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**Adults learn to identify pain in babies cries:
investigations from behavior to brain responses**

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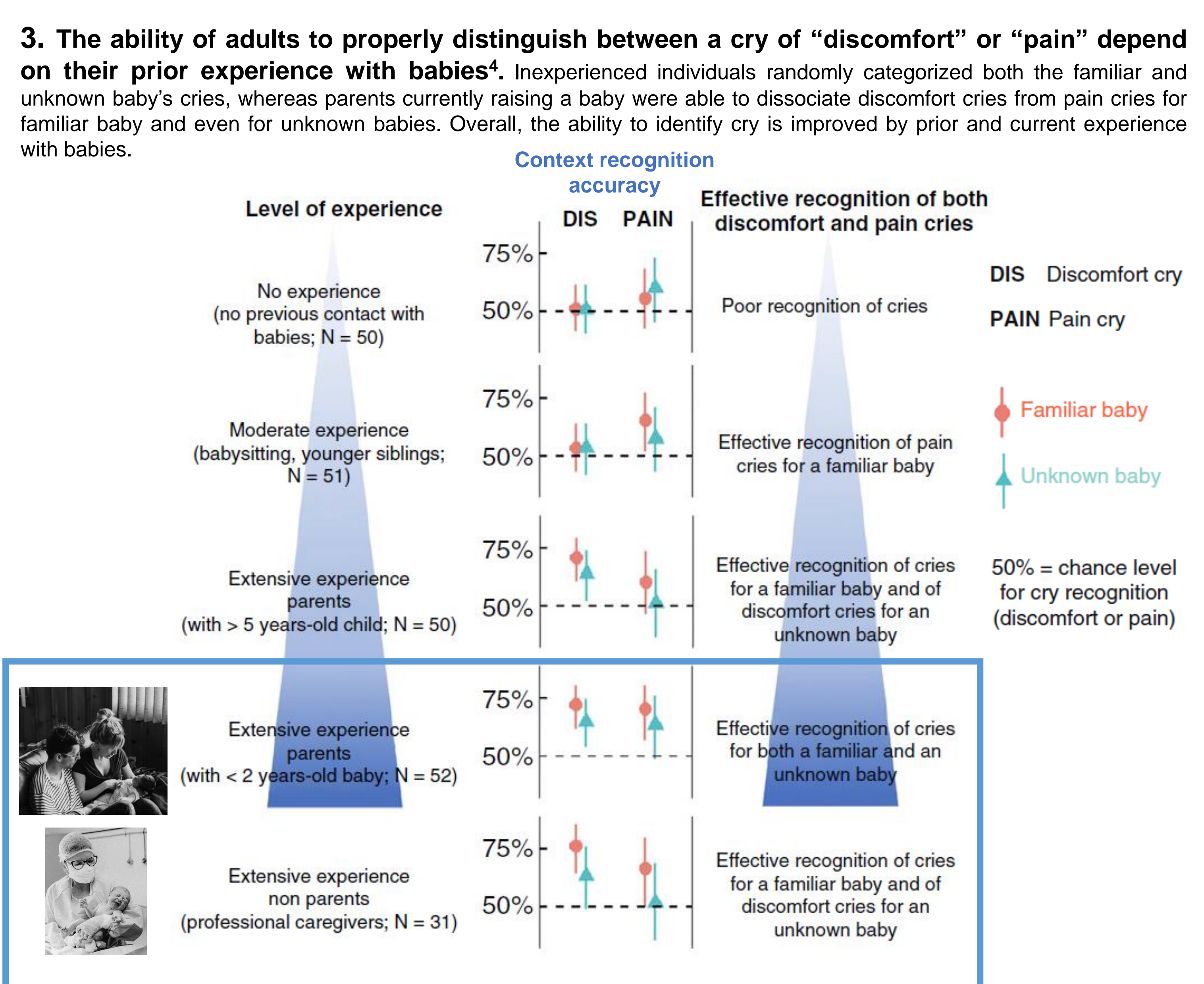
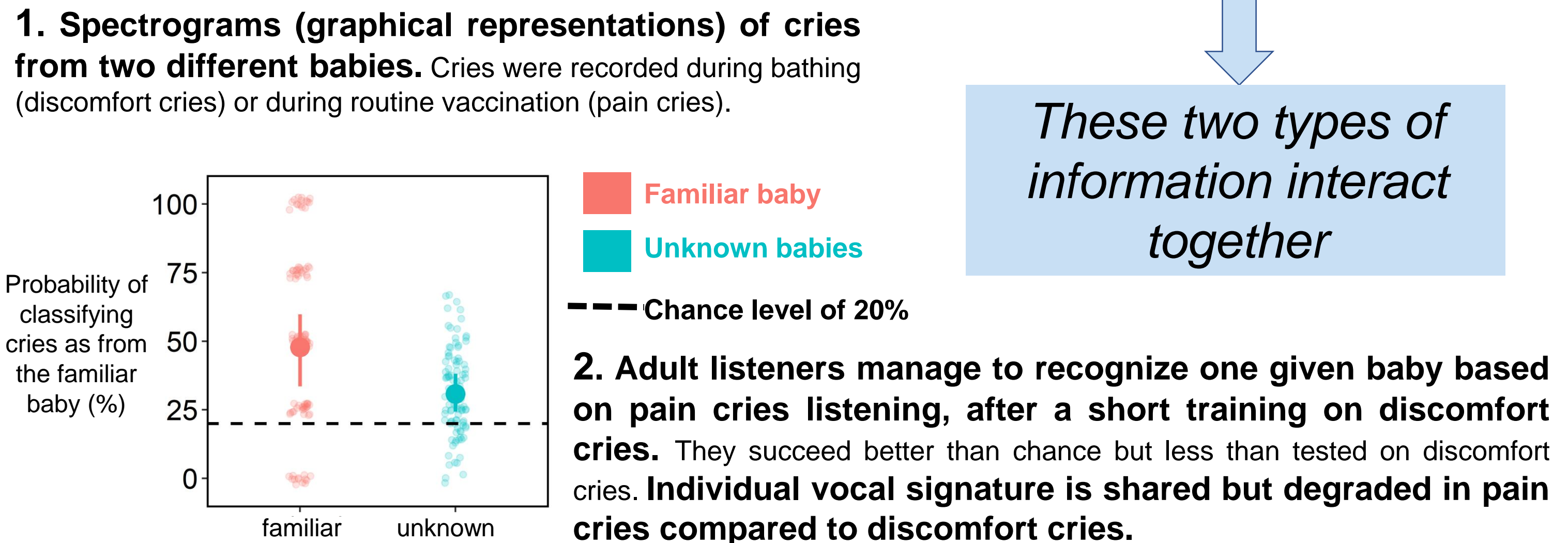
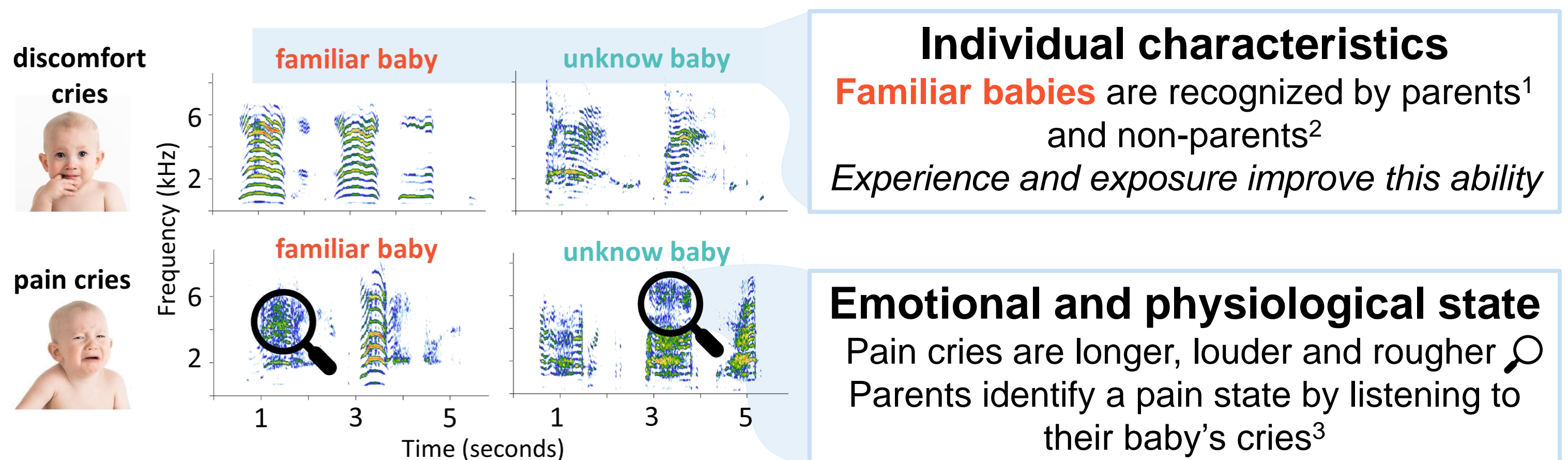
