, an automatic process could also be ballistic. I'll argue that an interesting set of perceptual processes is both. But I'll also argue that, upon examination, these two types of mandatory processes dissociate, not just conceptually, but also empirically, in taxonomically interesting ways.

Let's use vision as the paradigm example of a unimodal perceptual process. Consider the ease with which we parse a normal visual scene. We open our eyes and poof—the world just appears before us. Visual processors thus seem to be automatic: one doesn't expend any cognitive energy to see the ambient environment; one just opens one's eyes and puts the lights on. Vision is automatic in the sense that whenever the visual apparatus interacts with its proprietary stimuli (e.g., the transduction of impingements of light arrays on the retina), the apparatus must begin its processing.

Vision appears to be ballistic too. Take the canonical example of the Müller-Lyer illusion: perceivers can't help but form a percept of two lines of differing length, even though they know full well that the lines are the same length. The knowledge of the lines' lengths couldn't be more germane to the perceptual task at hand; nonetheless the visual system cannot use this information. If top-down feedback could occur, this would be as good of a place as any to find evidence of it: a non-load-inducing perceptual task in conjunction with a single, germane belief. Yet the fact that we don't find the informational intrusion gives us reason to think that central information cannot penetrate the visual system.

This obstinacy caused by informational encapsulation has been taken as the hallmark of modularity. The current suggestion is that informational encapsulation goes hand in hand with the processing being ballistic. Ballisticity helps to ensure a certain sort of informational encapsulation: knowledge that could bear on the formation of a percept cannot affect perceptual processing, in part because the modular process cannot stop once it has started. If the module were not ballistic, however, then there could be a halting point where germane information could be introduced.[5]

In multimodal perceptual processes, or at least our most detailed example of one, we do seem to find such halting points. Language perception is traditionally posited as the paradigmatic multimodal module (see, e.g., Fodor, 1983), for the mechanisms of phonetic and syntactic analysis can apply to inputs from a variety of modalities (e.g., vision and audition). The multimodality of language comprehension can be seen

in the McGurk effect, in which an illusory percept is created by one hearing 'ba-ba' while seeing lips that are producing the sound 'ga-ga', thus producing a multimodally determined percept that sounds like 'da-da' (McGurk & MacDonald, 1976).

Language perception is, no doubt, automatic. For example, one cannot help but hear a sentence in one's native language as *language*; one cannot hear it merely as an acoustic stream of sounds even when prompted to (see, e.g., Marslen-Wilson & Tyler, 1980). The semantic properties of a sentence just pop out effortlessly.[6]

But with eccentric stimuli, the situation looks a bit different. When given a garden-path sentence, perceivers still cannot help but hear the sentence as a *sentence* and not, say, as a purely acoustic object, yet the syntax and semantics of the sentence are often not specified—the parsing of the sentence "crashes." Garden path sentences have been a thorn in the side of modularists, for such sentences are more apt to be correctly parsed if the sentences mesh with contextual information. But contextual information is never intramodular; rather, such information must be located in central cognition. But, the thinking goes, if such central information can be used to guide linguistic processing, then linguistic processing isn't modular, for it isn't informationally encapsulated.[7]

In sum, the modularist has some trouble when it comes to garden paths. Language parsing appears to instantiate all the properties of a module, except it appears to lack the hallmark property of modules, informational encapsulation. However, realizing that modules needn't be ballistic can provide the theoretical leeway that the modularist needs. To see how, let's explore a popular class of psycholinguistic models of what happens during garden path crashes. The models posit that a context analyzer is continually monitoring the structural descriptions that are created during language perception (Crain & Steedman, 1985; Ni, Crain, & Shankweiler, 1996). Since the module is mostly informationally encapsulated, the context analyzer cannot introduce all the beliefs that could be relevant for parsing the sentence as the sentence is being processed. Instead, all the context analyzer can do is tell the module when it should discontinue its current processing stream. But discontinuing the current processing stream is only possible assuming the processor is not ballistic; were it not to be, no such discontinuation would be possible.

