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BRIEF REPORT

Intersensory Redundancy Hinders Face Discrimination in Preschool Children: Evidence for Visual Facilitation

Lorraine E. Bahrick, Sheila Krogh-Jespersen, Melissa A. Argumosa, and Hassel Lopez
Florida International University

Although infants and children show impressive face-processing skills, little research has focused on the conditions that facilitate versus impair face perception. According to the intersensory redundancy hypothesis (IRH), face discrimination, which relies on detection of visual featural information, should be impaired in the context of intersensory redundancy provided by audiovisual speech and enhanced when intersensory redundancy is absent. Evidence of this visual facilitation and intersensory interference was found in a recent study of 2-month-old infants (Bahrick, Lickliter, & Castellanos, in press). The present study is the first to extend tests of this principle of the IRH to children. Using a more difficult face recognition task in the context of a story, results from 4-year-old children paralleled those of infants and demonstrate that face discrimination in children is also facilitated by dynamic, visual-only exposure, in the absence of intersensory redundancy.

Keywords: audiovisual event perception, face–voice processing, dynamic face discrimination, child face perception, intersensory redundancy

Faces are arguably the most prevalent and meaningful stimuli in a child's environment and offer information about intentions, emotions, and the identity of individuals. Much recent research has focused on face perception in infants and children, particularly static images of faces, and has revealed excellent face-processing skills by infants and children alike (e.g., Baenninger, 1994; Bahrick, Hernandez-Reif, & Flom, 2005; Bushnell, 2001; Mondloch, Geldart, Mauer, & Le Grand, 2003; Pascalis, de Haan, Nelson, & de Schonen, 1998). In the present study, we explore discrimination of dynamic, speaking faces in preschool-aged children, a topic that has received little research focus. We evaluated whether recent findings of unimodal visual facilitation and intersensory interference in infant face perception (Bahrick, Lickliter, & Castellanos, in press) extend to young children, linking the infant and child face perception literatures and providing insight into developmental mechanisms and attentional patterns underlying face processing.

Infants orient to faces within hours of birth and discriminate and prefer the face of their mother over that of a stranger in silent visual displays (Bushnell, 2001; Field, Cohen, Garcia, & Greenberg, 1984; Goren, Sarty, & Wu, 1975; Johnson & Morton, 1991; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995; Sai, 2005). By 2–5 months, infants discriminate between the faces of unfamiliar adults in static (Blass & Camp, 2004; Kelly et al., 2009) and dynamic visual and audiovisual displays (Bahrick et al., 2005, in press). Between 4 and 10 months, infants shift from featural to holistic processing of photographs of unfamiliar faces (Schwarzer, Zauer, & Jovanovic, 2007). Six-month-olds show memory for an unfamiliar face after a 24-hr delay (Pascalis et al., 1998). Findings of exceptional face-processing skills in infants have led some researchers to propose that faces constitute a special stimulus category that is processed differently from other stimuli (e.g., Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Thompson & Massaro, 1989; Ward, 1989; Yovel & Duchaine, 2006), whereas others argue that general processing mechanisms underlie face perception (Bahrick, Gogate, & Ruiz, 2002; Bahrick & Newell, 2008; Gauthier & Nelson, 2001; Gauthier & Tarr, 1997; Nelson, 2003).

Less is known about how face-processing skills develop beyond infancy. Research indicates that early face processing relies primarily on detecting features of the face (e.g., nose, eyes, mouth), and across development, there is an increasing reliance on configural information (spatial arrangement among features such as distance between the eyes or mouth and nose; but see Quinn & Tanaka, 2009, for a reversal of this trend in infants). Some studies

Lorraine E. Bahrick, Sheila Krogh-Jespersen, Melissa A. Argumosa, and Hassel Lopez, Department of Psychology, Florida International University.

Sheila Krogh-Jespersen is now at the Department of Psychology, University of Chicago.

