Individual Differences in Intersensory Processing Predict Executive Functioning and Preliteracy Skills

FLORIDA INTERNATIONAL UNIVERSITY

Corresponding author: mmcnew@fiu.edu

Myriah E. McNew, James Torrence Todd, Katherine A. Zambrana, Katie C. Hart, & Lorraine E. Bahrick

Introduction

Intersensory redundancy, the temporally-synchronous and spatially-collocated occurrence of the same information across different senses (e.g., the sights and sounds of a person speaking), guides attention to unitary audiovisual events and promotes intersensory processing (Bahrick, 2010; Bahrick & Lickliter, 2012). Intersensory processing skills develop across early infancy.

We have previously reported that intersensory processing predicts preliteracy skills (letter names and letter sounds knowledge), one of many indicators of school readiness (Bahrick et al., 2017). Executive functions (EFs; e.g., inhibitory control, working memory) are also foundational for school readiness (Blair & Raver, 2015). Both intersensory processing and EFs require selectively attending to relevant information and filtering out irrelevant information. Thus, we predicted that individual differences in intersensory processing would predict EFs, which would, in turn, predict preliteracy skills.

Methods

Sixty-six rising kindergarten and first-grade students (*M* = 5.92 years, *SD* = .63; 43.7% male), primarily from low-SES Latino families, who were enrolled in a summer reading program, participated. They received the Intersensory Processing Efficiency Protocol (IPEP; Bahrick et al., 2018) to assess intersensory processing speed and accuracy, the 'Head, Toes, Knees, Shoulders' task (HTKS; Ponitz et al., 2001) to assess EFs, and a Curriculum-Based Measurement (CBM) probe (Fuchs et al., 2001) of Oral Reading Fluency (ORF; letter names knowledge).

The IPEP is a fine-grained individual difference measure of intersensory processing skills administered on a touch-screen tablet. On each of 48 8-second trials, a 2x3 grid of videos depicting either objects striking a surface (nonsocial trials) or women reciting stories (social trials) is presented (Figure 1). On each trial, one of the six videos is synchronous with its natural soundtrack (target event) and the other five videos are out of synchrony with the soundtrack. We calculated intersensory accuracy as the proportion of trials on which the target event was touched (PTTT). On the HTKS task, children were instructed to do the opposite of what the experimenter asked (e.g., "If I say touch your toes, touch your head"). For each of 26 trials, the child received 0-2 points (0 = incorrect, 1 = self-correct, 2 = correct), for a total of 52 possible points. On the ORF, children are asked to identify as many letter names as possible from a printed sheet of 77 letters in one minute.

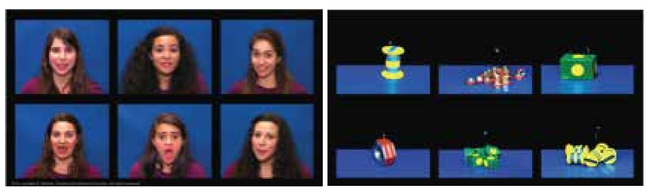

Figure 1. Static images depicting the dynamic social (left) and nonsocial (right) events shown to children in the IPEP.

Results

On average, intersensory accuracy was 49% on the IPEP (*SD* = 28%). Children scored 45.9% correct (out of 52 possible points) on HTKS (*SD* = 35.4%), and 53.7% (out of 77 possible letter names) on the ORF Letter Names task (*SD* = 33%). All measures were significantly positively intercorrelated (*r*s > .56, *p*s < .001; Figure 2). Chronological age was also correlated with all three measures (*r*s > .56, *p*s < .001; Figure 3). Note: similar findings were evident using the Letter Sounds probe of the ORF; not depicted here.

Using SEM, we tested a model (Figure 4) in which EFs (HTKS) mediate the relation between intersensory processing accuracy (IPEP PTTT) and preliteracy skills (ORF letter names) with age as a covariate. All paths were significant (*p*s < .05). Even when controlling for age, HTKS significantly mediated the relation between IPEP PTTT and ORF letter names, *b* = 8.27, 95% CI: .138-22.12, and accounted for 21.73% of the direct effect.

