Supplemental Material for "One-year-old infants follow others' voice direction"

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Additional Analyses

1 Noncompliant infants

A number of infants were dropped from analyses in Studies 1 and 2 for not moving from their parent during one or more trials. Because it is possible that they did not move because they could not follow the experimenter's voice direction, to be conservative, we reran the first-trial analysis with them included. In Study 1, of the four 16-month-olds dropped for this reason, three were distracted by the barrier and then eventually went to the incorrect box on their first trial, and one did not move. With them included as "incorrect choice," infants were still significantly above chance on their first trial (Sign test, n = 36, p < .05, g = .22). Similar results were found in Study 2. Of the seven 16-month-olds who were dropped for not moving during some trials, two went to the correct box on their first trial, one went to the incorrect box, and four did not move. With them included, infants were still significantly above chance in their first trial (Sign test, n = 43, p < .05, g = .20).

2 Performance across trials and number of calls listened to in Study 2

We think we are actually underestimating 16-month-old infants' ability to follow voice direction in the across-trials analysis presented in the main text, because of these infants' tendency 1) to perseverate in going to the box they went to previously, and 2) to become excited and move as soon as the experimenter started speaking on later trials, without taking the time to listen carefully to her. That is, after their first trial when they observed the toy in the box, 16-month-olds often became overexcited and attempted to move as soon as the experimenter started speaking. At that point, following their instructions, parents usually pulled infants back, which led to struggling by infants, which severely compromised infants' attention to the experimenter's voice.

We thus performed a Generalized Linear Mixed Model (GLMM; Baayen, 2008) in R (version 2.14.0, R Development Core Team, 2011) to investigate the effects of factors like trial number and number of calls infants listened to on their performance. We included counterbalancing order (of left/right position of the correct box; there were 6 possible orders), trial number (1–4), and number of calls infants heard before moving (1–3) as fixed effects, and infant ID as a random effect. The response was binary, indicating whether the infant went to the correct box or not in a given trial.

For the 16-month-olds, we found that counterbalancing order had no significant effect on infants' choice of the correct box (likelihood ratio test, LR(5) = 1.29, $p = .935$) and it was therefore excluded from the model. Number of calls listened to also showed no significant effect ($z = 0.19$, $p = .85$; note, however, that 16-month-olds listened to more than one call on only 7% of trials, so we might be underestimating the effect of number of calls on the results). Trial number did have a clear significant effect ($z = –2.75$, $p < .01$).

For 12-month-olds, the counterbalancing order also had no significant effect (likelihood ratio test, LR(5) = 4.19, $p = .52$) and was therefore excluded from the model. In the remaining model, there was no effect of trial number ($z = 0.01$, $p = .99$), but number of calls listened to before moving did have a significant effect ($z = 1.92$, $p = .05$).

Thus, for 12-month-olds, listening to more repetitions of the experimenter's call improved performance, whereas for 16-month-olds, impatience and/or perseveration had a bigger effect, as their performance became worse across trials. (It should be noted, however, that at both ages infants were quite enthusiastic and impatient to move toward one of the boxes, as 16- and 12-month-olds moved during or at the completion of the first call in 93%

and 79% of the trials, respectively. Thus, infants could infer the adult's voice direction with very little acoustic information.)

3 Assessing the role of sound intensity in voice following

An anonymous reviewer suggested that our results in Study 2 might not completely rule out the source-of-sound hypothesis because infants could still rely on the relative intensity of sound coming from the two sides of the barrier. To determine whether this was true, we conducted acoustic measurements of the sound intensity in our experimental setup.

We used a Sound Devices T788 multi-track recorder and 2 AKG C1000S condenser microphones with directional character placed 2 m from the front center of the barrier in the infant's starting position. The microphones were pointed toward the sides of the barrier at an angle of approximately 45° to simulate the infant's two ears (marked as 1 and 2 in Fig. S1), with the recording level manually controlled (–50.0 dB).

