Massive Modularity, Content Integration, and Language

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One of the obstacles facing massive modularity is how a pervasively modular mind might generate non-domain-specific thoughts by integrating the content produced by various domain-specific modules. Peter Carruthers has recently argued that the operations of the language faculty are constitutive of the process by which the human mind is able to integrate content from heterogeneous conceptual domains. In this article, I first argue that Carruthers's data do not provide support for either of two possible interpretations of his thesis. In addition, I provide empirical and theoretical reasons for thinking content integration is performed external to the language faculty.

1. Introduction. Carruthers (2006) presents an impressively extensive and empirically thorough account of a massively modular mind. One of the obstacles facing accounts of massive modularity is that modules are essentially domain specific, yet our minds are able to integrate content from almost any domain. For example, we have no problem thinking thoughts such as, THE TOY IS IN THE CORNER WITH A LONG WALL ON THE LEFT AND A SHORT BLUE WALL ON THE RIGHT, despite the integration of concepts from object-property and geometric domains.[1] This article focuses exclusively on Carruthers's suggestion as to how a massively modular mind might integrate the content produced by various domain-specific modules. Following his earlier work (Carruthers 2002), Carruthers argues

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1. I will use small caps to denote concepts.

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that content integration is realized within the functions of the language faculty (Chomsky 1968, 1975; Pinker 1997). In other words, Carruthers believes that *the operations of the language faculty are constitutive of the process by which the human mind is able to integrate content from heterogeneous conceptual domains*.

In this article, I argue that we have no empirical evidence in support of Carruthers's language-as-content-integrator (LACI) hypothesis, but we do have some empirical and theoretical reasons against it. First, in section 2, I give two possible interpretations—a strong and a weak version—of Carruthers's hypothesis. In section 3, I examine the evidence cited by Carruthers and show that it does not provide support for either version of the LACI hypothesis. Then, in section 4, I present empirical evidence against the strong version of Carruthers's thesis and discuss why obtaining empirical evidence concerning the weaker thesis is difficult. The final section presents additional theoretical arguments for thinking that content integration is performed external to the language faculty.

2. The Language-as-Content-Integrator Hypothesis. The language faculty, classically considered, consists of distinct production and comprehension subsystems. The production subsystem generates representations of natural language sentences from the outputs of central systems, which can then be passed on to motor control systems so as to be expressed in various ways. Conversely, the comprehension subsystem 'decodes' sentences of a natural language into mental representations with the appropriate content. These mental representations can then be presented to various central modules for processing.

Carruthers believes that the language faculty is capable of integrating content in the following way. First, the output representations of two distinct central modules are sent from the "central arena" (Barrett 2005) to the language faculty. There, each is translated into representations of natural language sentences, specifically what Chomsky referred to as Logical Form (LF).[2] Once the thoughts have been translated into this common format, they can be integrated via an inference generator. This yields a representation in LF with integrated content, which is then presented to the comprehension subsystem, where it is decoded, resulting in a thought with integrated content. Thus, the language faculty has produced a single content-integrated thought from two domain-specific thoughts.

However, to accurately understand Carruthers's proposal, we need to understand what it means for content to become integrated in the intended sense (Robbins 2002). One way to understand Carruthers's intended sense

2. The LF of a sentence is a formal representation of its structure, which specifies its logical role and properties.

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of content integration is as the use of a particular class of inferences, namely, those licensed by natural language, that are capable of generating a particular class of cross-modular thoughts. For instance, Carruthers believes the language faculty is capable of taking an output from a geometrical module (THE TOY IS IN THE CORNER WITH A LONG WALL ON THE LEFT AND A SHORT WALL ON THE RIGHT) and an output from an object-property module (THE TOY IS NEAR A RED WALL) and generating the cross-modular thought: THE TOY IS IN THE CORNER WITH A LONG WALL ON THE LEFT AND A SHORT *RED* WALL ON THE RIGHT (Carruthers 2006, 241). This transition involves the ability to embed multiple adjectives and phrases (i.e., there are additional 'slots' into which they can be inserted) and some method for indexing the reference of terms (e.g., the short wall). Both of these operations are used by natural language.