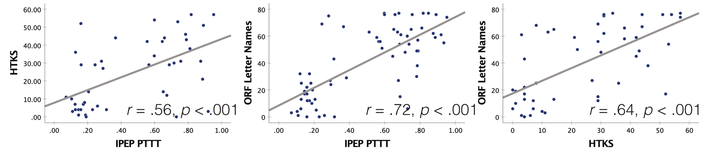

Figure 2: Correlations Among Measures. Scatterplots depicting relations between IPEP PTTT and HTKS (left), IPEP PTTT and ORF Letter Names (center), and HTKS and ORF Letter Names (right). Each dot represents an observation for one child, and lines represent linear regressions.

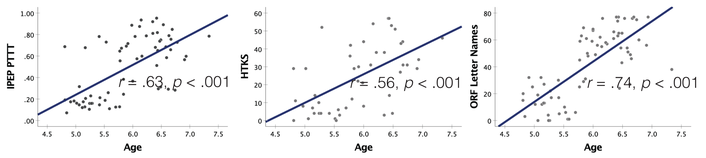

Figure 3: Correlations with Age. Scatterplots depicting relations between age and IPEP PTTT (left), HTKS (center), and ORF Letter Names (right). Each dot represents an observation for one child, and lines represent linear regressions.

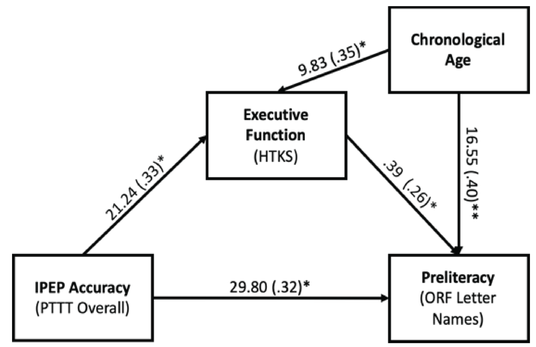

Figure 4. Model depicting relations between intersensory processing accuracy and preliteracy skills, partially mediated by executive functions with age as a covariate. Unstandardized regression coefficients are presented with standardized coefficients in parentheses. Note: *$p < .05$, **$p < .01$

Discussion

The present findings provide some of the first evidence linking individual differences in intersensory processing skills with executive functions in children. These results add to our prior research by demonstrating a link between the accuracy of intersensory processing and preliteracy skills (Bahrick et al., 2017). They reveal that this relation is partially mediated by children's EF skills. These exciting findings provide preliminary evidence for a developmental cascade from basic intersensory processing skills, to executive functions, and in turn, to preliteracy skills.

References

Bahrick, L. E. (2010). Intermodal perception and selective attention to intersensory redundancy: Implications for typical social development and autism. In G. Bremner & T. D. Wachs (Eds.). *The Wiley-Blackwell handbook of infant development: 2nd ed.* (pp. 120-166), Blackwell Publishing: Oxford, England.

Bahrick, L. E., & Lickliter, R. (2012). The role of intersensory redundancy in early perceptual, cognitive, and social development. In A. Bremner, D. J. Lewkowicz, & C. Spence (Eds.), *Multisensory development* (pp. 183-205), Oxford University Press: Oxford, England.

Bahrick, L.E., McNew, M.E., Todd, J.T., Martinez, J., Mira, S., Cheatham-Johnson, R., & Hart, K.C. (2017, April). Individual differences in intersensory processing predict pre-literacy skills in young children. Poster presented at the *Society for Research in Child Development*, Austin, TX.

Bahrick, L. E., Soska, K. C., & Todd, J. T. (2018). Assessing individual differences in the speed and accuracy of intersensory processing in young children: The Intersensory Processing Efficiency Protocol. *Developmental Psychology, 54,* 2226-2239.

Blair, C., & Raver, C. C. (2015). School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology, 66,* 711-731.

Fuchs, L. S., Fuchs, D., Hosp, M. K., & Jenkins, J. R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading, 5,* 239-256. http://doi.org/10.1207/S153279XSSR0503_3

Ponitz, C. E. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly, 23,* 141-158.

Presented in March 2019 at the biennial meeting of the Society for Research in Child Development, Baltimore, MD.

This research was supported by funding from the Children's Trust of Miami-Dade County awarded to the fourth author, and NIH RO1-HD53776 & K02-HD064943 to the last author.