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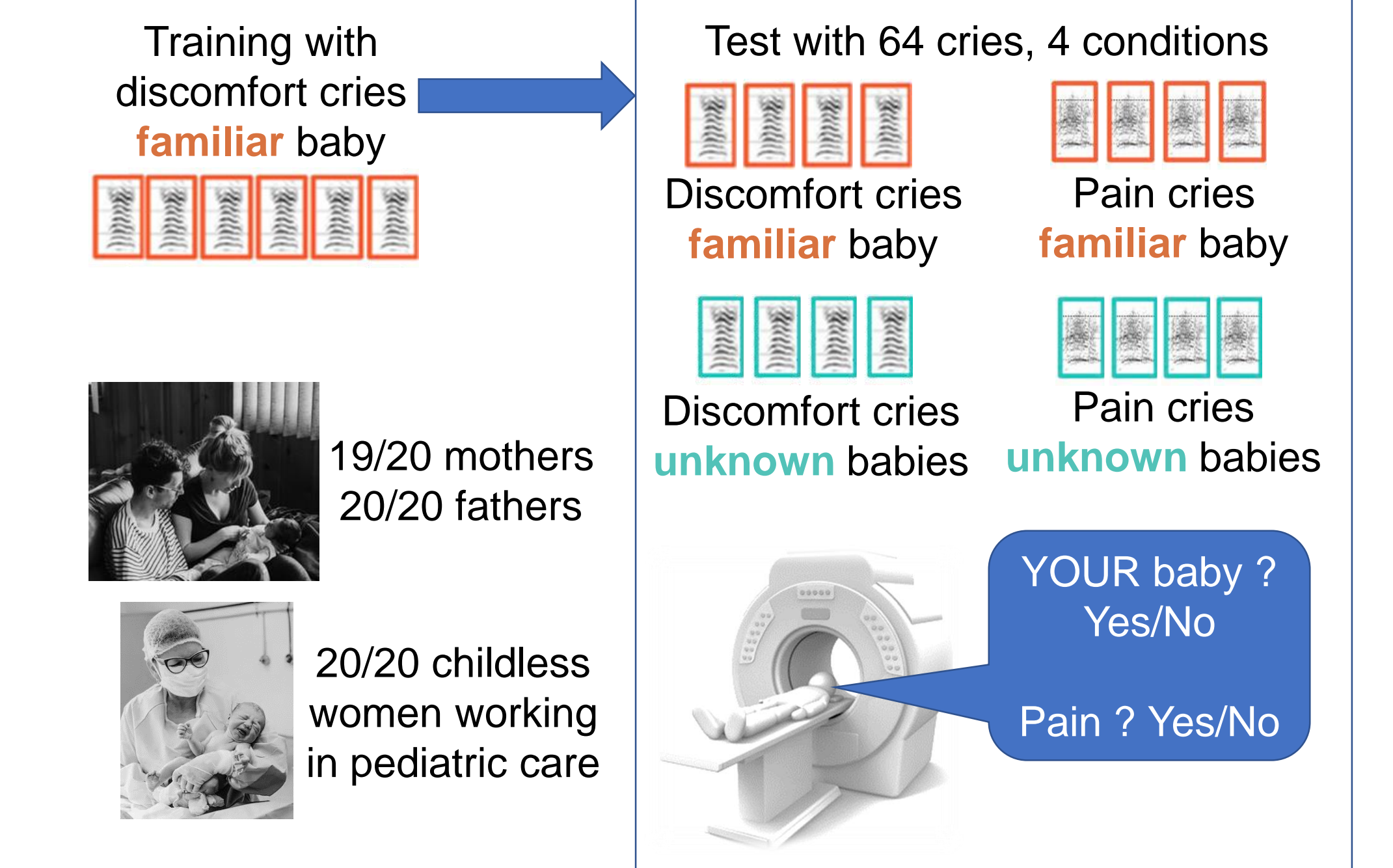
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Background: babies cries convey various information



