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Minds, Modules, and Meta-Analysis

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Wellman and colleagues' meta-analysis of performance on the false-belief task is methodologically useful, but it does not lead to any theoretical progress concerning the nature of the mechanisms that underlie the existence and development of "theory of mind." In particular, the results of this meta-analysis are perfectly compatible with "early competence" accounts that posit a specific, innate, and possibly modular basis for theory of mind. The arguments presented by Wellman and colleagues against such views stem not from their meta-analytic data, but from mistaken assumptions regarding the requirements of such theories (e.g., that there exist manipulations that improve performance only, or to a greater degree, in young children). Contrary to what Wellman and colleagues claim, their meta-analysis, while consistent with conceptual change, does not lend any new support for such theories.

INTRODUCTION

Many aspects of human behavior are the result of internal mental states such as beliefs and desires. Furthermore, as is well known, even young children perceive, interpret, predict, and explain the behavior of others in terms of their underlying mental states. The acquisition of such abilities—collectively referred to as a "theory of mind"—is early, universal (except in certain clinical populations), seemingly effortless, and largely dissociable from more general intellectual development. In adults, the exercise of such abilities is often irresistible and seemingly instantaneous. One hallmark of a mature theory of mind is the ability to reason about false beliefs: One can often successfully reason about true beliefs simply by considering the world itself as a proxy, but this heuristic fails in the case of false beliefs. As such, successful reasoning about false beliefs is a sufficient (although not necessary) criterion for the existence of a theory of mind (e.g., Dennett, 1978). It is precisely this ability that is tapped by the "false-belief task," wherein a child must infer that a protagonist will look for a target object where he mistakenly believes it to be, rather than looking in its actual location (Baron-Cohen, Leslie, & Frith, 1985; Wimmer & Perner, 1983; for a description and review, see Wellman, Cross, & Watson, 2001).

Of course, solving a false-belief problem also requires several other abilities that are not theory of mind specific, and the existence of theory of mind in young children is also indicated by many other types of experiment (see Bloom & German, 2000). Still, given the degree to which this single task has dominated developmental research on theory of mind, the meta-analysis conducted by Wellman and colleagues (2001) is extremely welcome. Furthermore, we agree that this analysis is methodologically useful: for example, it identifies several factors that, thus far, appear to play no substantive role in false-belief performance; it might be more permissible for future studies to ignore such variables (but see our final comment later). Aside from these methodological morals, however, this analysis, with one exception, does not lead to any theoretical progress concerning the nature of the mechanisms that underlie the existence and development of theory of mind. The one exception is that the meta-analysis confirms an important role for "executive processes" in false-belief performance, a finding that should encourage the "early competence" theorist. In any case, the results of this meta-analysis are perfectly compatible with early competence accounts that posit a specific, innate, and possibly modular basis for theory of mind.

In the remainder of this commentary, we discuss one such modular theory, and show how the arguments proffered by Wellman and colleagues against such views stem not from their meta-analytic data, but from mistaken assumptions about the requirements of such theories. We conclude by highlighting some of the general issues raised by this meta-analysis that actually favor modular theories over theories that invoke conceptual change.

THE MODULAR BASIS OF THEORY OF MIND

One early competence theory of theory of mind is the Theory-of-Mind Mechanism/Selection Processing (ToMM/SP) model proposed by Leslie and colleagues (e.g., German & Leslie, 2000, 2001; Leslie, 1987, 1994,

Commentary on Wellman, Cross, & Watson, "Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief."