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Correspondence concerning this article should be addressed to Lorraine E. Bahrick, Department of Psychology, Florida International University, Miami, FL 33199. E-mail: bahrick@fiu.edu

show evidence of configural processing by 4–6 years (Baenninger, 1994; Carey & Diamond, 1977, 1994; Freire & Lee, 2001; Pellicano, Rhodes, & Peters, 2006), and others show longer developmental trajectories (Mondloch et al., 2003; Mondloch, Leis, & Mauer, 2006). Across differing methodologies, studies indicate that young children recognize static faces under a variety of conditions and that face perception skills improve and become more adultlike through early childhood into adolescence (Brace et al., 2001; Carey, Diamond, & Woods, 1980; Chance, Turner, & Goldstein, 1982; Goldstein & Chance, 1980; Mondloch et al., 2003).

Although much research on face perception has focused on static or silent faces, faces are typically part of a dynamic multimodal person event. Thus, little is known about the conditions that enhance versus impair face perception in more naturalistic settings involving audiovisual speech and movement. Research indicates that young infants (Bahrick, Moss, & Fadil, 1996; Otsuka et al., 2009) as well as adults (Knight & Johnson, 1997; Lander & Bruce, 2000, 2003, 2004; Lander, Christie, & Bruce, 1999; Lander & Chuang, 2005; Pike, Kemp, Towell, & Phillips, 1997) show enhanced discrimination and recognition of dynamic faces with natural movement (but see Bahrick et al., 2002; Bahrick & Newell, 2008) and changes in expression as compared with static faces. Young infants also match faces and voices of individual women during audiovisual speech (Bahrick et al., 2005; Bahrick, Netto, & Hernandez-Reif, 1998). However, our recent study exploring the conditions that facilitate versus impair face perception found that face discrimination was impaired when the faces were part of a dynamic multimodal event that provides intersensory redundancy (Bahrick et al., in press).

Intersensory redundancy is the synchronous co-occurrence of the same information (*amodal* information, such as rhythm, tempo, prosody, affect, and intensity changes) across multiple sense modalities. According to the intersensory redundancy hypothesis (IRH; Bahrick & Lickliter, 2000, 2002, 2012; Bahrick, Lickliter, & Flom, 2004), most naturalistic events (e.g., a person speaking) provide intersensory redundancy across auditory and visual stimulation. Intersensory redundancy (e.g., audiovisual synchrony) makes redundantly specified amodal properties (e.g., rhythm, tempo, prosody, affect of audiovisual speech) salient at the expense of modality-specific properties (e.g., auditory pitch, timbre; visual pattern, color), including those that support face discrimination such as visual features and their configuration. This enhanced attention and perceptual processing of amodal properties in multimodal stimulation as compared with the same properties in unimodal stimulation is referred to as *intersensory facilitation*. Intersensory facilitation has been documented in both social and nonsocial events, and across species (Bahrick & Lickliter, 2002, 2012). Human infants show better detection of the rhythm and tempo of a toy hammer tapping (Bahrick & Lickliter, 2000; Bahrick, Flom, & Lickliter, 2002), emotional expressions, such as happy, sad, and angry during speech (Flom & Bahrick, 2007), and the prosody of speech conveying prohibition versus approval (Castellanos & Bahrick, 2008) in synchronous audiovisual stimulation than in unimodal visual, auditory, and asynchronous audiovisual stimulation where intersensory redundancy is absent.

In contrast, according to the IRH, face perception should be enhanced in unimodal visual stimulation (e.g., viewing a silent face), where attentional competition from salient intersensory redundancy (i.e., audiovisual synchrony) is absent. In unimodal stimulation, attention is free to focus on modality-specific information, which supports face discrimination, including visual features of the face, their shape, size, and spatial configuration. This enhanced attention and perceptual processing of modality-specific information in unimodal stimulation, as compared with the same information in the context of synchronous, multimodal stimulation, has been termed *unimodal facilitation* (see Bahrick & Lickliter, 2002, 2012).

Evidence of unimodal facilitation (both visual and auditory) for detecting modality-specific properties has been demonstrated across species and event types (Bahrick & Lickliter, 2002, 2012). Human infants show enhanced discrimination of modality-specific visual information, including the orientation of a toy hammer tapping (up vs. down) and the face of a woman (Bahrick et al., in press) in unimodal visual as well as asynchronous audiovisual stimulation where intersensory redundancy is not available to compete for attention (Bahrick, Lickliter, & Flom, 2006). Similarly, quail chicks show enhanced discrimination for the pitch of a maternal call (modality-specific auditory information) in unimodal auditory and asynchronous audiovisual stimulation as compared with synchronous audiovisual stimulation (Vaillant, Bahrick, & Lickliter, 2011).