For instance, when one encounters a token of 'fat people eat accumulates' one first builds the structure like in figure 1. This structure then crashes once the system encounters 'accumulates'. What happens then is that the context analyzer tells the module to stop its processing and opens up the online information to central cognition so that all of one's beliefs can be used to form the sentence. This is a much

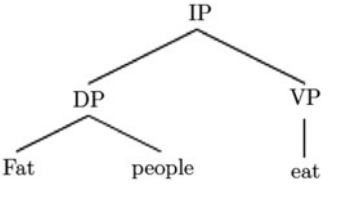

Figure 1. The initial incorrect structure created when parsing 'fat people eat accumulates'.

slower way of creating a structural description of a sentence and is rarely used; it is only brought to bear in situations where the modular processing has been stopped. Say we were just having a conversation about how lipids affect obesity, and you utter, 'Fat people eat accumulates'. Once the context analyzer starts the halting (after 'eat'), the contextual information can be used to create the correct structure of the sentence (figure 2), thereby specifying its correct meaning (where 'fat' is a noun, not an adjective; there is no grammatical reading of the sentence when 'fat' is read as adjectival). But note that this model entails that the modular process is not ballistic: the entire function of the context analyzer is predicated on there being a halting point. Halting points on their own may be an addition to the modular picture, but they don't contradict the core of modularity theory, once properly analyzed. By introducing ballisticity into the modularist's toolbox, we can explain how a processor can be mandatory and modular, while still allowing for some places for informational encapsulation, strictly speaking, to be violated in special circumstances.[8] We can now begin to see a real difference between unimodal and multimodal perceptual processes—perhaps unimodal perceptual processes in general are both ballistic and automatic, whereas multimodal processes may just be automatic and not ballistic.

Are there perceptual processes that are ballistic but not automatic? The evidence here is thin, but one can speculate. It seems plausible that the "cognitive modules" that evolutionary psychologists discuss are, in fact, ballistic but not automatic. Take the classic example of a cognitive module: cheater detection. When given a "social conditional"—that is, a conditional in which there is a benefit received without a requirement met, such as, 'if one is going out at night, then one must tie a small piece of red volcanic rock around one's ankle' (Cosmides, Barrett, & Tooby, 2010)—people often can correctly identify the situations that would falsify the conditional. However, people have serious trouble parsing the truth conditions of conditionals that aren't this type of social conditional—e.g., 'if one is taking out the garbage, then one must tie a small piece of red volcanic rock around one's ankle'. For example, 80% of participants correctly identified the situations that would falsify the former sentence, whereas only 44% did so for the latter one (which has no benefit involved, so isn't considered a "social conditional"; Cosmides et al., 2010).

Cosmides et al. claim that the processing of social conditionals is modular. But a popular criticism of this view notes that it's quite hard to predict when such conditionals are being processed as conditionals (see, e.g., Fodor, 2000). When one

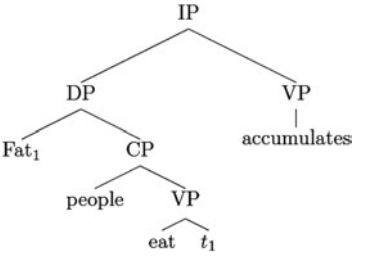

Figure 2. A more accurate depiction of 'fat people eat accumulates'.

isn't paying attention to a sentence one still processes it as a piece of language, but it doesn't appear that the same holds for processing the truth conditions of a conditional—to accomplish that, one needs to also pay attention. Hence, cheater detection appears to be more active than other candidate modules, so some have inferred that cheater detection isn't actually modular.

This line of criticism may be misguided, as it runs together questions of ballisticity and automaticity. Cheater detection appears to be ballistic but not automatic. There is no evidence that merely encountering these sentences makes their truth conditions pop out. One might immediately parse the sentences as a bit of language, but that in and of itself doesn't seem to produce apprehension of the falsifying conditions. However, once attention is paid to the sentence, the falsifying conditions do seem to pop out. I suspect cheater detection isn't automatic because the mere encountering of the output of the language parser (the conditional) does not in and of itself make the falsifying conditions apparent. To accomplish that one has to at least also trigger certain concepts having to do with benefits received and unmet requirements (Cosmides et al., 2010).

