Individual Differences in Intersensory Processing Efficiency for Dynamic Events Predict Infant Language and Cognitive Functioning

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BACKGROUND & MOTIVATION

Selecting and integrating perceptual information across sensory modalities form the building blocks for cognitive, social, and language development (Bahrick & Lickliter, 2012, 2014). Intersensory redundancy—stimulation that is temporally synchronized across sense modalities—promotes unitization of multimodal events (e.g., binding together the sights and sounds of a person speaking). Selectively attending to unified multimodal events, in turn, provides a meaningful basis for perception, learning and memory. However, early intersensory processing abilities have historically been studied at the group level, limiting assessments of individual differences and their relations with cognitive, social, and language abilities.

We have developed the Intersensory Processing Efficiency Protocol (IPEP), a fine-grained measure of the efficiency (speed and accuracy) of intersensory processing, opening the door to investigating early individual differences and their relations with outcomes (Bahrick et al., 2013, 2014). The purpose of the present study was to investigate relations between intersensory processing efficiency and standardized measures of cognitive and language development in infancy.

In the IPEP, participants must locate an acoustically-synchronized target event amongst five competing visual distractors—simulating the "noisiness" of the natural environment. Previous work revealed that the frequency of locating and attending to targets increases from infancy through childhood (Bahrick et al., 2013). Faster target selection is associated with greater accuracy in the first year (Bahrick et al., 2014).

METHOD

Forty-two 6-month-old infants were tested with the IPEP while their visual fixations were recorded using a Tobii X120 eye-tracker, after a 5-point calibration.

Infants saw a 2x3 grid (*Figure 1*) of dynamic social events (six women reciting different stories) and nonsocial events (six objects striking a surface in different temporal patterns) on separate blocks of trials, for a total of 48 trials. Each trial lasted 8s, with an accompanying soundtrack synchronous with only one of the six events. Useable eye-tracking data across all trials was M=68% (SD=15.7).
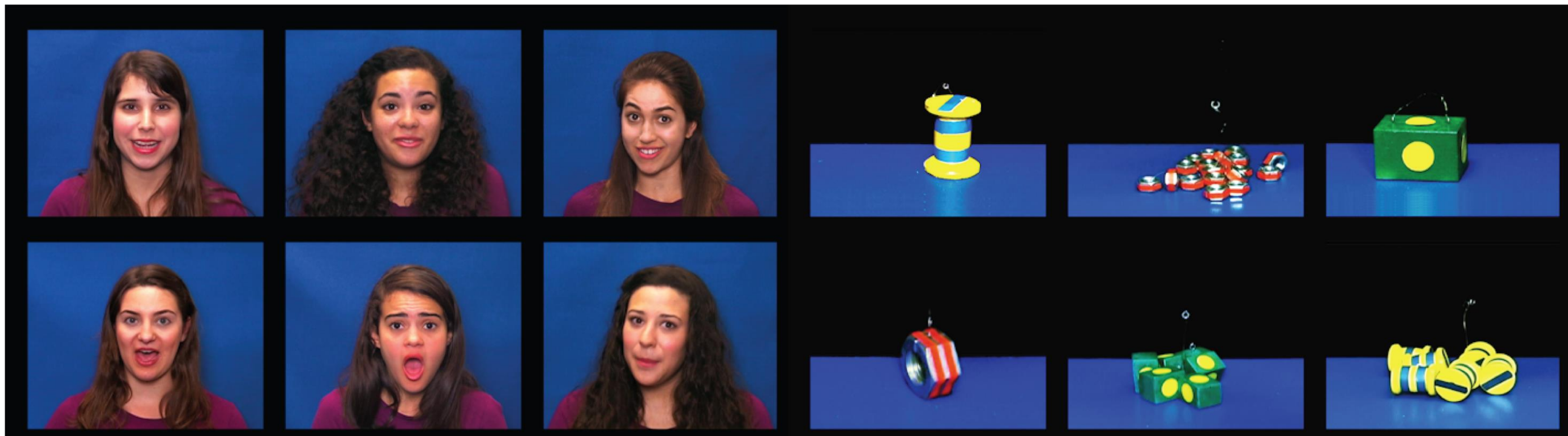

Figure 1. Static image depicting the dynamic social (left) and nonsocial (right) events shown to the infants in the IPEP.

These same infants were administered the Mullen Scales of Early Learning (MSEL; Mullen, 1995). Infants scoring ≥3 SDs below the group mean for visual reception (N=4) and receptive language (N=1) were removed from analyses involving their MSEL scores.