The effects of unimodal and intersensory facilitation are most pronounced in early development when attentional resources are limited and task difficulty is relatively high (see Bahrick, 2010; Bahrick & Lickliter, 2002, 2012). According to the IRH, attentional salience hierarchies direct attention to the most salient properties of stimulation during an episode of exploration and later extend to less salient properties. As development progresses, attention becomes more flexible and efficient, and progresses more rapidly along the salience hierarchy leading to detection of both amodal and modality-specific properties during an episode of exploration.

According to this logic, in early development, when attentional resources are most limited, face perception should be enhanced in unimodal visual stimulation (where intersensory redundancy is absent) and impaired in synchronous audiovisual stimulation (such as audiovisual speech) because intersensory redundancy interferes with attention to features of the face. This principle explains the results of our recent study demonstrating unimodal facilitation of face discrimination in 2-month-old infants (Bahrick et al., in press). Following habituation to the face of a woman, 2-month-olds discriminated between the faces of a novel and the habituated woman speaking when they were presented silently (unimodal visual speech; no intersensory redundancy) but failed to discriminate when the faces were shown speaking audibly (synchronous audiovisual speech; intersensory redundancy). Furthermore, infants also showed face discrimination in an asynchronous control condition that equated the amount and type of stimulation with that of the synchronous condition, but eliminated intersensory redundancy (synchrony), confirming that the presence of intersensory redundancy interfered with face discrimination. Moreover, consistent with our developmental predictions, the increased efficiency and flexibility of attention by the age of 3 months allowed infants to discriminate faces in both redundant audiovisual and nonredundant unimodal visual stimulation.

Thus far, tests of the IRH and demonstrations of unimodal and intersensory facilitation have focused primarily on infancy, the period when attention and perceptual processing skills are most limited. However, predictions of the IRH are proposed to extend across the life span, particularly when tasks are difficult in relation to the skills of the perceiver (Bahrick & Lickliter, 2002, 2012; Lickliter & Bahrick, 2013). For example, when learning new skills, or under conditions of high cognitive load or divided attention, children and adults are expected to show intersensory and unimodal facilitation similar to that of infants. Consistent with this hypothesis, older infants showed detection of tempo changes in both unimodal and redundant audiovisual stimulation (i.e., no intersensory facilitation). However, their performance reverted to the intersensory facilitation patterns of younger infants when the task was made more difficult (Bahrick, Lickliter, Castellanos, & Vaillant-Molina, 2010).

The present study is the first to test whether unimodal facilitation observed in infancy extends to children. We predicted unimodal visual facilitation and intersensory interference of face perception in young children paralleling our findings with infants. The face discrimination task for children was designed to be more difficult than that for infants. Exposure times were short (4 s rather than infant-controlled habituation trials), and hair cues were removed. Thus, we expected that for children (as long as the task was relatively difficult), face perception would be enhanced in unimodal visual stimulation and impaired in audiovisual stimulation. Furthermore, if unimodal facilitation is due to the lack of interference from intersensory redundancy (freeing attention to focus on modality-specific information such as visual features and their configuration), then eliminating intersensory redundancy in an asynchronous control condition should also lead to enhanced discrimination (just as in our prior studies; Bahrick et al., 2006, in press; Vaillant et al., 2011). Thus, findings from children are expected to parallel those of infants in which asynchronous faces and voices enhance (rather than impair) face discrimination and result in discrimination comparable to that for unimodal visual face displays.