The current suggestion is that attention and motivation help to activate certain concepts which can trigger cheater detection but that, once the processing is started, we can just sit back and wait for the answer to pop out: no further endogenous activity is necessary (and furthermore, subsequent endogenous activity won't be able to stop the process even if one wanted to). Endogenous activity may be necessary to start the module, but once started, the module runs on its own. If this is right, then cheater detection may in fact be perfectly mandatory and encapsulated; however, its processing may not be automatically triggered without the help of attention. Thus, separating out automaticity from ballisticity can show how central modules can still be mandatory, even if they aren't merely triggered via the presence of the relevant exogenous stimuli.

The automatic/ballistic distinction can also help deal with the other popular criticism that has beset central modules like cheater detection: that social exchanges don't have any sensory properties to mark them as social exchanges. For example, in Weiskopf's otherwise skeptical (and exceptional) review of Fodor (2000), he approvingly agrees with Fodor's anti-cheater detection argument. Weiskopf writes, "social exchanges are not, obviously, marked by any kind of apparent sensory properties. Figuring out whether something is a social exchange or not takes reasoning that is likely to be global" (2002, p. 557). However, if we allow that mandatory processing needn't be automatically triggered, then we can loosen the grip on what type of input is necessary for setting off the module. Perhaps it is the case that attention and motivation are necessary to activate centrally housed concepts of benefits and requirements and that this activation would take significantly more time than, e.g., visually identifying a cube. Nevertheless, that lack of automaticity wouldn't itself thereby doom cheater detection to be incoherent as a modular process. The lack of automaticity would allow the time needed for central cognition to activate the relevant concepts to set off the cheater detection process, thereby sidestepping the need for social exchanges to be sensorily identifiable (which is surely a lost cause).

Thus, a surprising consequence of separating out automaticity from ballisticitiy is that it loosens the grip on what type of information can be used as input to modules. Cheater detection would still be mandatory, in that it would still be ballistic, but its not being automatic would give the cognitive system the time it needs to detect its proper input even if that input is centrally stored.

3. A Possible Trichotomy of Mental Processes

Over and above aiding our understanding of what it means for a process to be mandatory (and thereby helping the modularist respond to certain criticisms), perhaps we can also start to see a real trichotomy of perceptual processes, one where unimodal perceptual processes are automatic and ballistic, multimodal perceptual processes are automatic but not ballistic, and central modular processes are ballistic without being automatic.

It is too early to make any definitive claim that such a taxonomy carves the mind at its joints. Even if these distinctions don't prove to delineate true psychological kinds on their own, they may aid our search to understand what makes unimodal and multimodal processes interestingly different—at the very least, they differ in terms of mandatoriness.[9]

Notes

[1] Siegel's focus, like Macpherson's (2012), pertains to how perceptual *experience* can be modulated by one's cognitive and conative states. These discussions differ from traditional debates about modularity which are focused on the modularity of perceptual processing. Questions of processing, not experience, are at issue in what follows in this essay.

[2] Initially, modules were also posited to be neurally localized and to have "shallow outputs," but these properties have since dropped out of most presentations of modularity. To my eyes, the neural localization criterion has been dropped both because of the increasing amount of anti-localization evidence (see, e.g., Anderson, 2010) and also because of all of the confusion it engendered between neurological modularity and psychological modularity, the latter being the topic at issue here. I suspect that discussions of shallow outputs have ceased in part because people had trouble making sense of exactly what constituted a shallow output and in part because, insofar as one does have an idea of what it is, it's hard to see how what would constitute a shallow output of, say, an auditory or gustatory module.

[3] There is also one further sort of ambiguity here that won't be the focus of the discussion; see note 9 for further details.

[4] I'll leave out the 'through psychological means' modifier from here on. Of course, non-psychological variables could shortcut either of these processing types; a mental process might be stunted because of a number of lower-level factors such as aneurysms, unfortunately aimed projectiles, or untimely death. This is just to say that here, as elsewhere in the special sciences, ceteris paribus clauses abound.

[5] Could there be a non-ballistic processor that is unable to use relevant outside information? We can certainly envision a processor that stops all the time yet is still encapsulated—it would just be a relatively inefficient processor. Nonetheless, there are some considerations that suggest human vision is indeed ballistic. For example, vision will process stimuli that only appear for incredibly short presentation times. Take the classic masked priming effect

(e.g., Forster & Davis, 1984; the following numbers are from there, but are common to many such demonstrations). A forward-masking stimulus (e.g., a barcode) will appear for 500 ms, and immediately be followed by a target prime (e.g., a word) which is presented for a mere 30 ms. The target is then overtaken by a masking stimulus which is presented for a much longer amount of time (e.g., 500 ms). In these paradigms, subjects successfully visually process the target stimulus. That means that the stimulus is being processed to completion even when the stimulus has already faded, and even though there are heavy interference effects. If vision were to have halting points, then presumably the masked priming paradigms would be the sort of place to detect them.

