Multiple-step actions in infancy - a model of reaching in sequences

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Human actions are always part of a larger context: When adults for instance reach for a cup, they might do so to bring it to the mouth. Similarly, an infant might reach for a toy to manipulate it or to throw it somewhere. Here, we propose a novel model aimed at describing these real-world, multiple-step actions by the example of reach-to-place in infancy (n = 61 18-month-olds). At this age, action capacities, the related kinematics, and the neural representations of the related limb dynamics are intensively developing.

Previous research demonstrates that infants and adults plan their actions across multiple steps. They adjust, for instance, the velocity of a reaching action depending on what they intend to do with the object once it is grasped. Current models (e.g., Fitts law) target single, isolated actions, as for example pointing to a target. Here, we develop and empirically test a more ecologically valid model of multiple-step action planning: Infants took part in a reach-to-place task and their reaching and placing durations were measured with a motion-tracking system. Our model with three significant predictors (goal size: $b = .29$, $p < .001$, goal distance: $b = .12$, $p = .002$; reaching duration: $b = .35$, $p < .001$) explained the highest variance in placing duration, $F(3, 296) = 19.53$, $p < .001$, and outperformed six previously suggested models, when using model comparison. We show that including parameters of the first action step, here the duration of the reaching action, can improve the description of the second action step, here the duration of the placing action.

This suggests that the steps in action sequences are more complexly related than previously assumed: It appears that infants not only adjust their reaching speed to upcoming action demands, as suggested by feed-forward models. Infants' later action steps are also influenced by the speed of previous action steps, which suggests additional carry-over effects, when infants carry out multiple-step actions. This move towards more ecologically valid models of action planning provides an updated way to quantify motor learning by the time these abilities develop, which might help to assess performance in typically developing human children.