In particular, the present study assessed whether 3.5- to 4-year-old children could differentiate between two dynamic faces presented in the context of a story about a birthday party. The story book format provides a context for remembering the faces and has been particularly successful in engaging young children's attention and revealing evidence of face discrimination (e.g., Brace et al., 2001; Mondloch et al., 2006). In the present study, preschoolers were familiarized with a series of six female faces speaking a nursery rhyme. They received either a unimodal visual (silent speech), bimodal synchronous (natural audiovisual speech), or bimodal asynchronous (audiovisual speech with the soundtrack displaced) condition. Test trials consisted of pairs of novel and familiar faces presented in a forced-choice format under their respective conditions. Given that modality-specific information, such as the configuration of facial features, distinguishes one face from another, and the task was designed to be somewhat difficult for preschoolers, it was predicted that discrimination of faces would be enhanced in the context of nonredundant stimulation (unimodal visual and asynchronous audiovisual speech) and attenuated in redundant stimulation (synchronous audiovisual speech, which focuses attention on other properties such as rhythm, tempo, affect, and prosody).

Method

Participants

Forty-eight 3.5- to 4-year-old children (M = 46 months; SD = 1.95) participated. There were 18 males and 30 females (11 Caucasian, 35 Hispanic, one Asian, and one African American). Data from 33 additional participants were excluded due to failure to respond correctly on one of the two practice trials (n = 9), experimenter error (n = 10), equipment failure (n = 3), unclear responses (e.g., pointing to both displays or failure to answer; n = 7), and side bias (n = 5; pointing only to one side of the computer monitor on all trials). Participants were recruited from an urban area and were from predominately middle-class families.

Apparatus and Stimuli

Microsoft PowerPoint presentations were shown on a Dell (Gx260) computer with a 14-in. screen (9.5 × 13 in.). Practice trials depicted three easily discriminable mechanical toys (robot, dog, and pony; see Figure 1). Each toy moved in synchrony with its characteristic sound (clicking, barking, neighing). The familiarization and test trials depicted 12 adult females, each filmed reciting the phrase, "Hickory dickory dock, the mouse ran up the clock" (3 s) and then returning to a neutral expression (1 s), creating dynamic familiarization and test stimuli, 4 s long. Each woman was filmed wearing a black T-shirt and backwards baseball cap to reduce hair and clothing cues (see Figure 1). All the women were Caucasian; nine were Hispanic, and three were non-Hispanic. Women were filmed while synchronizing their speech with that of a master film depicting a woman reciting the phrase. This enabled us to synchronize the speech of any of the 12 women with one another during the test trials.

Stimulus events for the synchronous audiovisual condition depicted the actress speaking in synchrony with the soundtrack (i.e., naturalistic audiovisual speech). The unimodal visual events depicted the actress speaking silently (no soundtrack). The asynchronous audiovisual events depicted the actress speaking out of synchrony with her voice. The soundtrack and video were displaced by approximately 1.5 s with respect to one another such that "Hickory dickory dock" was heard while the video depicted "The mouse ran up the clock," and vice versa. This was edited so that the speech sounds began and ended simultaneously with the visible movements of speech. Thus, the amount and type of stimulation and onset/offset audiovisual synchrony were controlled across the synchronous and asynchronous conditions, and only the audiovisual temporal microstructure (timing of speech sounds and mouth movements within the phrase) was asynchronous. Pairs of test trials were created for each condition, with careful attention to synchronizing the movements of the speech in the side-by-side displays. During the audiovisual synchronous and asynchronous test trials, the movements and soundtracks to both side-by-side faces were synchronous with each other and simultaneously audible. The physical set-up and videos used in each of the three conditions were identical; only their relation with the soundtrack varied.

