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Erratum

The journal production department of Ablex Publishing Corporation regrets that errors in pagination and date citation of references were printed in, "Reflections on infants response to temporally based intersensory equivalence: Response to Spelke (1994),'' by David J. Lewkowicz, which appeared in the previous issue (Volume 17, No. 3, pp. 289–292) of the journal of *Infant Behavior and Development*. We apologize to Dr. Lewkowicz and to the readers of the journal for the inconveniences that were incurred and hereby reprint this response article to Elizabeth S. Spelke's, "Preferential looking and intermodal perception in infancy: Comment on Lewkowicz (1992),'' which appeared in that same issue on pp. 285–287, in its entirety and with all of the necessary corrections.

Reflections on Infants' Response to Temporally Based Intersensory Equivalence: Response to Spelke (1994)

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In her commentary on my article (Lewkowicz, 1992a), Spelke (1994) points to agreement between the results from my studies and the results from her studies (Spelke, 1979; Spelke, Born, & Chu, 1983). Although there are some important similarities, there are also some notable differences. When the similarities and the differences are considered together along with some other data, a complex picture of the mechanisms underlying auditory–visual integration of temporal information in infancy emerges.

There is no question that the consistency in some of the findings is impressive despite the fact that markedly different stimulus materials and different experimental procedures were used. Both Spelke (1979) and Lewkowicz (1992a) found no evidence of rate-based intersensory matching when measures of visual preference were used and when moving visual stimuli were presented. Moreover, Lewkowicz (1985) found no evidence of rate-based intersensory matching in earlier studies when the visual stimuli were static. Despite the consistency, however, data from other studies in my laboratory (Lewkowicz, 1994) have pointed to the complexity of the intersensory matching task when rate is the intermodal invariant. In these studies, infants first were familiarized with the same auditory and visual stimuli used in Lewkowicz (1992a) until they reached a predetermined criterion. Then the infants' detection of intersensory relations was tested with the same type of paired-preference intersensory test that was administered in the Lewkowicz (1992a) study. In several studies, infants were familiarized with a compound auditory/visual stimulus where the components were either explicitly related or unrelated. Despite the fact that the infants had additional experience with the auditory–visual relations, I found no evidence of intersensory matching of rate. Following familiarization with a silently moving visual stimulus, however, I found that the infants looked longer at the fast visual stimulus in the presence of the fast sound but not at the slow visual stimulus in the presence of the slow sound. This result is similar to the result reported by Spelke (1979) in her Experiment 2. What is different about this finding, however, is that such an effect was obtained only after familiar-

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ization with the visual stimulus first. In addition, Spelke (1979) obtained this effect with her search measures, whereas we obtained the effect with visual preference measures. Given the different stimuli and procedures used in the two sets of studies, these findings suggest that matching of concurrent auditory and visual inputs on the basis of rate is particularly difficult even when synchrony accompanies the rate information.

Although Spelke's and my data are generally consistent when measures of visual preference are considered, they are at odds when Spelke's (1979) first look data, which constitute one of several search measures employed by her (Experiments 1 and 2), and Lewkowicz's data on the first look measures are compared. In the two studies where Spelke (1979) studied infants' response to rate, she found that a significantly greater number of first looks were directed at the sound-specified event than at the nonspecified one. In contrast, Lewkowicz (1985, 1992a) found no differences in first look measures in any of the experiments investigating infants' response to rate. An important procedural difference between Lewkowicz's and Spelke's experiments suggests a reason for the difference. In all of Spelke's experiments, the search trials always were presented after the visual preference test trials. In contrast, the trials which yielded the first look measure in Lewkowicz's experiments were not preceded by prior experience with the stimuli. This procedural difference sheds light on the possible mechanisms underlying infants' auditory–visual integration of temporal information. The visual preference trials in Spelke's studies concerned with responsiveness to rate (Experiments 1 and 2 in Spelke, 1979) lasted for a total of 3.3 min. This is a relatively long time in studies of this sort. Although our new data on familiarization suggest that prior experience may not facilitate intersensory matching, it is likely that this effect interacts with the types and number of discriminative cues available in the intersensory matching situation (Lewkowicz, 1993). Given that Spelke's visual and auditory stimuli differed on a number of dimensions (color, shape, type of sound), it is possible that the initial visual preference phase allowed the infants to differentiate the two objects and the two sounds, and that it allowed them to learn the association between each object and its corresponding sound. This explains why the infants in Lewkowicz's studies, who never had the opportunity to see the visual stimuli nor hear the sounds before, did not show a preference at the very beginning of a test trial. Thus, the difference between Lewkowicz's and Spelke's results on the first look measure suggests that prior learning about the relation of the auditory and visual events might eventually enable infants to detect rate. The key to this outcome and to other demonstrations of robust intersensory effects, however, seems to be the presence or absence of additional modality-specific cues (Lewkowicz, 1993). Lewkowicz's (1994) failure to obtain matching of rate, despite the initial opportunity to learn about the intersensory relation, suggests that detection of the intersensory relation is only possible when additional modality-specific cues that help to differentiate the stimuli are available. Only then, as in Spelke's studies, do infants seem to profit from the initial period of familiarization.

