Assessing the Cost of Competing Stimulation on Attention to Multimodal Events: Longitudinal Findings from 3 to 12 months

James Torrence Todd, Myriah E. McNew, Kasey C. Soska, & Lorraine E. Bahrick

Introduction

The world provides a continuous flux of multimodal stimulation, far more than can be attended at any time. Infants learn to selectively attend to unified multimodal events (e.g., face and voice of a speaker) while ignoring the vast amount of concurrent, irrelevant stimulation. This provides a foundation for social, language, and cognitive development (Bahrick & Lickliter, 2012, 2014). However, few studies have characterized the cost of competing stimulation on selective attention to multimodal events. Our new individual difference measure, the Multisensory Attention Assessment Protocol (MAAP; Bahrick et al., submitted; Todd et al., 2016) fills this need. It can characterize the cost of competing stimulation from a distractor event on three basic indices of attention (duration, speed, accuracy) in infants and children.

The MAAP presents two dynamic visual events (social and nonsocial) across multiple trials, while a soundtrack synchronous with only one event guides visual attention. On half the trials, a central visual distractor event competes for attention. The attentional cost of competing stimulation on duration of looking, speed of shifting, and accuracy of intersensory (audiovisual) matching is assessed by comparing performance on trials in which the distractor event is present (*high competition*) versus absent (*low competition*). Here, we present findings from a longitudinal sample of infants at 3, 6, and 12 months of age. We predicted 1) impaired performance (lower duration, slower speed, lower accuracy) when competition was high, and 2) that the cost of competing stimulation on these measures would decrease with age as attention became more flexible and efficient.

Methods

Seventy-five infants were tested with the MAAP at 3, 6, and 12 months of age, and those with data for at least two ages (N = 72) were included in analyses. Each of the 24 trials began with a 3-s central visual event (morphing geometric forms), immediately followed by two side-by-side, lateral events (12 s), one in synchrony with its natural soundtrack (Figure 1). Lateral events were social (women speaking) or nonsocial (objects dropping into a clear container). On half of the trials, the central visual event remained on throughout the lateral events (high competition) and on the other half of the trials, it was turned off (low competition). We calculated measures of *duration of looking* (proportion of available time looking to the lateral events), *speed of attention shifting* (reaction time to look from the central to either lateral event), and *accuracy of intersensory matching* (proportion of total looking time to the sound-synchronous events). Difference scores reflecting performance on high vs. low competition trials were calculated as an index of the cost of competing stimulation on duration, speed, and accuracy.

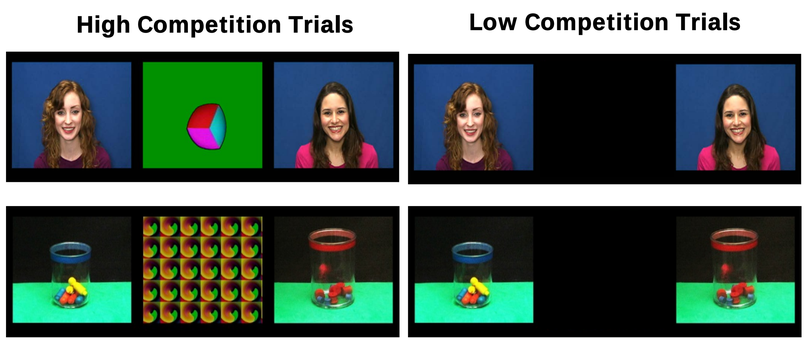

Figure 1. Static images depicting the social and nonsocial events along with the visual distractor events for high and low competition trials.

Results: Attention on High and Low Competition Trials

Results for the three measures (duration, speed, accuracy) for social and nonsocial events are presented in Figure 2. Planned single degree of freedom contrasts were conducted (Jaccard & Guilamo-Ramos, 2002) and missing data was estimated (Mplus robust maximum likelihood algorithm). Consistent with our first prediction, at all three ages, we found evidence of impairments in duration and speed of attention, with lower duration of looking and slower speeds of shifting on high compared to low competition trials for both social and nonsocial events (*p*s < .001; Figures 2A & B). In contrast to our prediction, there were no significant differences in accuracy of intersensory matching between high and low competition trials at any age (*p*s > .24; Figure 2C), Instead, infants showed general improvements in intersensory accuracy across age, with significant intersensory matching (greater than 50% chance) for nonsocial (but not social) events on both high and low competition trials by 12 months (*p*s < .02; Figure 2C).

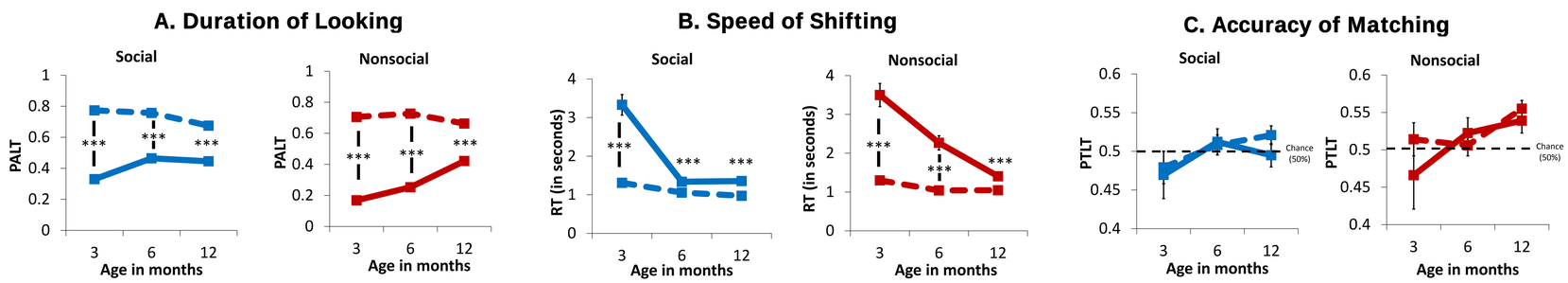

Figure 2. Mean performance on the three measures of attention to social and nonsocial events – A) duration of looking (proportion of available looking time; PALT), B) speed of shifting (reaction time, RT, to shift attention from the central distractor to the lateral events), and C) accuracy of intersensory matching (proportion of total looking time; PTLT) – as a function of competition (high, low), and age (3, 6, 12 months). Error bars depict standard errors of the mean. *Note*: *** *p* < .001.