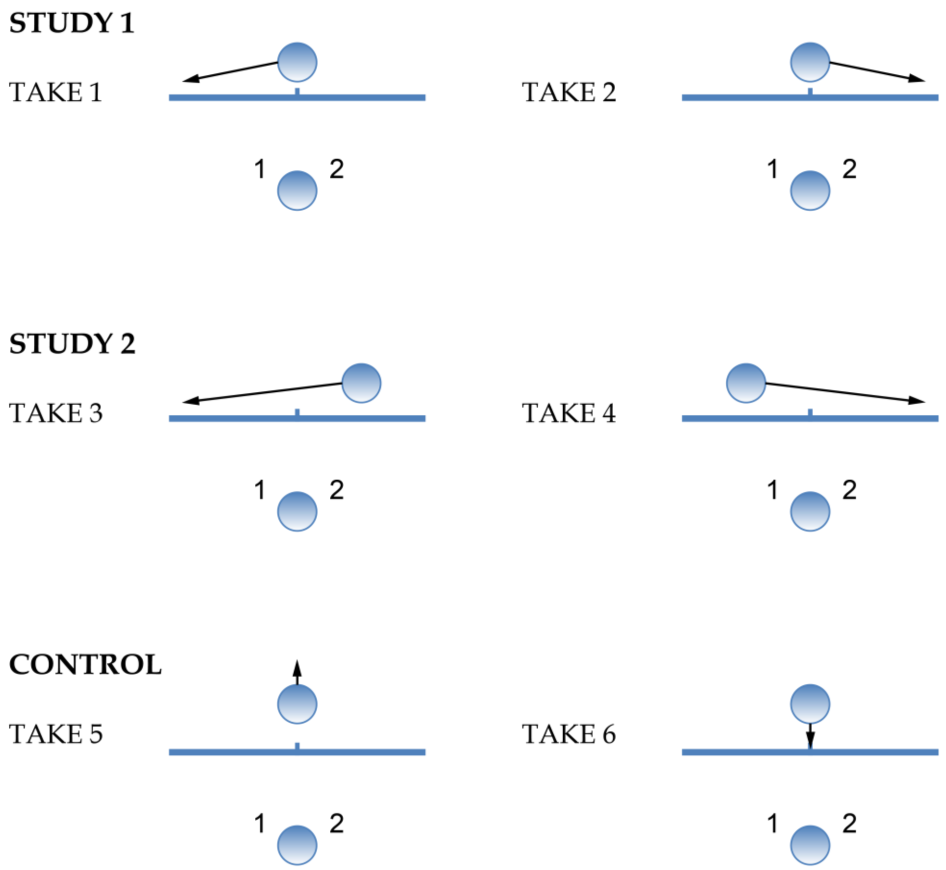

Fig. S1: The position of the speaker and microphones in each of the 6 takes. The circle with the arrow represents E's position behind the barrier; the circle between microphones 1 and 2 represents the infant's position.

The experimenter squatted behind the barrier in the positions used in Studies 1 and 2 (see Fig. S1) and held a speaker (Creative Inspire T10 2.0, 80 Hz to 20k Hz response, 5W RMS power) at chin level that played a recording of her calls (a recording was used instead of her live voice to minimize differences across trials for better comparison). In each of the 6 takes the call was repeated twice. Takes 1 and 2 correspond to the conditions in Study 1, takes 3 and 4 correspond to the conditions in Study 2, and takes 5 and 6 are control conditions. With the experimenter facing directly toward or away from the infant, we would expect there to be no difference in the sound intensity reaching each microphone/ear (i.e., these values should be very close to 0). This analysis thus checks for an acoustic side bias due to the configuration of the room or the microphones.

Intensity levels were determined using absolute values in Praat (Boersma & Weenink, 2012). Intensity was measured in periodic (mostly vocalic) parts of the speech signal, which resulted in approximately 25 measure intervals for each recording (one recording per take). Within each take, the same measure intervals were used for each individual channel (microphone).