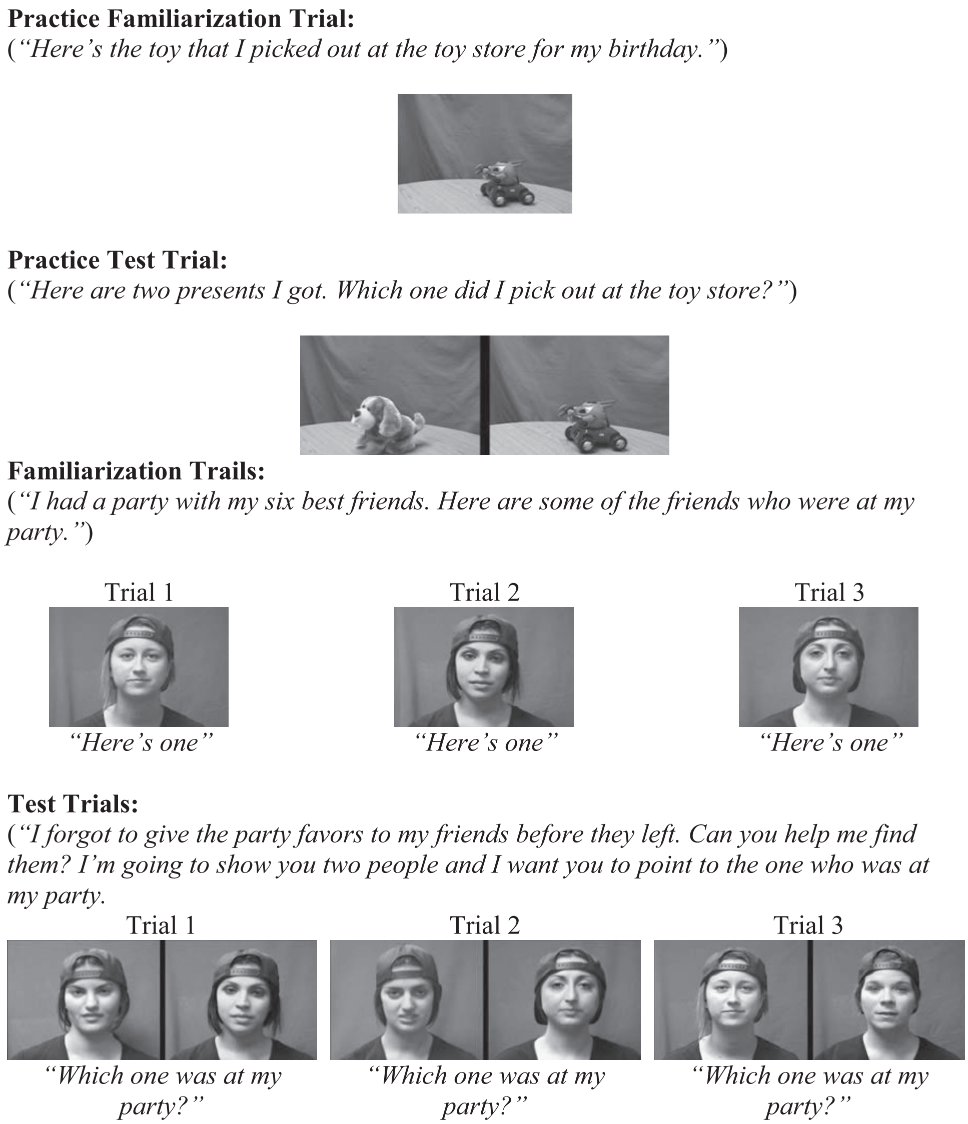

Figure 1. Photo of stimulus events and instructions to participants for one practice trial and one block of familiarization and test trials.

Design and Procedure

Participants were randomly assigned to one of three conditions: unimodal visual, synchronous audiovisual, or asynchronous audiovisual ($n = 16$ each), and all trial types (practice, familiarization, and test) for a given child were presented in the assigned condition. In each condition, the same dynamic visual events were presented and only the nature of the soundtracks differed. Following two practice trials, children received a total of six faces for familiarization.

Within each condition, four participants were randomly assigned to each of four stimulus presentation/test orders. For each order, six faces were selected from the pool of 12 for familiarization, and the remaining six faces served as the novel distractor items during test trials. The six familiarization trials within an order were presented in two blocks of three, each followed by three paired test trials (see Figure 1). The faces used for familiarization were randomly selected with the constraint that each woman's face appeared as a familiarization stimulus in two of the orders and as a novel distractor stimulus in the two remaining orders. The presentation order of the faces across familiarization trials within each order, the order of the test trials within a block, and the pairing of novel distractor faces with familiar target faces during the test trials were randomly determined. The target faces occurred on the right on half the trials and on the left on the other half of the trials within each order and across orders. The experimenter depressed a key to begin each familiarization/test trial and a static image of the face/faces appeared. Once the child looked, the experimenter recited the appropriate script (e.g., "Here's one") and started the 4 s dynamic video, creating trials approximately 5–6 s long. Following each test trial, a trained observer, unaware of the lateral positions of the novel and familiar displays, recorded the child's response. A refusal to make a choice was coded as incorrect. Sessions from 13 participants were videotaped for calculating interobserver reliability. The average Pearson product–moment correlation between the judgments of two independent observers regarding the direction of pointing on each trial (right vs. left screen) was .995 (SD = .02).