What are the neural correlates of identifying these cries in expert participants?

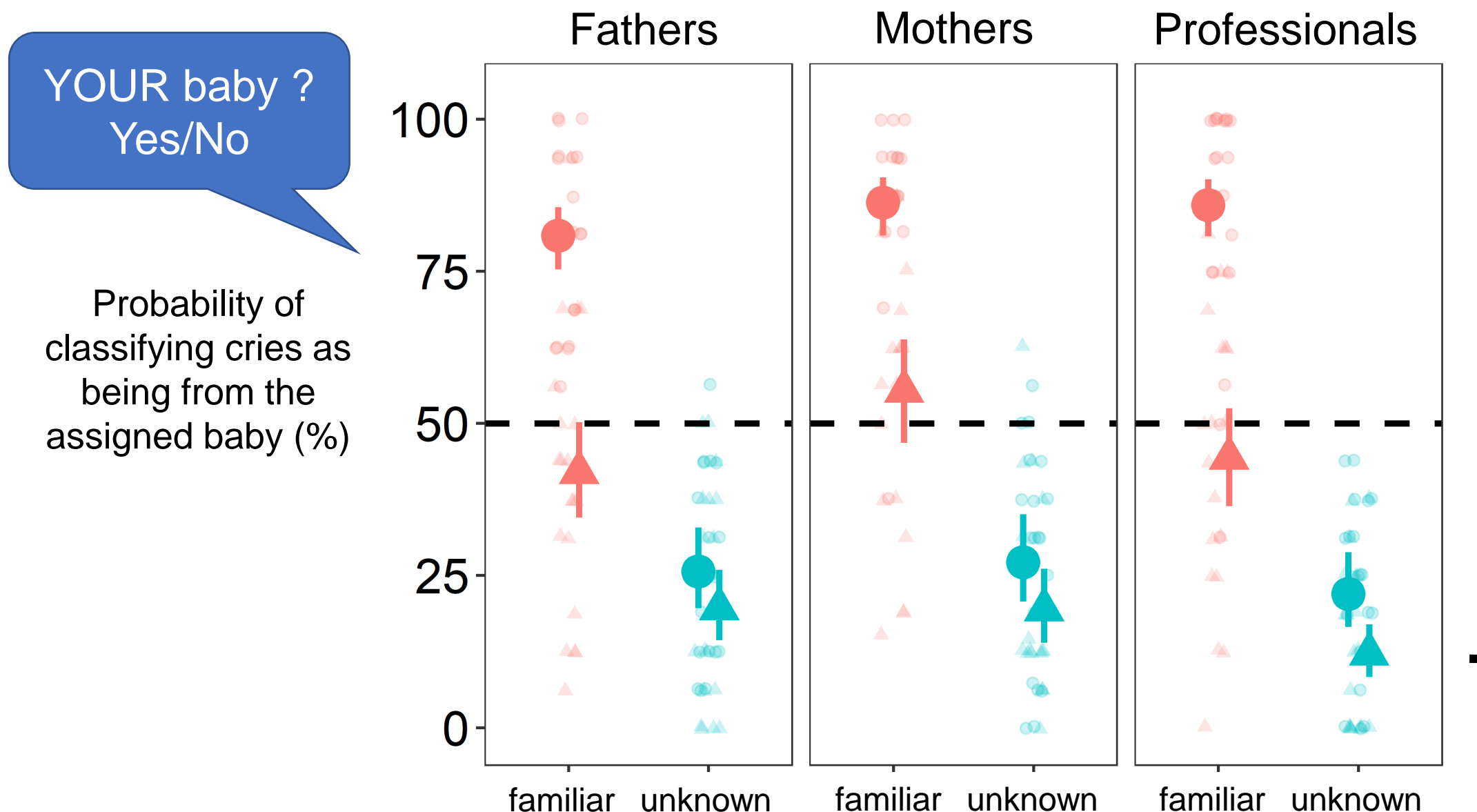
Methods



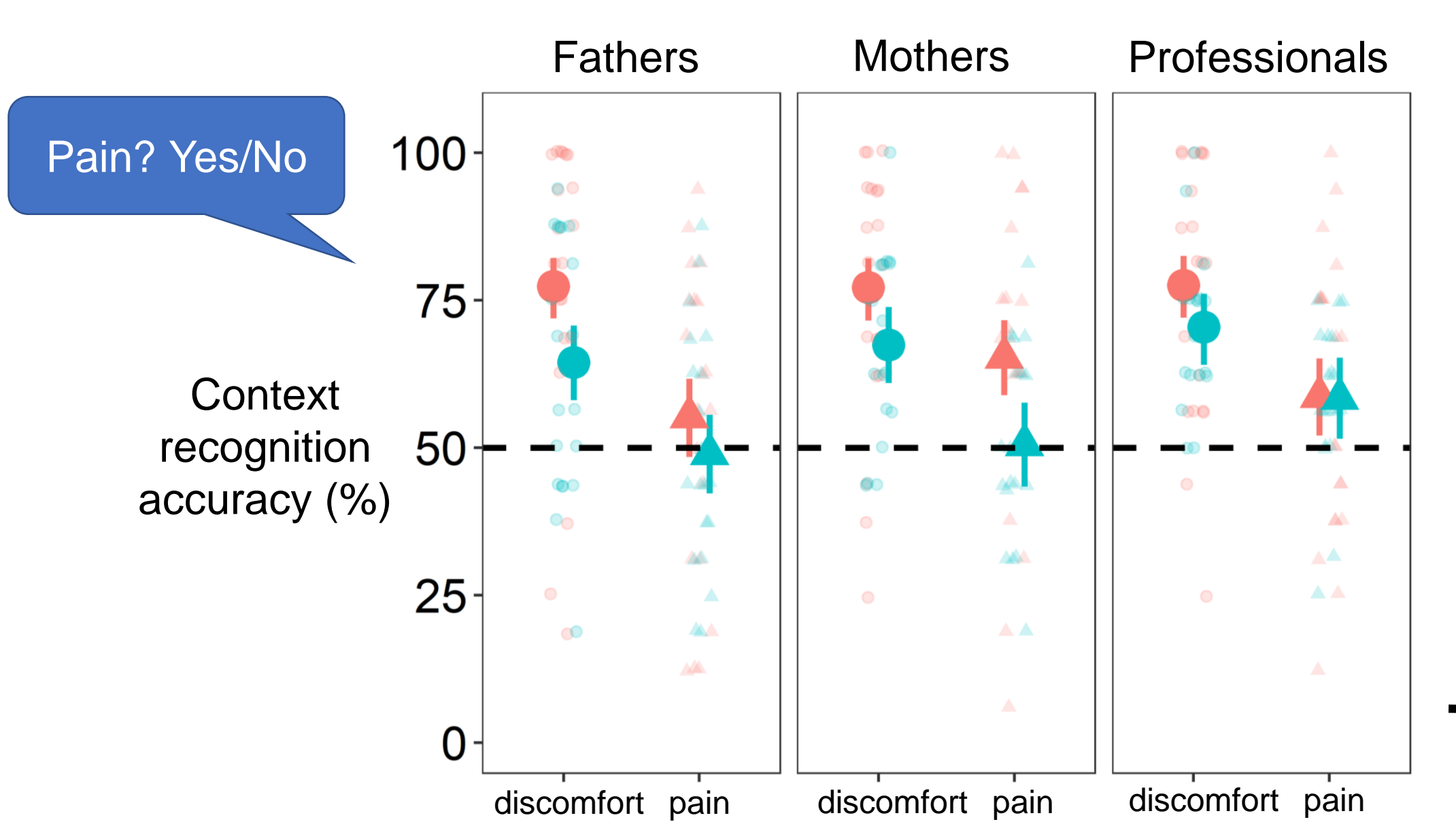
4. Experimental design. Adult subjects were first trained by hearing discomfort cries from an assigned baby. In a second step, subjects listened to cries from 4 conditions (familiar/unknown; discomfort/pain). After each cry, they had to tell if they recognized their baby or not, and if they recognized pain or not.

