The effects of prosody on the listener's representation of the speaker's thoughts: The functional localizer fMRI approach.

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A critical question at the intersection of language and social cognition concerns whether in conversations one partner represents the other partner's productions as simply their meanings or as the partner's beliefs about their meanings. For example, in (1), does Speaker1 represent Speaker2's utterance as [*Kyle consulted Joel*] or as [*Speaker2 thinks/believes that Kyle consulted Joel*]?

(1) Speaker1: Who did Kyle consult about the investment?
Speaker2: He consulted Joel.

Whereas representing utterances as others' beliefs may be socially-relevant, it is also computationally intensive. A plausible hypothesis is that ***the probability of representing the speaker's utterances as beliefs depends on how salient the speaker is in the comprehender's mind.*** We manipulated the speaker's saliency by varying the prosodic contour of the phrase "I think" which preceded the speaker's utterances in naturalistic dialogs. Three prosodic contours were used: (a) "I" stressed; (b) "think" stressed; or (c) both words unstressed. We reasoned that prosodic contours in (a) and (b) increase the speaker's saliency by stressing the fact that (a) the utterance represents the speaker's opinion, in contrast to the opinions of others, or that (b) the speaker is uncertain of the information, compared to (c) which is associated with politeness in expressing opinions and should not make the speaker salient. A control condition without "I think" was also included. An acoustic analysis of the "I think" fragments of the materials (n=300) demonstrated that six acoustic features (duration, mean, max and min pitch, energy and power) distinguish among the three prosodic contours with the 81.3% accuracy (chance=33%).

In a **behavioral study** we found that comprehenders distinguish the three contours of "I think": they infer the greatest confidence in the speaker's belief in the statement when "I" is stressed (but do not themselves form more confident opinions), followed by the unstressed condition, followed in turn by the "think"-stressed condition. In the **fMRI study** we used the functional localizer approach, which involves identifying a set of regions of interest using a task that targets particular representations/processes, and then investigating the response of these regions to the target conditions. In the current study, we localized regions selectively engaged in representing other people's thoughts (e.g., Saxe&Kanwisher,2003; Saxe,2006) by comparing brain activations in response to false-belief stories (requiring an inference about another person's *thoughts/beliefs* (3a)) and false-photograph stories (requiring an inference about a hidden *physical* process (3b)). We then examined these regions' response to the four conditions. As predicted, these regions (critically, the right temporo-parietal junction) responded more to the "I"-stressed and "think"-stressed conditions, compared to the two control conditions (4). (Additional

control conditions with different elements stressed were included to rule out the possibility that the critical difference is due to the presence/absence of stress.) The results support the hypothesis that comprehenders are more likely to represent utterances as beliefs when the speaker is salient in their mind. This is the first demonstration of the regions that have been implicated in representing others' thoughts interpreting utterances as others' beliefs during online language comprehension.

(2) Sample dialog with the experimental manipulation (always in Speaker3's utterance):
Speaker 1: Who did Kyle consult about the investment?
Speaker 2: He consulted Joel.
Speaker 3: {*I* think / I *think* / I think / No,} he consulted Ben.

(3a) ***False belief***: When Christine labeled the pie at the school's bake sale, she thought it was cherry, and labeled the pie "cherry". Actually, the pie was strawberry.
(3b) ***False photograph***: When the picture was taken of the house, it was one story tall. Since then the renovators added an additional story and a garage.

(4) Percent signal change in the right temporo-parietal junction (rTPJ):
I* think*: .12; *I *think: .17; *I think*: -.06; *No*: -.04
I think vs. I think: p<.01; I *think* vs. I think: p<.02