A brief word of explanation is needed before we get to the results of these measurements. Interaural intensity difference (IID) is the difference in sound intensity perceived by both ears due to the shadowing of the sound wave by the head. It is one of the two main cues used for sound localization, the other being interaural time difference (ITD; Yost, Tanis, Nielsen, & Bergert, 1975). Previous experiments have established that the just noticeable difference (JND) in IID when measured with pure tones as signals is approximately 1 dB (Yost & Dye, 1988; Mills, 1960). Recent experiments run with more complex stimuli, such as tone signals masked by noise of different frequencies (e.g., Bernstein, Trahiotis, & Hyde, 1998; Francart & Wouters, 2007), have shown the JND of IID to be between 2 and 2.6 dB. Our measurements used the experimenter's speech as a signal. This signal is significantly more complex than a pure tone or white noise and, more importantly, it is not constant through time. Thus, it is not completely clear exactly what the JND is for this signal, but given previous results we assume it should be at least 2 dB.

We found that the average difference between the speech intensity measured by microphone 2 and microphone 1 (see Fig. S2) never reached 2 dB and in most cases was less than 0.5 dB. It thus never reached the JND and so could not be detected by the infants.

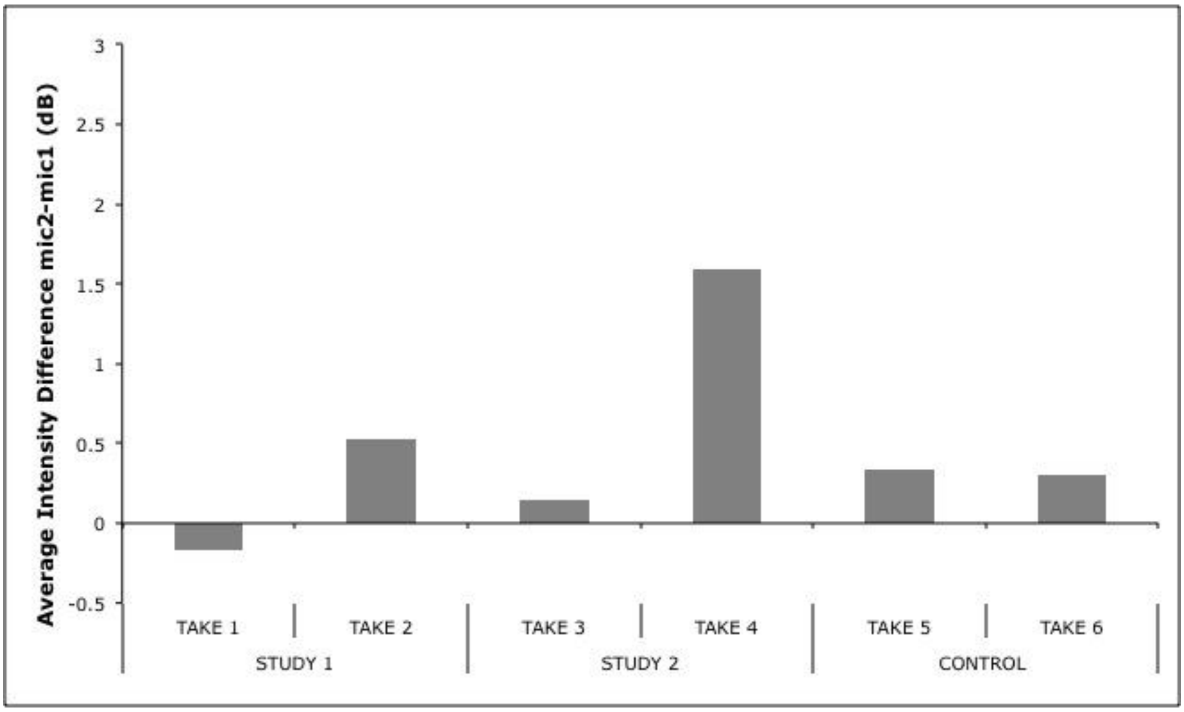

Fig. S2: Average difference between the speech intensity measured by microphone 2 and microphone 1.

We should note that it is likely that an important role in the solution of the voice-direction task might be played by the time lag with which sound reaches one ear after the other. However, a number of complex trading effects can occur between time difference and intensity difference, so that one can compensate for the other in specific situations (see, e.g., Howard & Angus, 2009). Therefore, more detailed investigations are necessary to assess how exactly infants can solve the voice-following task from a psychoacoustic point of view with such a complex stimulus in such a complex environment.

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