Bayesian mixed models and BOLD contrasts

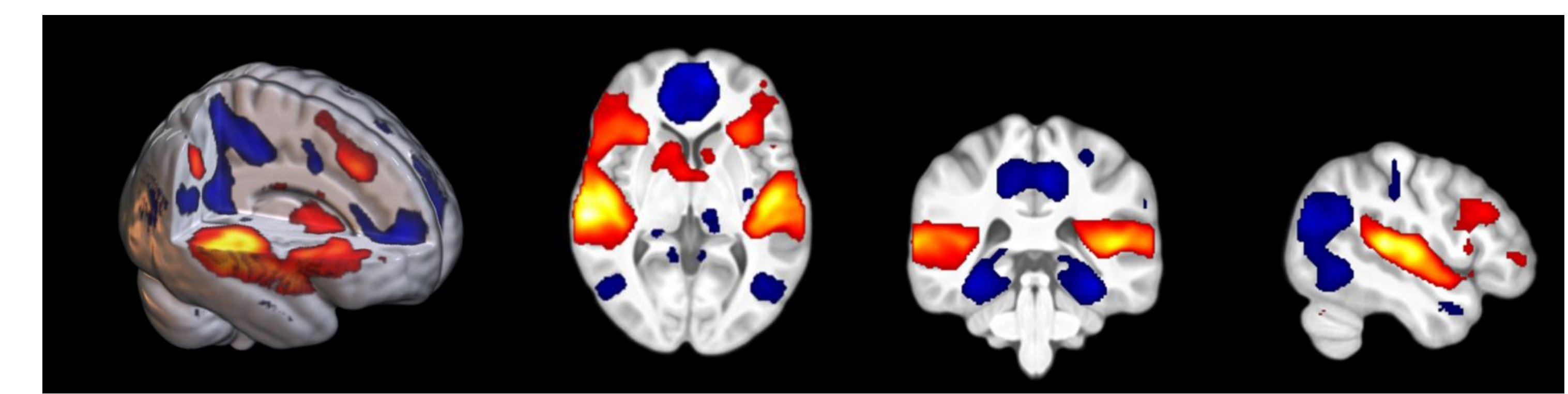
Results



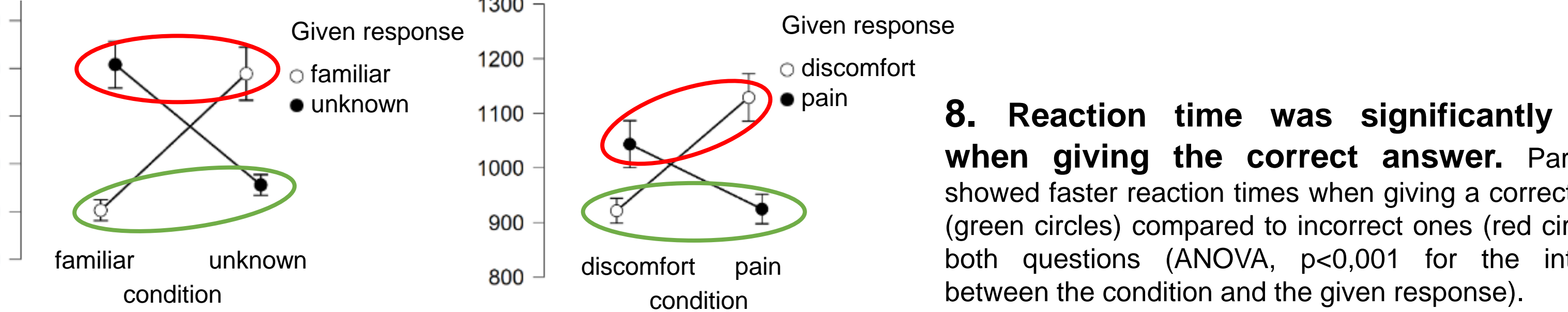
5. Adult listeners recognized very well their familiar baby based on discomfort cries, but not based on pain cries. Participants showed 84% of correct recognition (95% credible interval CI [81,87], 100% of the posterior distribution above the chance level) based on discomfort cries, but only 47% [43,52] based on pain cries listening. They