Results: The Cost of Competing Stimulation – Developmental Change

Consistent with our second prediction, the cost of competing stimulation (high vs. low competition difference) on duration of looking and speed of shifting attention significantly decreased from 3 to 12 months (*p*s < .001; Figures 3A and B). For *social events*, there was a significant decrease in the cost of competing stimulation on duration and speed from 3 to 6 months (*p*s < .001) before plateauing from 6 to 12 months (*p*s > .10). For *nonsocial* events, change appeared more linear, with significant decreases (or marginally significant, *p* = .065, at 3-6 mos for duration) in the cost of competing stimulation on speed and duration from 3 to 6 to 12 months (*p*s < .001). In contrast, for accuracy of intersensory matching, there was no significant decrease in the cost of competing stimulation across age (*p*s > .47; Figure 3C).

Relations among measures. Finally, robust correlation analyses (which minimize the influence of outliers) indicated a positive relation between the cost of competing stimulation on duration and speed at 12 months (but not younger), $r(69) = -.32$, $p = .009$. No other correlations were significant (*p*s > .22).

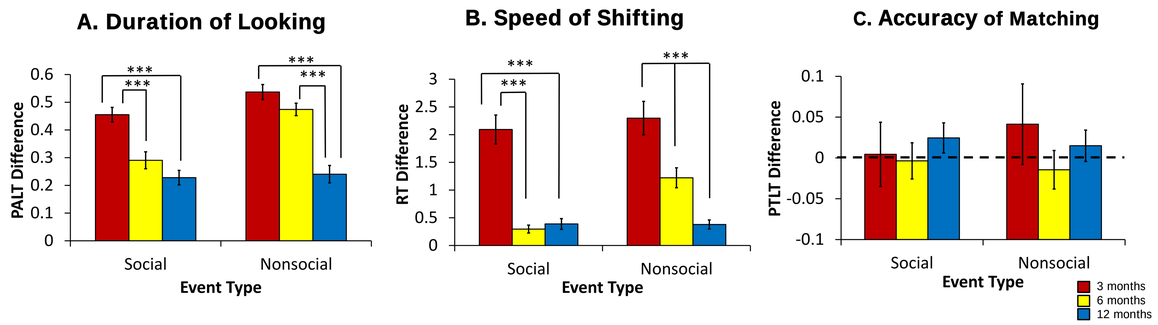

Figure 3. Mean difference scores (high versus low competition trials) reflecting the cost of competing stimulation of the distractor event on A) duration of looking (proportion of available looking time; PALT), B) speed of shifting (reaction time, RT, to shift attention from the central distractor to the lateral events), and C) accuracy of intersensory matching (proportion of total looking time; PTLT) – as a function age (3, 6, 12 months) and event type (social, nonsocial). Error bars depict standard errors of the mean. *Note:* *** *p* < .001.

Conclusions

Between 3 and 12 months, infants show improvements in the duration of looking, speed of shifting, and accuracy of intersensory matching and become increasingly effective at filtering out irrelevant visual stimulation. Across age, they show faster attention shifting and longer duration of looking to audiovisual social and nonsocial events in the presence of competing visual stimulation. Surprisingly, there was no change across age in effectiveness of filtering out irrelevant stimulation on accuracy of intersensory matching. Further, a significant relation between the cost of competing stimulation on speed and on duration emerged by 12 months, suggesting a tighter coupling between these measures with age. The MAAP provides a novel approach appropriate for infants and children, for characterizing individual differences in skills of selective attention and filtering out irrelevant, competing stimulation when attending to audiovisual events. Given the noisiness of the natural, multimodal environment, this new protocol has high ecological validity and potential for assessing the central role of multisensory selective attention in cognitive, social, and language development.

References

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. 183–206). New York: Oxford University Press. doi:10.1093/acprof:oso/9780199586059.003.0008

Bahrick, L. E., & Lickliter, R. (2014). Learning to attend selectively: The dual role of intersensory redundancy. *Current Directions in Psychological Science, 23*, 414–420. doi:10.1177/0963721414549187

Bahrick, L. E., Todd, J. T., & Soska, K. C. (2016). *The Multisensory Attention Assessment Protocol (MAAP): A new measure characterizes individual differences in speed, duration, and accuracy of attention to audiovisual events in infants and children.* Manuscript submitted for publication.

Jaccard, J., & Guilamo-Ramos, V. (2002). Analysis of variance frameworks in clinical child and adolescent psychology: Advanced issues and recommendations. *Journal of Clinical Child and Adolescent Psychology, 31*, 278–294. doi:10.1207/S15374424JCCP3101_15

Todd, J. T., Soska, K. C., & Bahrick, L. E. (2016, May). *Attention to multimodal events from 3 to 12 months: Developmental differences are magnified by competing stimulation.* Poster presented at the International Congress on Infant Studies, New Orleans, LA.

Presented in April 2016 at the meeting of the Society for Research in Child Development, Austin, TX. This research was supported by NICHD RO1 HD053776 and K02 HD064943 grants awarded to the fourth author.