Practice trials. Children received one or two practice trials to familiarize them with the procedure. While the experimenter explained she had chosen a toy for her birthday, she presented a dynamic video of one of the three toys (counterbalanced across participants; see Figure 1). Then, the target and novel toys appeared side-by-side, and the child was prompted to "Point to the toy that I picked out at the toy store." Children who pointed to the target toy were considered to have passed the practice phase. Of the 48 children, 44 responded correctly after receiving only one practice trial, and four required a second trial (with a different novel toy). If participants failed to respond correctly on the second practice trial, their data were not included.

Familiarization and test trials. Children received six faces (approximately 5–6 s each) for familiarization in two blocks of three. In each block, the three faces were presented successively, followed by three paired preference test trials (approximately 5–6 s each) depicting the familiar target side-by-side with a novel distractor face (see Figure 1). The second block depicted a different set of familiarization and test faces. The experimenter explained that the faces depicted some of her friends who were at her party. After presenting three faces, children were told that the experimenter had forgotten to give out party favors and asked the child to help by pointing out the friend who was at her party. Then, children received three forced-choice test trials, one with each target face alongside a different novel face. During each test trial, the experimenter again asked, "Which one was at my party?"

Results

The proportion correct (out of six test trials) served as our primary dependent variable. Single sample t tests against chance (.50) were conducted to assess whether participants in each condition showed significant evidence of face recognition. Results demonstrated that in the unimodal visual condition (M = .67, SD = .25), $t(15) = 2.62$, $p = .02$, and the asynchronous audiovisual condition (M = .65, SD = .23), $t(15) = 2.51$, $p = .02$, children showed a significant proportion of correct responses to the target face. In contrast, children in the synchronous audiovisual condition did not (M = .47, SD = .21), $t(15) = -0.58$, $p > .1$ (see Figure 2). These findings demonstrate face discrimination in unimodal visual and asynchronous audiovisual speech, in the absence of intersensory redundancy.[1]

To compare the proportion of correct responses across conditions, an analysis of variance (ANOVA), with condition (unimodal visual, synchronous audiovisual, asynchronous audiovisual) as a between-subjects factor, revealed a significant main effect of condition, $F(2, 45) = 3.43$, $p = .04$, $\eta^2 = .13$. Planned comparisons revealed that children in the unimodal visual and asynchronous audiovisual conditions showed a greater proportion of correct responses than did children in the synchronous audiovisual condition, $t(30) = 2.37$, $p = .02$; $t(30) = 2.24$, $p = .03$, respectively. There was no difference between the unimodal visual and asynchronous audiovisual conditions, $t(30) = 0.22$, $p > .1$. These findings are consistent with predictions of the IRH and indicate that modality-specific information supporting face recognition is attended and perceived better in nonredundant than in redundant stimulation in preschool-aged children.

Further analyses evaluated effects of secondary variables. A two-way condition (unimodal visual, synchronous audiovisual, asynchronous audiovisual) by ethnicity (Hispanic, non-Hispanic) ANOVA revealed a main effect of condition, $F(2, 42) = 4.19$, $p = .02$, $\eta^2 = .16$, and no main effect of ethnicity or interaction of ethnicity with condition on proportion correct (ps $> .1$). An ANOVA conducted on the proportion correct as a function of condition and test order of the six faces (Order 1, 2, 3, 4) revealed no effect of order, $F(3, 36) = 1.01$, $p > .1$, and condition remained a significant factor, $F(2, 36) = 3.84$, $p = .03$, $\eta^2 = .13$. A two-way ANOVA with condition as a between-subjects factor and exposure block (Block 1 vs. Block 2) as a repeated measure revealed a main effect of condition, $F(2, 44) = 3.47$, $p = .04$, $\eta^2 = .13$, with no effect of block and no interaction (ps $> .1$). Thus, performance was influenced by the modality in which the faces were presented and not by the ethnicity of the child, the order in which the faces were presented during test, or which three faces were presented in the first versus second blocks.