Yet, there is another way to interpret Carruthers's proposal. According to the alternative interpretation, a thought will be content integrated just in case it involves concepts from heterogeneous domains. This interpretation extends the set of salient cross-modular thoughts to include all those that involve concepts from more than one domain. This would substantially strengthen Carruthers's thesis to the claim that *the operations of the language faculty are constitutively involved in the generation of all cross-modular thoughts*. It is not entirely clear which thesis Carruthers intends to endorse. Carruthers's original article (2002) certainly suggests that the content-integration capacities of the operations of the language faculty ought to be understood in this stronger sense. For instance, Carruthers claims, "The hypothesis, then, is that non-domain-specific, cross-modular, propositional thought depends upon natural language. . . . Specifically, language is the vehicle of non-modular, non-domain specific, conceptual thinking which integrates the results of modular thinking" (666). However, in his more recent book, Carruthers frequently appears to retreat to the weaker thesis (2006).

Given this ambiguity, I will simply refer to the thesis that the operations of the language faculty are constitutive of the generation of all cross-modular thoughts as the *strong-LACI hypothesis*. This, of course, contrasts with the *weak-LACI hypothesis*, which claims that the operations of the language faculty are constitutively involved only in a limited set of inferences (i.e., those licensed by natural language) that can be used to generate a particular subset of cross-modular thoughts. With this distinction in place, the next section shows why Carruthers's empirical evidence is unable to support either version of the LACI hypothesis.

3. Disarming the Supposed Evidence. In critiquing Carruthers's proposal, it is important to note the relevant competing hypotheses. After all, content integration is happening somewhere. Although various alternative

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accounts have been proposed,[3] it suffices for the purposes of this article to understand that the general relevant alternative hypothesis is just that some other module (or modular system) distinct from the language faculty is responsible for the mind's ability to integrate content (in the intended sense). It should be kept in mind, however, that this alternative system might be part of a larger cognitive system. Furthermore, any alternative content integrator can likewise avail itself of translations into a 'common code' so as to avoid the need to postulate a general-purpose inference module (as this would run afoul of the massive modularity hypothesis). Having noted the relevant competing hypothesis, I turn now to the empirical evidence touted as support for the LACI hypothesis.

3.1. The Reorientation Data. The first set of data appealed to by Carruthers comes from reorientation studies performed by Elizabeth Spelke and her colleagues (Hermer and Spelke 1994, 1996; Shusterman and Spelke 2005). These studies were designed to test human beings' ability to employ cross-modular content during reorientation tasks. Subjects were placed in a rectangular room in which one of the walls was distinctively patterned (e.g., there might be three white walls and one red wall), giving the environment both geometric information (geometrically equivalent corners) as well as object-property information (the red wall). Once in the room, subjects watched as the experimenter hid an object in one corner of the room. They were then disoriented. After disorientation, the subjects were asked to relocate the object. The results showed that young children generally failed to make use of the object-property information and instead searched equally often in one of the two geometrically equivalent corners. This indicates a predisposition to rely solely on geometric information in cases of disorientation. However, adults and children older than 6 or 7 had no difficulty solving the tasks, presumably due to their use of both types of information. Hermer and Spelke next tried to identify factors predictive of subjects' success. They found that success was not directly correlated with age, nonverbal IQ, verbal working-memory capacity, size of vocabulary, or comprehension of spatial vocabulary. Rather, the only significantly correlated factor was the spontaneous use of spatial vocabulary conjoined with object properties (e.g., "It is to the right of the blue one"). Moreover, adults reported mentally rehearsing a sentence similar to "It is left of the red wall," to help them solve the task.[4]

3. Some have argued that the mind-reading system is what allows for content integration (Atran 2002; Nichols and Stich 2003). Alternatively, there might be a dedicated content-integration system.