Spelke (1994) cites my studies in which a habituation/test technique was used (Experiment 2 in Lewkowicz, 1992a, 1992b) to indicate that infants can detect rate intermodally. The data from Experiment 2 actually were quite weak for the 4-month-old infants. Following habituation to a sound whose occurrence was synchronous with the bounce of a single object, the 4-month-old infants exhibited only marginal detection of the disruption of the synchrony. The more recent studies (Lewkowicz, 1992b) might be cited as more reliable evidence of infants' detection of the auditory–visual relation. After infants were habituated to a single bouncing object and a sound that occurred in synchrony with the bounce, they exhibited a recovery of response when the rate of either the auditory or the visual component was changed. This effect can be interpreted to mean that the infants detected the change in the relation between the auditory and visual components. Given that the change in rate involved a simultaneous disruption in synchrony, we also tested infants with a change in the synchrony relation when rate was kept constant. In this case, the infants also performed a reliable discrimination, but the magnitude of response was significantly lower than

the magnitude of response that was found in response to the concurrent change in rate and synchrony. The differential magnitude of response recovery suggests that responsiveness to intersensory rate and to intersensory synchrony may be different. The data on infants' responsiveness in the paired-preference matching task supports this conclusion. When infants have to make matches based on rate, they do not do so, but when they have to make them on the basis of synchrony, they do. This result, however, appears to be opposite to what might be expected on the basis of the discrimination data and thus seems paradoxical. The reason for the paradox may be that rate is a highly discriminable stimulus feature for both the visual and auditory modalities. When infants are asked to use it to recognize correspondences across modalities, it is difficult for them to do so precisely because rate is such a powerful cue. It is as if they are so captivated by the difference in the rates of motion of the visual stimuli that they fail to notice the correspondence of the auditory stimulus to one of them. Spelke expresses a similar view when she suggests that the absence of a visual preference for the sound-matched visual stimulus in her 1979 studies may have, in part, been due to the repetitive nature of the stimuli. I reached a similar conclusion in my 1992a article. It seems that the power of the rate-based temporal differences to capture the infants' attention, together with the fact that the infant must process the synchrony relations of the auditory and visual events, is what makes the information-processing task too complex and, as a result, the infant fails to notice the intersensory relation.

Spelke (1994) states that "... weak and inconsistent preferences were observed when the auditory–visual relationship was specified by synchrony" (p. 286) The data from Lewkowicz (1992a) Experiment 3, however, are reliable according to conventional statistical standards. The preference for the visual stimulus that was synchronized with the sound was significant in both the slow and the medium velocity conditions at both ages, though the effect was more robust in the 8-month-old infants. Perhaps the fact that no preference was observed in the *fast* condition and that the effect was only consistent for the condition where the visual stimulus was the leading one prompted Spelke's conservative interpretation of these data. These data, however, accord very well with Spelke et al. (1983), which also showed that infants detected auditory–visual synchrony even with the duration of fixation measure.

Spelke (1994) suggests that the specific method used to test infants' intersensory capacities determines their success on the task. Although the habituation/test method provides evidence of intersensory integration in cases when the paired-preference method does not, this is not always the case. Lewkowicz (1988a, 1988b) found that both 6- and 10-month-old infants' responses to the disruption of the relation between the auditory and visual components of a compound stimulus depended on the temporal complexity of the information. For example, when the infants were habituated to temporally identical and synchronous auditory and visual components, they did not respond to the disruption of their temporal relation at all at 6 months of age, and did not respond but only when the disruption was the result of a change in the rate of the auditory component, but not the visual one, did they respond at 10 months.

Earlier, I discussed the important role of modality-specific cues in infants' intersensory perception. Spelke (1994) makes the interesting observation that many studies of intersensory functions that have used the preference method to study infants' response to natural events and nonarbitrary auditory–visual relations have found more robust preferences for acoustically specified events. Recently, I have proposed (Lewkowicz, 1994) that the detection of temporal, intersensory relations is dependent on the number and the types of modality-specific cues that distinguish the visual and the auditory events. Thus, for example, when the visual events differ in terms of color, shape, and size, and the auditory events differ in terms of their spectral characteristics, infants appear to detect the intersensory relations in a more robust fashion. In addition to modality-specific cues, however, the specific kind of temporal information also appears to play a role in intersensory integration in early development. Thus, when auditory–visual synchrony is embedded even in a relatively simple informational context without any differential modality-specific cues, infants as young as 4 months of age detect it

(Lewkowicz, 1992a, 1992b). Detection of auditory–visual synchrony embedded in a more complex informational context, however, requires the presence of differential modality-specific cues and prior opportunity to differentiate the stimuli intramodally and to associate them intermodally. Detection of other types of temporal information, such as duration or rate, appears to be more difficult (Lewkowicz, 1992c), and their emergence also seems to depend on the "richness of the information" in terms of modality-specific cues and on whether other intersensory correspondences are present. Thus, auditory-visual matching of duration, when it is correlated with synchrony, emerges sometime around 6 months of age. The existence, and/or the eventual emergence, of the capacity to detect the auditory–visual correlation of rate is, of course, of greatest interest here. In my opinion, the answer to the question of when the capacity to detect rate intermodally emerges is still in question. Parsimony dictates that, because of the lack of consistency in the aggregate data from all the studies on infants' intersensory response to rate, we be cautious about attributing the existence of even a most elementary perceptual capacity to young infants when, in fact, it may only just be emerging. It could be that the observed fragility of the phenomenon reflects the beginning developmental stages of this capacity.

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