Secondary analyses also examined whether the lateral positioning of the familiar and novel faces during the test trials influenced responses. The proportion of total responses to the left side was tested in single-sample t tests against the chance value of .50. Preferences of children in the unimodal visual (M = .49, SD = .18), $t(15) = -0.23$, $p > .1$, and the asynchronous audiovisual condition (M = .55, SD = .18), $t(15) = 1.18$, $p > .1$, did not differ from chance. However, left-side preferences of children in the synchronous audiovisual condition (where no evidence of face recognition was found) differed from chance (M = .63, SD = .15), $t(15) = 3.23$, $p = .01$. Given that the physical set-up, procedures, and lateral positions of novel and familiar faces were identical across conditions, it may be that when the task is difficult and/or participants fail to detect relevant stimulus variables, side preferences become evident.

Discussion

The present findings provide insight into the conditions that promote versus impair face perception. They demonstrate that 3.5- to 4-year-old children can discriminate dynamic displays of novel female faces under conditions in which intersensory redundancy from audiovisual speech is eliminated. Consistent with predictions of the IRH (Bahrick & Lickliter, 2000, 2002, 2012), children showed unimodal visual facilitation of face perception. Face discrimination was significantly greater during unimodal visual than synchronous audiovisual speech. In unimodal visual speech, attention is free to focus on modality-specific information such as facial features and their configuration. In contrast, face discrimination

[1] These findings contrast with those of a pilot study with younger children, age 3 to 3.5 years (n = 16, M = 38 months, SD = 2.05), who received unimodal visual exposure to the faces using identical procedures. No evidence of face discrimination was found (M = .46, SD = .32), $t(15) = 0.52$, $p > .1$. It was concluded that the task was too difficult for children of this age and older children (3.5 to 4 years) were thus tested in the present study.

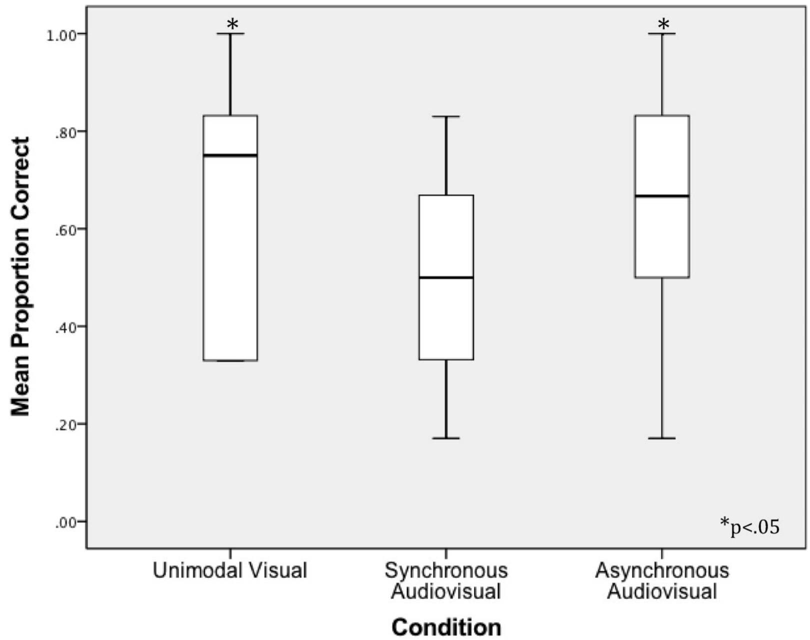

Figure 2. Box plots depicting the median values (inner horizontal lines) and interquartile range (top and bottom of each box) for the proportion of correct responses to the familiar target faces as a function of condition (unimodal visual, synchronous audiovisual, asynchronous audiovisual). Bars above and below the boxes denote values 1.5 times the interquartile ranges. * $p < .05$.

was impaired during synchronous audiovisual speech, a natural context that provides intersensory redundancy that focuses attention toward amodal properties of stimulation such as rhythm, tempo, affect, and prosody (see Bahrick & Lickliter, 2012, for a review). These results demonstrate that unimodal visual stimulation enhances face discrimination and indicate that intersensory redundancy in the form of temporal synchrony between audible and visible speech can interfere with face discrimination.