4. A follow-up study showed that training in the use of "left" and "right" greatly improved the same subjects' performance (Shusterman and Spelke 2005).

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Previously, Carruthers had been optimistic that these findings suggested that their more developed language faculty is what enabled older children and adults to integrate domain-specific information in order to solve the task (2002). However, for various reasons, Carruthers's revised position (2006) is appropriately more skeptical of how much these results actually support the LACI hypothesis.[5] First, the sentence "It is left of the red wall" does not involve any geometric information; it only conjoins spatial information with object-property information. Therefore, the results do not demonstrate that language is integrating the output thoughts from geometric and object-property modules. What is more, these tasks can presumably be solved without entertaining any cross-modular thoughts by entertaining information sequentially: first focusing on geometric information to eliminate two of the possible corners and then using object-property information to decide between the remaining two. In fact, according to Carruthers, this is plausibly the method employed by chickens, monkeys, pigeons, and fish; all of which are capable of solving similar reorientation tasks despite their lack of language (Vallortigara, Zanforlin, and Pasti 1990; Kelly, Spetch, and Heth 1998; Gouteux, Thinus-Blanc, and Vauclair 2001; Sovrano, Bisazza, and Vallortigara 2002, 2005).

However, Carruthers does believe that these reorientation studies suggest that language plays a constitutive role in our practical reasoning processes (2006, 246–47). According to Carruthers, the fact that mentally rehearsing the sentence "It is left of the red wall" helps subjects to solve the task suggests that language is constitutive of our practical reasoning, which presumably makes frequent use of content integration. Furthermore, Carruthers believes that slightly altered versions of these studies could demonstrate that language is responsible for the generation of non-domain-specific thoughts. He suggests that subjects might be placed in a room with geometric properties more easily expressed in natural language, such as "the acute corner." Subjects could then simply rehearse sentences such as "It's in the acute corner near the red wall," in order to solve the task—and this sentence does contain concepts from both geometric and object-property domains (247).

Unfortunately, there are further reasons why the reorientation data do not provide support for the LACI hypothesis, and these reasons entail that the further studies suggested by Carruthers will not either. The problem is that correlations between success on a reorientation task and vocalization (or mental rehearsal) of sentences combining information from the relevant domains do nothing to show that language is responsible for generating cross-modular thoughts. Rather, we can explain the correlation

5. One problem is that if young children's attention was drawn to the red wall, they showed increased success without altering their linguistic capacities.

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by the fact that subjects who are disposed to have thoughts combining the information salient to the task will surely be found to more frequently vocalize or mentally rehearse language expressing those cross-modular thoughts. Classically construed, language is expressive of thought. Consequently, increased use of sentences that combine geometric and object-property concepts would suggest that a person is more frequently entertaining thoughts about those domains. Moreover, frequently vocalizing and mentally rehearsing the relevant cross-modular sentences suggests that an individual is more inclined to spontaneously draw associations between those domains. Therefore, we can always explain the correlation in the following way: using (i.e., vocalizing or mentally rehearsing) cross-modular language suggests that subjects are entertaining cross-modular thoughts, which in turn explains their success on the reorientation task. That is, entertaining more non-domain-specific thoughts is a common cause of using more non-domain-specific sentences and more probable success on the reorientation task, whether or not language is involved in the generation of those thoughts. Therefore, correlations between spontaneous vocalization or mental rehearsal of sentences combining the relevant domains and successful reorientation task performance can always be explained in this way, regardless of where content integration is taking place. Consequently, even if the same types of correlations were found in future studies, this still would not show that language is responsible for generating cross-modular thoughts. The correlations are just what we should expect if content integration is performed elsewhere.

