Face-Selective Responses in FFA and MPFC Emerge Early in Human Infancy

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ABSTRACT

Faces are a rich source of social information that activate many different regions in the human brain. How do these regions develop? According to one prominent hypothesis, face selectivity must emerge in visual regions (e.g., the fusiform face area (FFA)) prior to regions in higher-order association cortex (e.g., the medial prefrontal cortex (MPFC)). To test this hypothesis, we combined functional magnetic resonance neuroimaging (fMRI) datasets from awake human infants (total n=65 infants, aged 2.6-11.9 months) while they watched movies of faces, bodies, objects, and scenes. The youngest and oldest infants in this group had face-selective responses in both the ventral temporal cortex (the approximate location of adult FFA) and MPFC. Although the overall magnitude of responses to visual stimuli increased with age in FFA, face selectivity did not increase significantly with age in either region. Taken together, these results do not support the hypothesis that cortical function develops in visual regions like FFA prior to amodal regions like MPFC, instead suggesting that face-selective responses emerge in parallel across the brain.

Keywords: infants, cerebral cortex, fMRI, FFA, MPFC, OFA, STS, faces

INTRODUCTION

In adults, many cortical regions show increased activity when people see faces (1–3). These regions are found in distant parts of cortex, and likely have distinct functions. Visual regions like the fusiform face area (FFA) are involved in detecting and perceiving faces (4, 5). By contrast, responses to faces in amodal association regions like medial prefrontal cortex (MPFC) have been implicated in recognizing the social and emotional meaning of faces (6, 7). When and how do face-selective responses in these regions arise in human development? Testing when each region first exhibits face selectivity allows us to put a lower bound on the amount of visual and social experience required to initially form face-selective responses in these regions. In addition, investigating these two regions in the same infants allows us to test whether face selectivity emerges in series, with visual regions necessarily becoming face-selective before amodal associative regions. We call this the Serial Hypothesis of cortical functional development and test it in a sample of awake human infants using fMRI. Our results do not support the Serial Hypothesis, and instead suggest that face-selective responses in both FFA and MPFC emerge early, and in parallel, in infancy.

Serial Hypothesis of Cortical Development

The Serial Hypothesis of cortical functional development holds that brain regions become selective for higher-level visual categories, like faces, in a bottom-up, feed-forward developmental sequence (for recent reviews see: (8–11)). On this view, face-selective responses arise first in subcortical regions (12). The frequent appearance of face-like images in infants' visual experience then drives bottom-up, self-organizing specialization of regions in the cortical visual system (8, 13). For example, the area of ventral temporal cortex (VTC) that becomes the FFA would acquire its face-selective response profile gradually, through visual exposure to the combination of curvy, low spatial frequency characteristics of faces (14, 15). In line with this hypothesis, the extent of cortex in the fusiform gyrus that responds selectively to faces (i.e., the size of FFA) increases throughout childhood (16–25) and macaques raised without exposure to faces do not have face-selective responses (26).

Along with FFA, the occipital face area (OFA) in inferior occipital gyrus (IOG) and the posterior superior temporal sulcus (STS) compose the classic cortical "face network" (2). In early formulations, the OFA was proposed to be first in a visual hierarchy providing input to FFA and STS (2, 27). However, this online processing hierarchy is disputed (28–30), and it is unknown if face-selective responses in OFA, FFA, and STS emerge in sequence or in parallel during development.

Once faces are visually detected and identified, they often evoke rich social and emotional responses in viewers. In adults, a region in MPFC responds more when adults view dynamic faces compared to other visual categories (6). However, this region's response profile across other stimuli and tasks is distinct from the response profile in classic face-selective regions like FFA. The face-responsive region in MPFC has high responses to social stimuli, like faceless animated shapes conveying social interactions, and verbal narratives about the thoughts and feelings of others (6, 7).