Results of an asynchronous control condition confirmed this interpretation and cast doubt on a number of alternative hypotheses. The asynchronous speech eliminated intersensory redundancy but preserved the same amount and type of stimulation as the synchronous speech by presenting the same audible and visible speech out of synchrony with one another. During asynchronous speech, children no longer showed impaired face discrimination. Discrimination was on par with that of visual speech and was significantly greater than during synchronous audiovisual speech. Thus, the addition of audible speech did not overstimulate children or distract attention from the face. Rather, speech interfered with face discrimination only when it was synchronized with facial movements, providing intersensory redundancy. Furthermore, there was no indication that attention was reduced in the synchronous condition (children actively participated and completed all trials in all conditions). In fact, a recent event-related potential study showed that synchronous speech was more salient and processed more deeply than asynchronous or unimodal speech by infants (Reynolds, Bahrick, Lickliter, & Guy, in press). These results highlight the role of attentional salience hierarchies and suggest that in synchronous speech, attention is initially directed to properties of stimulation other than facial features—properties common to audible and visible stimulation.

These findings support predictions of the IRH and are the first to extend our recent findings of unimodal facilitation in young infants (Bahrick et al., in press) to children. Findings indicate that 3.5- to 4-year-old children can discriminate and recognize six faces of unfamiliar women in unimodal visual but not synchronous audiovisual speech following brief (4 s) presentations in a relatively difficult task (where recognition averaged only 67% correct in a two-choice preference task during unimodal visual stimulation). Hair cues were obscured (with a baseball cap), and there was a substantial memory load in that faces were presented in blocks of three followed by three test trials, requiring children to remember three faces at a time. In contrast, in our infant study (Bahrick et al., in press), only a single face with hair cues was presented across a lengthy habituation period (2–4 min). Together, these findings reveal that unimodal facilitation of face discrimination extends from infancy through early childhood when tasks are relatively difficult in relation to the skills of the perceiver. When processing resources are taxed, only the most salient aspects of stimulation are attended.

Across development, increased attentional flexibility and efficiency lead to detection of modality-specific properties, even in the context of interference from highly salient intersensory redundancy. In Bahrick et al. (in press), 2-month-olds showed no evidence of face discrimination during audiovisual speech, but by 3 months, infants were able to discriminate the faces even during audiovisual speech. Thus, we predict that if the present task were made easier, the exposure time lengthened, or older children were tested, children would show evidence of face discrimination even during interference from audiovisual speech.

The present findings of face perception parallel those of nonsocial events (Bahrick et al., 2006) and indicate that unimodal facilitation of attention and perceptual processing is a general principle that applies to both face and nonface events alike. Detection of modality-specific information, whether it is visual information for facial configuration (present findings and Bahrick et al., in press), the orientation of an object's movements (Bahrick et al., 2006), or auditory information such as the pitch of a quail call (Vaillant et al., 2011), is detected better in unimodal and bimodal asynchronous stimulation than in synchronous audiovisual stimulation where the salience of amodal properties competes for attention. The present findings of unimodal facilitation of face processing thus converge with those of other studies and demonstrate that heightened attention to modality-specific information in unimodal events is a fundamental and domain-general principle of perceptual processing, generalizable across age (infants and preschoolers), event type (social and nonsocial), and species (human and avian). Together with findings of intersensory facilitation demonstrating heightened attention to amodal properties in synchronous stimulation from the same events (e.g., a person speaking), these findings highlight the central role of attention allocation to different properties of stimulation as a function of the presence or absence of intersensory redundancy.

The present findings also have implications for education and intervention. They suggest that the most effective strategies for teaching or training face perception skills would parallel those for training discrimination of visual features of nonsocial events. In both cases, this would involve presenting silent dynamic visual displays, in the absence of multimodal stimulation.

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