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## What is embodied: "A-not-B error" or delayed-response learning?

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**Abstract:** The procedures used to ensure reliable occurrences of the A-not-B error distort and miss essential features of Piaget's original observations. A model that meshes a mental event, highly restricted by testing procedures, to the dynamics of bodily movement is of limited value. To embody more than just perseverative reaching, the formal model must incorporate Piaget's essential features.

All cognitive functions (e.g., perceiving, remembering, thinking and planning) may be subordinate to and derivative from the neural organization and control of movement (Sperry 1965). Thus, mental phenomena may be embodied in the neural dynamics of action. Thelen et al. have provided a formal model of a specific phenomenon (the A-not-B error) believed to reflect a mental event (a stage in the development of the object concept) that nicely integrates it with the domain of movement control. By critically reviewing the studies of this error, they were able to demonstrate how dependent the error is on the typical processes that influence the control of movement. Using that information, their model accounts for the apparent inconsistencies in the reported research and predicts new observations, some of which have been confirmed by subsequent investigation. Although I support the goal to embody mind, I am concerned that those procedures that ensure the occurrence of the A-not-B error miss or distort important aspects of the phenomenon.

In the 1960s and 1970s, those who tried live demonstrations of the Piagetian sensorimotor stages had difficulty finding infants who showed the A-not-B error. However, when the error occurred, it was striking. These demonstrations closely matched the procedure described by Piaget (cf., Gruber & Voneche 1977, pp. 259–60). An attractive toy would be taken from the infant and covered with the "A" cloth of the two cloths in front of the infant. If the infant retrieved the toy, it would be taken again and placed under the "A" cloth. On the third trial, the toy was placed under the second "B" cloth. The error occurred when the infant searched under the A cloth and not the B cloth. Once the error occurred, the infant's memory for sequential events would be assessed. A toy was placed under one cloth and after the infant retrieved it, the toy was placed under the same cloth; but before the infant could uncover it, it was removed and immediately placed under the second cloth. Again, the error occurred when the infant

removed the first cloth and did not search under the second cloth. Piaget described these errors as “the active search for a vanished object but without taking account of the sequence of visible displacements” (Piaget 1954, in Gruber & Voneche 1977, p. 257). The A-not-B error was a convincing but elusive occurrence in development until several procedures were created that ensured that a good proportion of infants between 9- and 11-months-old would perform the error. However, these procedures, so well described in Thelen et al., transformed the task into a delayed-response spatial learning task with the toy as the reward. Re-examination of Piaget’s original account (Piaget 1954, in Gruber & Voneche 1977, pp. 250–72) highlights the significance of this transformation.

Piaget argued that the infant conceives reality differently from the adult. His “experiments” were designed to identify these differences and to demonstrate how certain categories of mind (e.g., the object concept) are neither innate nor given ready-made in experience. Rather, these categories are constructed step-by-step from the infant’s actions. Actions define an object. Initially, the object concept does not include existence beyond the immediate engagement of infant’s actions. The infant will behave as though the object ceases to exist when it disappears from view. Eventually, the infant actively searches for an object that had disappeared no matter what the circumstances of the disappearance. Between these two extremes, Piaget observed that when the object disappears in two or more distinct places, the infant does not seem to track, conceptually, the sequence of the disappearances. Thus, the A-not-B error makes its appearance. Piaget reported that his daughter Jacqueline continued to search manually for a toy that she previously had found hidden under his hand when he placed the toy in plain sight but in a different place and even when she looked at the visible toy. To examine this error, Piaget created the prototypic task described above. Performance on this task together with several anecdotes about his daughter Lucienne defined a “stage four” object concept. For example, in response to the question Where’s papa? (posed while in the garden), Lucienne turned away from her father standing in front of her and visually searched the window where she had frequently seen her father whenever she and her mother were in the garden (p. 260).

Piaget offered three interpretations of these errors:

1. A defect of memory – the infant, as may the adult, forgot the sequential displacements of the object. However, why did Jacqueline seek a toy where she found it last when it was in plain view and she looked at it several times?
2. A defect of spatial localization – the infant’s spatial search strategy is first to search where the object is seen, or search where it was last seen, or search where the object was last found. Again, this interpretation fails to account for erroneous search when the object is in plain sight but in an unfamiliar location.
3. A defect of objectification – the object is only a salient as-

pect of the total context in which it is contained, including the infant’s actions and not a substantial, individualized phenomenon. There are “papa-at-the-window-when-in-the-garden” and “papa-in-front-of-oneself” or “toy-under papa’s hand and “toy on the table.”

Piaget argued that the three interpretations were complementary because “the object is not a thing which is displaced and is independent of those displacements; it is a reality at [the infant’s] disposal in a certain context, itself related to a certain action [of the infant]” (p. 264).

The end of this stage occurs when the child does not return to search a previously successful position A when the object has disappeared at position B, even when the object cannot be found at B. The “toy-in-plain-view” the “toy found-at-position-A,” and the “toy-hidden-at-position-B” have become the “same” toy. This compares well with Thelen et al. “there is only ‘knowledge’ of objects embedded in the immediate circumstances and the history of perceiving and acting in similar circumstances.” Missing from Piaget’s account are multiple reinforcements of successful retrieval from position A. He permitted only two such successes so

as to avoid habit formation. Also missing is any notion of a delay between hiding and retrieval. Indeed, Piaget stated that “at the moment when the [toy] disappears in B [Jacqueline] turns to her left side and looks where it was before, in A” (p. 260). So, will the simulation show a search at A after only two successes and no delay? Will it “search” at A when the desired toy is in plain view but in a different location? Will it “follow” a sequence of disappearances? Will it stop searching when the toy is not found at B or will it return to A? Too much of what defined the infant’s performance as the development of the sensorimotor embodiment of a “concept” is missing from just those operational procedures needed to ensure that a reliable proportion of infants will make the error at the time of testing. Concepts may only be movement dynamics but the complexity of such dynamics should not be hidden by the constraint of the testing procedure.