correctly rejected cries of unknown babies (21% [18,24] of false-positive), either discomfort and pain cries.



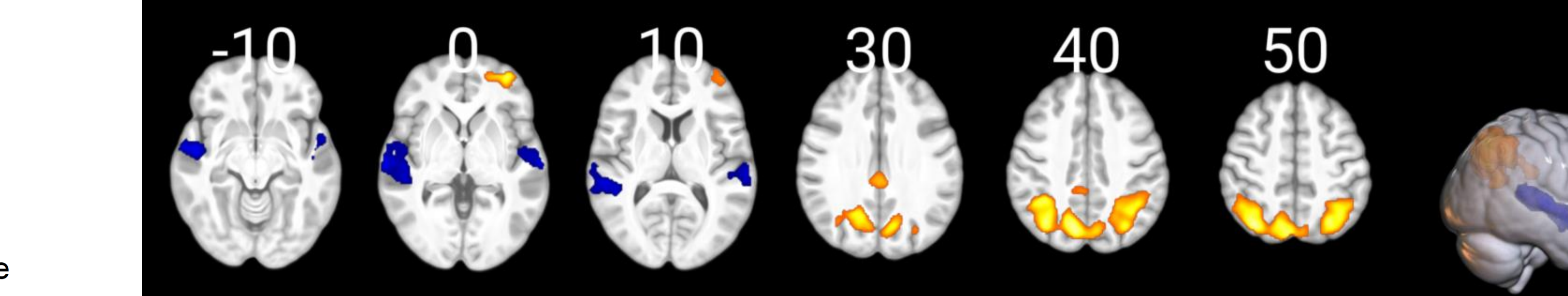
6. Pain cries were recognized slightly above chance, and less than discomfort cries. Participants showed on average 64% of correct recognition of cry's context (95% CI [61,67], 100% of the posterior distribution above the chance level). This was higher for discomfort cries (72% [70,75]) than for pain cries (56% [53,59]).