2000a, 2000b; Leslie & Polizzi, 1998; Leslie & Roth, 1993; Leslie & Thaiss, 1992; Roth & Leslie, 1998; Scholl & Leslie, 1999; Surian & Leslie, 1999). The essence of this model is that theory of mind has a specific, innate basis. Each part of this claim is crucial. First, theory of mind has a *specific* innate basis in that the essential character of theory of mind is determined by specialized mechanisms deploying specialized representations that do not apply to other cognitive domains, and that can, therefore, be selectively impaired. In the limit, the origin of theory of mind may be a cognitive module (for a recent discussion of the relation of modules to development, see Scholl & Leslie, 1999). This contrasts with the "theory-theory," in which the processes underlying theory of mind are simply general processes of theory or knowledge formation (i.e., general induction), and are presumed to be the same as those employed in scientific reasoning (e.g., Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1994).[1]

Second, theory of mind has a specific *innate* basis in that the essential character of theory of mind—including the concepts of belief, desire, and pretense—is part of our genetic endowment, which are triggered by appropriate environmental factors, much as, for example, is puberty. In Wellman's terminology, that is what makes this view a type of early competence theory. However, it is worth noting the possibility that the concept belief is triggered relatively late, around 4 years of age, rather than early, around 3. This is entirely consistent with our general view, just as it is consistent with the theory-theory view that the child discovers the representational theory of belief early rather than late. The controversies remain, even if the ages are different.

Finally, the ToMM/SP model's claim is not that the entirety of theory of mind is modular, but rather that theory of mind has a specific innate *basis*. That is, this theory is intended primarily to capture the origin of theory of mind abilities, and not the full range of mature activities that may employ them. Clearly the totality of theory of mind is not modular, any more than the totality of perception is modular. In each case the interesting question is whether a significant part of such a capacity has a modular origin. This appears to be the case with "early vision" (see Pylyshyn, 1999), and it seems equally likely in the case of "early theory of mind." Consistent with this modular view, theory of mind acquisition is universal and follows a consistent timetable, and the interpretation of people in terms of their underlying mental states appears to be fast and irresistible. In addition, theory of mind ability is subject to specific neuropsychological impairments (e.g., Baron-Cohen et al., 1985; Langdon & Coltheart, 1999), is resistant to others (Varley & Siegal, in press), and recruits specific brain structures (Frith & Frith, 1999).

The ToMM/SP theory has two parts. The first, ToMM, is essentially a module that spontaneously and postperceptually processes behaviors that are attended, and computes the mental states that contributed to them. In doing so, it imparts an innate concept, belief, which is thereby available to a child long before other abstract concepts are acquired via general theory construction. Leslie and Thaiss (1992) introduced the idea that ToMM by itself has limited powers that need to be supplemented in certain situations if the child is to select the correct content for mental states; in particular, if the child is to select the correct content of beliefs that are false. They dubbed this supplemental processing, Selection Processing (SP). SP was conceived to be a general executive process required in many situations to inhibit salient but unwanted responses. (Although Wellman and colleagues discuss such inhibition in a section on Executive Function, they discuss the ToMM/SP theory in a separate section and thus appear not to recognize that executive function is also a crucial feature of the ToMM/SP theory.) The theoretical idea behind the ToMM/SP model is that ToMM automatically attributes beliefs with contents that are true. This default or best-guess strategy is thought to reflect the fact that a person's beliefs *ought* to be true and, indeed, typically *are* true. The strategy thus represents an optimal design for default attributions that should have been favored in the evolution of ToMM and that plausibly form the initial state of this cognitive mechanism. However, it does so at the cost of producing a prepotent response, which, in false-belief situations, needs to be inhibited. Thus, in the false-belief task, in order to compute the content of the protagonist's belief about the location of the target object (a job for ToMM), the child must first inhibit ToMM's initial response based on the target's salient actual location (a job for SP). Recently, Leslie and Polizzi (1998) have published two distinct models that develop the ToMM/SP theory in greater detail.

The ToMM/SP model has given rise to the following theory of normal and abnormal development.

[1] It has been suggested to us that some theory-theorists might be happy with the idea that theory of mind rests on a modular basis, which then provides a specialized database for general "theorizing" processes to work on. If so, there would be little disagreement between us. However, this type of view is not consistent with the idea of "theories all the way down"—an idea that Wellman and others have advanced. It is crucial to distinguish mechanisms that may be theorylike from knowledge of something that really is a theory (see Leslie, 2000a for an extended discussion on this point).