Nevertheless, we do require an explanation of why rehearsing natural language sentences appears to help us solve practical reasoning tasks. Does this require that language play a constitutive role in generating cross-modular thoughts during practical reasoning? No, it does not. These observations can be explained by the fact that contemporary human language—and thus our language faculty—routinely employs certain inferences capable of generating cross-modular thoughts. Contemporary human language routinely makes use of inferences that result in concept-integrated sentences. Therefore, it is plausible to assume that whenever (or usually when) the subsystems of the language faculty are activated so too is the system responsible for the forms of inference employed by the language faculty. This process can be actualized in one of two ways. Either the language faculty is responsible for drawing its own inferences, or it makes use of an external system capable of performing the required inferences. However, regardless of which realization is true, rehearsing natural language sentences will likely be beneficial in many problem-solving tasks. This is because employing the subsystems of the language faculty presumably "turns on" the content-integration system as well. Therefore, we should expect this strategy to be useful as long as rehearsing natural

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language sentences "turns on" a system whose inferences are responsible for generating cross-modular thoughts, regardless of its location.[6]

3.2. Shadowing of Speech. The other source of evidence cited by Carruthers is a study conducted by Hermer-Vazquez, Spelke, and Katsnelson (1999) in which subjects were asked to solve the same types of reorientation tasks, except that they were now asked to simultaneously shadow speech (i.e., repeat back what they heard through headphones). In another trial, subjects were asked to shadow rhythm with their hands while attempting the same task. The results showed that shadowing of speech was highly disruptive to subjects' ability to solve the task, whereas shadowing of rhythm had relatively little effect. A subsequent experiment showed that shadowing speech did not disrupt subjects' ability to use geometric information or object-property information independently. According to Carruthers, these results suggest that language is required for adults to use content from the two domains (2006, 245).[7]

These results, however, are once again perfectly consistent with the alternative hypothesis that content integration takes place outside of the language faculty. Recall that in using the subsystems of our language faculty we will presumably be making use of the (or a) content-integration system. Consequently, it is reasonable to assume that shadowing of speech is sufficient to activate the content-integration (i.e., inference) system used by natural language, thereby making it less available for use in other tasks.[8] If this is correct, then we should expect speech shadowing to disrupt our abilities to integrate content in certain ways even if the language faculty is not directly responsible for performing that task. That is, we should expect the disruption regardless of where content integration takes place. The shadowing of rhythm, however, does not employ content integration, and, thus, we should not expect it to cause any interference. Therefore, once again, the results are predicted equally well by the hypothesis that content integration is performed outside of the language faculty.

6. Of course, language might be employed during practical reasoning for reasons apart from content integration. However, other roles for language will not provide support for Carruthers's LACI hypothesis. I only wish to contend that if language is employed for content-integration purposes, the language faculty is not required to perform any content integration itself.

7. It is worth noting that entertaining information sequentially would appear to be sufficient for solving these tasks as well.

8. Even though subjects will not be consciously processing the content, they will employ the language faculty, which in turn will presumably activate the content-integration system(s).

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4. Evidence Contrary to the Strong-LACI Hypothesis. I turn now to empirical evidence that suggests that the strong-LACI hypothesis is false. Much of what follows relies on the following assumption: if the strong-LACI hypothesis were true (i.e., if the operations of the language faculty were constitutively involved in the generation of all cross-modular thoughts), then in the absence of a functioning language faculty we should expect other systems believed to make use of cross-modular thoughts to be detrimentally affected. Instead, we find that aphasics whose language faculties are severely damaged are still able to use these other systems quite effectively. Furthermore, aphasics appear to retain the ability to use inferences identical to those licensed by natural language, despite the loss of a functioning language faculty.