The Serial Hypothesis of cortical functional development posits that only after the FFA has developed face-selective responses, can MPFC develop responses to the social and emotional significance of faces. Consistent with this view, anatomically, MPFC matures substantially later than VTC (31–36). Signatures of cortical maturation including expansion (37), increased sulcal depth (38),

and myelination (39–41) occur in VTC earlier in developmental than in MPFC. Indeed, new neurons are still migrating and being integrated into prefrontal cortex well into the second year of life (42) – while this process is completed in primary sensory areas around the time of birth (43). If cortical functions mature at the same rate as anatomical development, MPFC should develop face responses slowly and late (44).

Parallel Cortical Development

By contrast to the Serial Hypothesis, we propose that face responses in MPFC may emerge just as early in development as face responses in FFA. This alternative is inspired by substantial behavioral and neural evidence.

Behaviorally, infants' attention to socially and emotionally relevant faces begins extremely early in development. Within hours of birth, neonates can distinguish a familiar face from an unfamiliar one (45–47). Furthermore, infants' attention to faces reflects integration of multimodal cues to social value. Young infants prefer to look at one face more than another based on non-visual (e.g., speaker language, prosody, social behavior) properties (48–50). For example, infants recognize and preferentially attend to a stranger who had briefly addressed them in their own language, accent, or in infant-directed speech, compared to an equally familiar stranger who had not (49, 51). Even within the first 12 hours after birth, infants prefer to look at their own mother's face, compared to a female stranger (45–47), identified by association with the mother's voice (47). In one series of studies, three-hour-old infants looked more at their mother's face, than a female stranger's face, when they had experienced their mother's voice and face together in those three hours; but not if their mother had been instructed to remain silent during those hours (47, 52). These behavioral data suggest that infants' brains must be able to rapidly learn and represent not just the visual form, but also the multimodal associations, social meaning, and emotional value of faces.

Consistent with these behavioral data, studies using functional near-infrared spectroscopy (fNIRS) in human infants show responses to faces in the MPFC by 5 months (the earliest age reported) (53–60). Activity in MPFC is influenced by multimodal cues to social value: infants' MPFC responses are greater when infants see a face accompanied by infant-directed speech compared to other sounds (61, 62) (but see (63)), especially when the speaker is the infant's mother (62, 64), using the infant's name (64), or is looking directly at the infant (61). Infants with more activity in MPFC have a stronger behavioral preference to look at smiling faces (55).

Current Study

In sum, within the first year of life, infants respond behaviorally to the social meanings of faces and have responses in MPFC to socially meaningful stimuli including faces. These results call into question the Serial Hypothesis that infant cortex learns to identify and selectively respond to the visual forms of faces well before they start to associate social meaning with faces. However, no previous study has directly tested whether face-selective responses in human infants emerge in FFA prior to amodal regions like MPFC. To test this hypothesis requires simultaneously measuring responses in FFA and MPFC in young infants. A key challenge for testing these alternatives is that FFA is located on the ventral surface of the brain, and so not readily accessible to skull-surface-based measurements like fNIRS and EEG. Functional MRI is the only neuroimaging method that has the coverage and spatial resolution to measure neural responses simultaneously in FFA and MPFC. A substantial challenge for fMRI with infant populations, however, is that fMRI requires the

participant to be still for long periods of time during data acquisition. Awake infant fMRI studies remain rare (65).

For the current study, to more densely sample infants' neural responses to faces in the first year of life, we analyzed fMRI data (Figure 1a) from 65 infants (Figure 1d) while they watched dynamic videos of faces (Figure 1b), bodies, objects, and scenes (Figure 1c). Infants ranged in age from 2 to 9 months, meaning that the oldest infants had three times as much post-birth experience as the youngest ones. Thus, these data allow us to test distinctive predictions of the Serial Hypothesis. First, we tested whether infants as a group have any face-selective responses in the purported latest developing face region (MPFC). Second, we tested whether younger infants have face-selective responses in FFA but not yet in MPFC. Third, we tested whether cortical face-selective responses are correlated with age, and in particular whether face-selective response in MPFC arise and increase later than in FFA.