ToMM is thought to be specifically impaired in autism (Baron-Cohen, 1995, 2000; Frith, Morton, & Leslie, 1991; Happé, 1995; Leslie, 1987, 1991, 1992); for this reason autistic individuals fail the false-belief task despite intact selection processing. By contrast, normally developing 3-year-olds have an intact ToMM, but fail the false-belief task because of immature selection processing. The critical aspect of this difference is that autistic individuals have an impairment that is specific to theory of mind, whereas 3-year-olds have a domain-general impairment of inhibitory control. Experimentally, this contrast has been supported by demonstrations that autistic individuals, but not 3-year-olds, easily pass exact analogues to the false-belief task that do not employ theory of mind (e.g., false photographs and maps); whereas 3-year-olds, but not autistic individuals, can be aided in false-belief tasks by manipulations that decrease the need for inhibition (for a summary of these experiments, see Leslie, 2000b). As Roth and Leslie (1998) recognize, subtly different versions of this general thesis are possible. For example, selection processing may itself come in different "flavors" depending on the task (e.g., ToMM may have its own on-board selection processing rather than drawing on a selection-processing resource that is entirely general across domains).

Wellman and colleagues (2001) lump the ToMM/SP theory in with several other variants of what they call early competence theories, and maintain that the results of their meta-analysis are "completely inconsistent" with such views. We completely disagree. In fact, for the reasons discussed in the next sections, the results of the meta-analysis are entirely consistent with both early competence views and conceptual change accounts.

MODULAR VIEWS DO NOT REQUIRE ABOVE-CHANCE PERFORMANCE IN YOUNG CHILDREN

Wellman and colleagues argue that in order to confirm early competence theories, some task manipulations must be found that yield above-chance performance on the false-belief task for even young children. Since such performance was not observed in the meta-analysis, even in the best-effects model, Wellman et al. take early competence models to be disconfirmed. We agree that above-chance performance at young ages would tend to support early competence models. However, the inverse is simply not true. In fact, from an early competence viewpoint, there are many reasons why young children might still fail, despite being given a package of helpful task manipulations. We highlight two such reasons.

First, it might simply be the case that the particular task manipulations considered in the meta-analysis did not sufficiently attenuate the need for inhibition by immature selection processing. Moreover, inhibitory control may not be the only limiting performance factor; future research may well uncover new such factors. There may even be no combination of manipulations that makes the task easy enough for 3-year-olds to perform above chance. Even if this is the case, unless one is simply going to *define* the concept belief as the passing of a given task and thus trivialize a serious empirical issue, the 3-year-old may still have the concept. As Bloom and German (2000) stress, the false-belief task is intrinsically difficult for a host of reasons (many not specific to theory of mind), and reasoning about false beliefs is much harder than, for example, simply recognizing that beliefs can be false. It is for this reason that passing a standard false-belief task is sufficient *but not necessary* for demonstrating that a child has the concept belief.

Second, even when only theory of mind-specific factors are considered, it is still not the case under a modular theory that theory of mind competence be in place from birth, any more than puberty (or mature visual processing) must be in place from birth. The ToMM module itself may still require environmental triggering and tuning to mature. Furthermore, there is nothing in the notion of modularity that prevents even matured modules from learning and developing. Modularity is primarily defined in terms of restrictions on informational access (see Fodor, 1983), and it is perfectly consistent with this idea that the processes inside the module develop on the basis of their limited input (Scholl & Leslie, 1999). In sum, modular theories are in no way "antidevelopmental," as Wellman has claimed in the past (Gopnik & Wellman, 1994, p. 283). This is a common misconception and a source of unnecessary heat in many discussions. Modules are distinguished by how they develop, not by the fact that they don't develop. Although there is more we could say, the above two reasons suffice to establish that modular early competence theories impose no requirement that extremely young children be able to pass false-belief tasks at above-chance levels.