First, Rosemary Varley and her colleagues have studied an aphasic man (S. A.) who has lost almost all of his linguistic capacities (Varley and Siegal 2000; Varley, Siegal, and Want 2001; Varley 2002). S. A. displays impairment across input and output processing modalities in sentence parsing and verb comprehension. In fact, unlike most aphasics, S. A. has apparently lost nearly all of his grammatical capabilities.[9] Amazingly, however, S. A. is still capable of performing at a high level on casual-reasoning tasks and is able to attribute false beliefs to other individuals. S. A. performed at near perfection on three different sets of false-belief tests and scored perfectly on all causal-reasoning tests.[10]

Important for our discussion, the mind-reading system used in false-belief tests is believed to use inferences similar to those Carruthers cites as capable of generating cross-modular thoughts. For instance, it is believed that attributing false beliefs requires the ability to embed false propositions into slots within true statements (e.g., MARY KNOWS THAT JOHN (FALSELY) THINKS THERE IS CANDY IN THE BOOK; Astington and Jenkins 1999). If this is correct, then the results demonstrate that S. A.'s mind is capable of employing inferences used by natural language, despite his severely damaged language faculty. This suggests that the language faculty is not the exclusive resource for performing inferences that could generate cross-modular thoughts.

Furthermore, being able to employ a human's 'theory of mind' at least sometimes involves entertaining cross-modular thoughts since our conspecifics are capable of having cross-modular beliefs and desires. For example, the mind-reading system might entertain the thought MY

9. On both spoken and written production and comprehension tasks, S. A. performs at chance.

10. For example, S. A. was shown a picture of a car crash and three possible causes, an alcoholic drink, a helicopter, and an ax. On 15 tests, S. A. correctly pointed to the most likely cause of the event.

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BROTHER KNOWS THAT JOHN FALSELY THINKS THAT HE *CHEATED* ON THE TEST, which would plausibly integrate content from kinship and cheater detection modules. Additionally, the causal reasoning system—which connects events with their likely causes—is also likely capable of using thoughts with cross-modular content (e.g., MY *BROTHER'S* GRADES CAUSED HIM TO *CHEAT* ON THE EXAM). What these results show is that the loss of a functioning language faculty appears to have little effect on the operation of these systems. Therefore, the results at least tentatively suggest that the language faculty is not vital for the high functioning of those systems despite their employment of cross-modular thoughts.

Moreover, studies involving subjects with primary progressive aphasia (PPA) suggest that other central systems that employ cross-modular thoughts are largely preserved when the language faculty is damaged. PPA subjects showed preserved capabilities for various forms of practical reasoning despite the gradual loss of language capabilities (Wicklund, Johnson, and Weintraub 2004). However, it is unclear whether subjects are using cross-modular thoughts when performing these tasks.

In addition, studies by Varley et al. demonstrate that agrammatic aphasics are also able to retain their capacities for various mathematical inferences often claimed to require the resources of the language faculty (2005). Agrammatic aphasics showed preservation of the ability to perform mathematical procedures involving recursiveness and structure-dependent operations (e.g., solving problems involving brackets). Both of these operations are believed to be features of natural language syntax. These results suggest that either the systems for language and mathematics have independent access to the same inference system or each has its own inference system. More conclusively, these results suggest that the inferences Carruthers attributes to the language faculty are sometimes performed outside of the language faculty. Therefore, even if the language faculty can execute the required inferences, it is unclear why we should think that the language faculty is constitutive of the generation of all cross-modular thoughts.

The empirical evidence surveyed here is insufficient to conclusively rule out the strong-LACI hypothesis. However, the evidence does recommend that the strong-LACI hypothesis is simply too strong to be likely to be true. The data suggest that the loss of a functioning language faculty does not disrupt other cross-modular systems, and the inferences used by natural language are not always performed within the language faculty. Furthermore, these conclusions provide some motivation for doubting the weak-LACI hypothesis as well. Regrettably, however, providing empirical evidence directly concerning the weak-LACI hypothesis is currently extremely difficult. First, it is difficult to devise tasks that require a specific

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class of content-integrated thoughts. Second, it is difficult to pinpoint precisely where content integration is taking place.