RESULTS: INTERSENSORY PROCESSING EFFICIENCY (ACCURACY & SPEED)

Accuracy-intersensory selection: Infants found (visually fixated) the synchronous target event on 48.2% (SD=11.8) of the trials for social events and on 60.4% (SD=13.5) of the trials for nonsocial events. Frequency of fixating the target event was significantly greater for nonsocial than social events, $t(41)$=4.22, $p<.001$.

Accuracy-intersensory matching: At 6-months, infants looked for a marginally longer proportion of time at the target when it was in sound than when it was a silent distractor for nonsocial events (M=.013, SD=.04), $t(41)$=1.85, p=.07, but not for social events (M=.002, SD=.05). However, intersensory matching did not reliably differ between social and nonsocial events, $t(41)$= 0.93, p=.4.

Speed-intersensory selection: On average, infants took M=2.73 s (SD=0.89) to fixate the target on social trials and M=2.91 s (SD=0.66) on nonsocial trials. These means did not differ significantly.

RESULTS: INDIVIDUAL DIFFERENCE RELATIONS BEWEEN INTERSENSORY PROCESSING EFFICIENCY & COGNITIVE AND LANGUAGE FUNCTIONING

Figure 2 presents individual relations between measures of accuracy on the IPEP and T scores on the MSEL for visual reception and receptive language. Replicating our previous individual difference results, infants who found the target on more trials (accuracy-intersensory selection) also attended to the target for a greater proportion of time (accuracy-intersensory matching) for both social and nonsocial events, rs>.41, ps<.008 (*Figure 2A*).

Moreover, intersensory selection and matching (overall across both social and nonsocial events) were positively correlated with visual reception T-scores on the MSEL, rs>.33, ps<.04 (*Figures 2B-C*), and intersensory selection predicted receptive language T-scores, r=.41, p=.018 (*Figure 2D*). In all relations reported, the mean number of events that individual infants fixated per trial was controlled, and thus differences in the speed of visual foraging across infants did not bias results. In contrast with accuracy, speed to locate the target event did not reliably predict outcomes at 6 months of age. Frequently locating and attending to the sound-synchronized events predicted object tracking and retrieval (visual reception) and responding to and following a social partner (receptive language) in this naturalistic assessment.
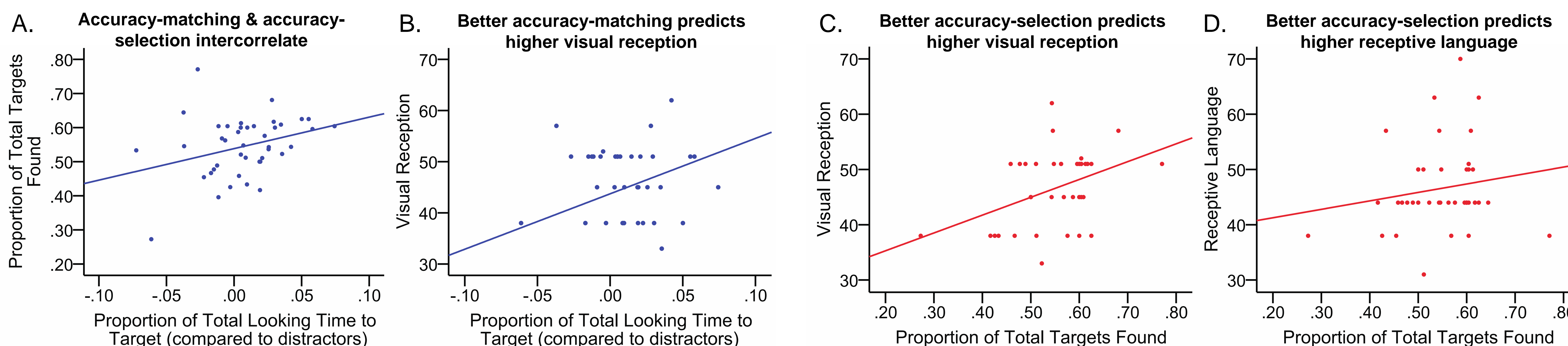

Figure 2. Relations for individual infants between (A) accuracy-selection and accuracy-matching on the IPEP, (B) accuracy-matching on the IPEP and visual reception on the MSEL, (C) accuracy-selection on the IPEP and visual reception on the MSEL, and (D) accuracy-selection on the IPEP and receptive language on the MSEL. Lines represent linear regressions.

CONCLUSIONS

The IPEP provides a fine-grained, individual differences measure of intersensory processing efficiency, sensitive enough to reveal relations with cognitive, social, and language skills. The present results are among the first to indicate that accuracy of intersensory processing is associated with language and cognitive functioning in infancy—consistent with the view that intersensory processing lays the foundation for higher-level learning. In conjunction with prior studies indicating compromised language and intersensory processing skills in children with autism (Todd et al., 2014), the IPEP holds promise for differentiating typical from atypical developmental trajectories.

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