MODULAR VIEWS DO NOT REQUIRE THAT TASK MANIPULATIONS HELP ONLY YOUNG CHILDREN

Wellman and colleagues (2001, p. 672) also impose the following requirement on early competence theories: there must be some task manipulations that improve performance on the false-belief task *only* in younger children, or at least provide *more* improvement in

younger than in older children: "this requirement derives from the essential claim that . . . task factors mask *early* competence, thereby artifactually producing apparent *developmental* differences on the target tasks." Actually, we believe that changes in performance factors constitute *genuine* developmental effects, not just artifacts, and we strenuously resist the attempt of Wellman and colleagues to equate development exclusively with conceptual change. In the meta-analysis, several factors were found to improve performance—for example, having the actual target object absent (or at least not visible) at the test. Presumably, such manipulations improve performance by facilitating inhibition of the actual location of the target object (the true belief), thus reducing the load on selection processing. (For other recent demonstrations of such effects, see Carlson, Moses, & Hix, 1998; Leslie & Polizzi, 1998; Roth & Leslie, 1998; Surian & Leslie, 1999.) Wellman and colleagues stress, however, that none of these factors interacted in the allegedly required way with age; rather, they improved performance at all ages.

We agree that improvements only in young children might be required by some extreme versions of early competence theories, but we also think such theories are obvious strawmen. In the ToMM/SP theory (which Wellman and colleagues explicitly cast as an early competence theory), this requirement clearly does not apply. At any age at which at least some children are failing the false-belief task, various manipulations should improve performance by facilitating inhibition of the actual location of the target object. Moreover, the more likely disparity would involve greater improvement in older children, who enjoy more matured selection processing, and therefore require less facilitation of inhibition to pass the false-belief task. To make this concrete: suppose that passing some version of the false-belief task requires that 10 units of inhibition be exerted via selection processing. Children at age 3,0 can by themselves muster only 5 units of inhibition, whereas children at age 3,6 can supply 7 units, and children at 3,11 can supply 9 units. Now suppose that some task manipulation is introduced that reduces the demand for inhibition by 2 to 3 units. Clearly, on this model, it is the older children who will reap the largest benefit until ceiling effects kick in. Far more complex models of the interaction between competence, performance, and age are of course possible. These possibilities will have to be investigated by seeking to actually quantify executive functioning and other performance factors. Further serious open-minded research is very much required.

The selection-processing model predicts not only that older children will tend to be helped more (aside from ceiling effects) for a fixed amount of help with inhibitory processing; it also predicts that the ability to solve false-belief tasks will continue to increase right through age 5 and beyond. Thus, the fact that 4-year-olds show better-than-chance performance is not to be read as "they have reached the end of the line developmentally" as fans of conceptual change would believe. We have known for 15 years, ever since Perner and Wimmer (1985) showed that 4-year-olds typically fail second-order false-belief tasks, that there must be performance-related development in false-belief processing after 4 years of age, because their failure cannot be due to lack of the concept belief or lack of a "representational theory." More recently, German and Leslie (2001) showed that 4- and even 6-year-olds typically fail a false-belief task requiring an inference from lack of generic knowledge. Finally, Leslie and Polizzi (1998) and Cassidy (1998) showed that 4-year-olds perform above chance in the standard false-belief task only as long as the protagonist's desire is to approach the target object. If, instead, the desire is to avoid the object, the 4-year-olds show a 3-year-old level of performance, with fewer than 40% passing. The conclusion that Leslie and Polizzi drew from this striking finding is not that 4-year-olds lack the concept belief; instead, they argued that a false-belief + avoidance-desire task demands much more complex inhibitory control.

In sum, early competence views do not require targeted improvement only in younger children, and if anything, they predict the opposite pattern of results. There clearly are developmental processes in theory-of-mind and false-belief reasoning that go beyond 4-year-old success on standard tasks and that have nothing to do with conceptual change. These developments can all be given a detailed account within a modular early competence theory.

CONCLUSION: WHY FAVOR A MODULAR THEORY OF THEORY OF MIND OVER CONCEPTUAL CHANGE?

In both of the arguments discussed above, the alleged theoretical implications of Wellman et al.'s meta-analysis stem not from their data, but rather from mistaken theoretical assumptions. When these assumptions are dispatched, we find that the results of the meta-analysis are perfectly compatible with at least one view labeled by Wellman et al. as an "early competence" theory. Their meta-analysis of the false-belief task may be methodologically useful, but it does not lead to any theoretical progress concerning the nature of the mechanisms that underlie the existence and development of theory of mind.