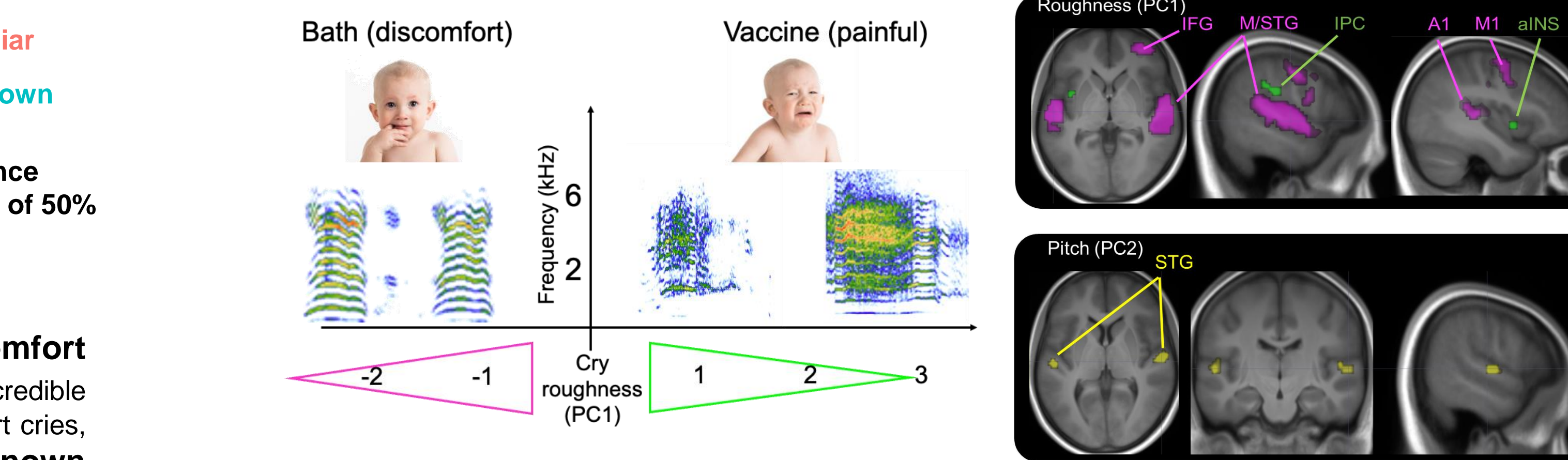
7. Cries listening involved activation in a large-scale brain circuit (including auditory, cognitive, attention, emotion regulation and mirroring brain networks). BOLD activations (in orange) were mainly observed bilaterally in the middle and superior temporal gyri (MTG, STG), in the angular gyri and supramarginal gyri (SMG). Decreased BOLD signal (in blue) was observed bilaterally in the superior frontal and middle occipital gyri.



8. Reaction time was significantly faster when giving the correct answer. Participants showed faster reaction times when giving a correct answer (green circles) compared to incorrect ones (red circles) for both questions (ANOVA, $p < 0.001$ for the interaction between the condition and the given response).



9. Successful recognition of the assigned « familiar » baby activated brain areas known to be involved in perspective-taking and emotion regulation. BOLD activations (in yellow) were found in angular gyri bilaterally, the precuneus, the posterior part of the cingulate cortex and the left middle frontal gyrus. Deactivations (in blue) were mostly found in auditory areas.



10. Pain cries were characterized by acoustic roughness, which recruited the empathy brain network. Pain cries are associated with vocal roughness (biphonation, subharmonics, and deterministic chaos). Listening of rougher cries was associated with stronger brain activity in the bilateral anterior insula and the inferior parietal cortex (in green), whereas lower roughness was associated with activity in the bilateral auditory association cortex, premotor areas, and the right dorsolateral and inferior frontal cortex (in purple). The cry average pitch, a poor marker of pain, mainly recruited auditory areas (superior temporal gyrus, in yellow).

Conclusion

Cries contain strong information on baby's identity allowing expert listeners to recognize one given baby. This identification relies on brain areas known to be involved in recognition of familiar features⁵ (familiar faces, places, music...).

Pain cries are associated with acoustic roughness. Despite this acoustic specificity, identifying pain in cries is difficult for experts in babies care, both parents of young babies and professional caregivers, leading to no specific BOLD activation. However, acoustic roughness, specific to pain in cries, is linked to increased activity in brain areas involved in empathy.

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