In sum, then, Carruthers's data are unable to support either version of the LACI hypothesis. Furthermore, the empirical evidence presented in this section provides reasons for believing that both versions are false.

5. Additional Theoretical Considerations. I turn now to some more theoretical arguments concerning Carruthers's LACI hypothesis. First, Carruthers argues that there are straightforward reasons for the language faculty to have developed the means to generate content-integrated thoughts. Language presumably integrates sentences so as to express them faster. As Carruthers puts it, "There *is* good reason to think that the content-combining functions *will* come for free with the language module, given the constraint of speed of sentence-production" (2006, 249). Therefore, Carruthers contends, the advantages of faster communication provide reasons for thinking the language faculty would have developed the ability to integrate content.

Carruthers is certainly correct that some types of integration are extremely useful for communication. However, content integration is a useful tool for numerous other central systems, as well as the mind in general. Numerous central systems, many of which provide significant survival advantages (e.g., memory, mind reading, practical reasoning) benefit greatly from their employment of various forms of content integration. Therefore, each of these other systems would have analogous reasons to have evolved its own content-integration systems. In addition, content integration provides benefits to the mind in general. For one thing, a mind capable of content integration will be more efficient since fewer resources will be required to process and store information when it can be condensed in content-integrated ways. These considerations suggest that the selection pressures in favor of a content-integration system would have been strong and multifaceted. Although it is advantageous to be able to communicate the content of two thoughts within a single sentence, it is more advantageous to be able to generate content-integrated thoughts that can be used by various central systems and minimize processing and storage costs. Therefore, it is likely that a system dedicated to content integration would have evolved—or at the very least, Carruthers's story makes it no more likely that content integration would have evolved within the language faculty than in any other system that benefits from the employment of content integration.

What is more, it is unclear why the language faculty would have any reason to generate thoughts with integrated content. Presumably, merely being able to form concept-integrated sentences would equivalently increase the speed of communication. Indeed, the ability to generate con-

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cept-integrated sentences is all Carruthers claims the inferences of the language faculty were selected for. It is then up to the comprehension subsystem of the language faculty to "pick up" those concept-integrated sentences and translate them back into thoughts with integrated content. But why should we think the language faculty has developed this bridge between its production and comprehension subsystems for the purpose of generating content-integrated thoughts? That is, there might be clear-cut reasons for the language faculty to have developed the ability to generate concept-integrated sentences. This, however, falls short of showing that there are reasons for thinking the language faculty would have developed the ability to generate content-integrated thoughts. Other systems, however, directly benefit from the employment of content-integrated thoughts and would, therefore, appear to have more straightforward reasons for having developed or co-opted the ability to generate those thoughts.

One final consideration: even if language first gave rise to a particular class of content-integrated thoughts, had a system exclusively dedicated to content integration arose it would presumably have been selected for. This is supported by the assumption that, in general, when two adaptive problems (e.g., language and content integration) are present, having two more specialized systems will be better than having a single more general solution. Along these lines, not having to occupy various central systems (e.g., language) in order to generate content-integrated thoughts would presumably provide survival advantages. Furthermore, content integration is employed by so many central systems that it would be beneficial to have one dedicated system rather than several distinct systems that would need to replicate many of the same processes. Therefore, we should plausibly expect the evolution of a dedicated (i.e., independent) content-integration system.

6. Conclusion. Proponents of massive modularity must explain how a pervasively modular mind can generate non-domain-specific thoughts by integrating the content produced by domain-specific modules. The above discussion demonstrates that Carruthers's empirical evidence provides no support for the hypothesis that the operations of the language faculty are constitutively involved in any content integration. Furthermore, there are empirical and theoretical reasons for rejecting both versions of the LACI hypothesis. Therefore, future research concerning how content integration is realized within a massively modular mind should be focused on systems external to the language faculty.

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