Still, this meta-analysis does highlight some useful comparisons between modular theories of theory of mind and the conceptual change view favored by Wellman and colleagues. According to this competing view, theory of mind development involves a fundamental change in how children conceive of people and their behavior. Prior to age 4, children fail the false-belief task because they have no concept of belief; after age 4, when this concept is acquired, they pass the false-belief task. The content of this concept—which is typically thought to embody a bona fide theory of belief (e.g., Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1994; Perner, 1995)—does not simply mature in the child, but is learned from scratch (or nearly so) via interaction with the environment. Furthermore, the processes that drive this acquisition are considered to be completely general; in fact, they are thought to be the same processes involved in theory construction in science (e.g., Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1994). (For extensive discussions on why such views are misguided, see Carey & Spelke, 1996; Leslie, 2000a; Stich & Nichols, 1998.) As Wellman and colleagues stress, this theory is consistent with the results of the meta-analysis. We agree, of course, but this conclusion was virtually preordained, since the only pattern of results inconsistent with conceptual change is one wherein children's performance on these tasks does not improve with age (which, of course, it does). Given the expected robust effect of age in all of the meta-analytic results, no pattern of effects regarding the many other variables could disconfirm the conceptual change view.

This point highlights an important contrast between modular theories and theory-theories. Both views are consistent with the universality of theory of mind acquisition; its consistent timetable; the fast, effortless, and often irresistible computation of the mental states underlying behavior, and so forth.[2] The modular theory *must* predict these features, however, whereas the conceptual change theory is also equally consistent with nonuniversal acquisition, a wildly variable timetable, effortful and voluntary operation, and so forth. Ironically, this makes the ToMM/SP model a stronger *theory* than the theory-theory. To highlight this excessive flexibility in conceptual change stories, consider the strongest prediction that Wellman et al. are able to muster on their behalf in the context of the meta-analysis: "performance on [the false-belief task and related tasks] must change from incorrect to systematically above-chance judgments with age." In other words, this view makes the single daring prediction that children should get better as they get older! Surely, however, a meta-analysis was not required to uncover the truth of such development, which is perhaps the single prediction that is common to all theories of theory of mind!

Wellman et al. conclude "the meta-analysis suggests that an important conceptual change is taking place between the ages of 2½ and 5 years in children's understanding of persons" (p. 673). We disagree: what it demonstrates is just what we knew all along—that there is an important change that takes place between these ages regarding the ability to compute the mental states that underlie behavior. The burning question is what is driving this change. We have argued here that Wellman et al.'s meta-analysis is silent on such issues, that at least one early competence view is perfectly consistent with the outcome of the meta-analysis, and that several other factors favor modular theories of theory of mind over theories that appeal to an unconstrained notion of conceptual change.

Finally, the meta-analysis conducted by Wellman et al. will undoubtedly attract a great deal of attention, and may well be appealed to as an authoritative statement on certain methodological issues in theory of mind. It would be tragic, however, if readers take away from it the conclusion that "the meta-analysis should lay to rest a great many questions about how task modifications enhance performance," and that research on false-belief performance can now be safely abandoned. Just consider the residual factor that Wellman and colleagues would like to think is accounted for by conceptual change. The statistical analysis tells us no such thing. It simply tells us that there is a pool of variance that is unlikely to be mere noise. What causal factors in the real world account for the variance—and indeed how many such factors are pooled in the term—is not determined by the meta-analysis. Should we really believe that such tough and important questions could possibly be laid to rest with a simple meta-analysis? Of course not! We conclude our commentary then with a plea to workers in this area to avoid such intellectual complacency and to continue, and indeed redouble, their efforts to understand the neurocognitive basis of theory of mind and its development.

[2] This is not to say that conceptual change stories are necessarily consistent with all aspects of theory of mind development. For example, the specialized nature of theory of mind, which is highlighted by the many studies involving autistic individuals (see Baron-Cohen, 2000), is naturally explained by modular theories, but sharply contrasts with the supposed domain-general nature of the cognitive processes underlying conceptual change.

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