Temporal dynamics in infantile multimodal word and action learning

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Word-object and action-object understanding is an important milestone in development and central to social interaction (Gogate & Hollich, 2010). In their natural learning environment, children are often presented with information from multiple modalities at a time (i.e., actions and words for objects, "*multimodal settings"*) and might be able to simultaneously learn to associate both actions and words with objects. Such multimodal settings reveal different patterns of learning of word- and action-object associations relative to unimodal settings (e.g., Eiteljoerge et al., 2019), where children are solely presented with words or actions and objects. Here, first, we investigate how word learning occurs in such multimodal environments and second, we explore what factors influence early word learning when children are presented with information from multiple domains. For instance, stimulus synchronicity (i.e., momentary alignment of two stimuli) has been shown to boost learning in the early stages of development (Gogate, 2010). We hence examine how the temporal alignment of stimuli from different domains may influence learning in multimodal settings, while controlling for individual differences in children's word- and action-learning success at 12- and 24-months. During familiarization, children will be trained on word- and action-object mappings as they are presented with two novel objects, each associated with a novel name (e.g., "Oh, a Tanu!") and an arbitrary action (e.g., a hand rotates the object around its axis). Half of the children will experience word-action-object presentations synchronously, and the other half in a sequential manner. In a following test phase, first, children's looking patterns to the target object (upon seeing the associated action being performed on a control object or hearing its associated label) will serve as an index of learning of the word- and action-object mappings. In a consecutive violation of expectation task, changes in children's pupil dilation will be compared across word- and action-object match trials (i.e., children see previously associated action being performed on the now familiar object) and mismatch trials (i.e., children see other action being performed on the now familiar object). Increased pupillary dilation during mismatch trials relative to match trials would indicate learning of the word-action-object associations. Power analyses (simr package, Green & MacLeod, 2016) revealed 90% power to detect a difference between conditions (effect size = .54) with a sample size of 39 children per condition and age group. Growth curve models will estimate change in children's looking behavior within word-object and action-object trials. Temporal synchronicity, cognitive and language measures will be included as covariates to examine the extent to which they predict children's learning of word-object mappings. We expect learning of the word- and action-object mappings to be stronger in children who experienced these associations in a synchronous manner relative to children who experienced multimodal input sequentially, and more so for younger children (e.g., Gogate, 2010) and when cognitive and language scores are high. Additionally, this study will offer methodological insights on how in-the-moment recognition of previously experienced multimodal information can be quantified using two different experimental tasks to observe word-action-object associative learning. Systematic patterns of word-object learning in a multimodal setting will hence allow us to identify factors underlying word learning in early development.

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