[6] In fact, dichotic listening experiments show that you needn't even be conscious of the stream in order to unconsciously process it as language and encode its semantics (Bentin, Kutas, & Hillyard, 1995).

[7] Burnston and Cohen (forthcoming) cleverly suggest that we reinterpret the conception of modularity because of what they take to be the evidence for integration of central (or at least "higher," hierarchically speaking) information's effect on perceptual processing. They argue that informational encapsulation shouldn't be understood in terms of a proprietary database of intramodular information, but rather it should be interpreted as the rigidity with which a processor integrates information regardless of the locus of the information. Thus, for them, anisotropic processes are modular because they can only process a delimited set of informational inputs regardless of which other processes can also access those inputs. But the introduction of contextual information in linguistic processing would spell doom for their conception of modularity too, since contextual information can be any information a person has access too, in which case the language parser would be as isotropic as any process could be. Hence they too will need to capture something like the automatic/ballistic distinction in order to deal with putative counterexamples to traditional modules. They could of course also just decide to accept that language processing isn't modular, but that wouldn't quite help patch up a lacuna in their view: their reconceptualization of modularity leaves out the mandatory and fast nature of modular processing altogether. Anisotropy crosscuts both the automaticity and ballisticity criteria (for example, an automatic process can, for all automaticity cares, take in inputs from everywhere, as long as it starts its processing once it encounters those inputs, mutatis mutandis for ballisticity). Thus, for all their view cares, a modular process could take a week to complete its processing. But surely the introduction of modularity is there to separate out processes like long-term planning, from not just encapsulated but also fast and mandatory processes like vision. The fact that their criteria cannot capture this difference is problematic.

[8] And parsing a garden path is a special circumstance if anything is. Part of what makes garden paths so jarring is how infrequently they are actually encountered in everyday speech. People are just not apt to utter, for example, sentences with doubly center-embedded relative-clause constructions. The rarity of garden paths in the wild gives us some reason to think that they are very much an exception to the rule of normal speech processing (and production).

[9] Perhaps it's worth adding that there is at least one further disambiguation of the notion of mandatoriness, at least as it's used in the literature. Most confusingly, Fodor not only ran both the automaticity and ballisticity readings together in the original presentations of modularity, but he also introduced a third, wholly separate notion and claimed that it was the most conservative one, even though it appears to be the most tendentious. When discussing mandatoriness, Fodor writes:

> Perhaps the most conservative claim is this: input analysis [i.e., modular processing] is mandatory in that it provides the *only* route by which transducer outputs can gain access to central processes; if transduced information is to affect thought at all, it must do so via the computations that input systems perform. (1983, p. 54)

Fodor's basic idea is that no raw sensations (i.e., transduced information) can get into central cognition without first moving through a modular process. I suspect that this supposedly conservative test of mandatoriness has been the source of much confusion in debates about modularity. For example, Bar (2003); Fenske, Aminoff, Gronau, and Bar (2006); and Kverga, Ghuman, and Bar (2007) all claim that modularity is false because of certain sorts of top-down facilitation of object recognition. However, these claims are made on the basis of data using low-spatial-frequency images (that is, images that are very hard to see as images of anything). The modularist might object (as in fact many do; see, e.g., Fodor, 1988) on the basis that degraded stimuli encourage guessing, and guessing is cognitive, not perceptual; degraded stimuli would thus not count as proper inputs. However, for this type of explanation to work, there has to be a bound on what can set off the module; that is, it has to be allowed that certain sorts of raw, transduced information, such as the retinal array of low-spatial-frequency images, can bypass a module completely. It seems that the "conservative" sense is thus much more tendentious than either the automatic or the ballistic sense. Moreover, I am satisfied that the work of Bar and others shows that the putatively conservative sense is quite probably false, and therefore have ignored this third sense in this essay.

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