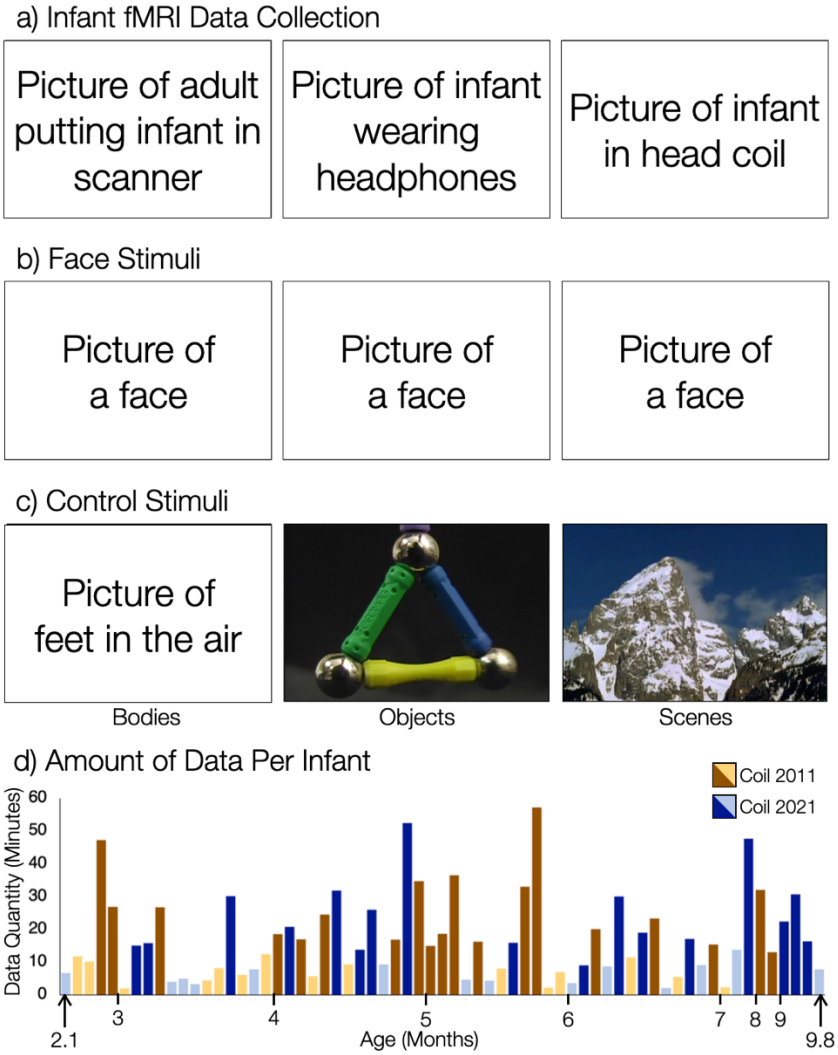

Figure 1. Awake Infant fMRI Scanning and Stimuli. (a) For each MRI visit infants were swaddled, scanner safe headphones were used for hearing protection, and infants were placed in a custom 32-channel infant head coil. Movies were projected in a mirror over infants' eyes. Photo credit for images in the middle and right to Caitlin Cunningham Photography. Photo credit for the

image on the left to Kris Brewer. (b) Example frames from dynamic face stimuli. (c) Example frames from dynamic body, object, and scene stimuli. (d) Infants that had enough usable data to compute a whole-brain contrast image are plotted on the x-axis, ordered by age in months. Data collected using Coil 2011 is indicated in brown, data collected using Coil 2021 is indicated in blue. Darker color indicates inclusion in fROI analyses (see Methods for inclusion criteria).

RESULTS

Infant fMRI Data

To increase our ability to measure age effects, we collapsed our analysis across data that were collected using two different infant head coils. We attempted to scan one group of infants (n=31, from June 2016 to July 2019) on Coil 2011 (66) with a sinusoidal acquisition sequence (67) and a second group of infants (n=56, from July 2019 to February 2020) on Coil 2021 (68) with a standard acquisition sequence (see Methods). Each infant was scheduled for up to 8 visits. Any usable data that were collected within a 30-day window on the same coil with the same acquisition sequence were analyzed as a single session. In total, we had 74 sessions from 61 individuals (2.0-9.8 months, mean=5.2 months). For each session, we collected 4.30-112.70 minutes of data (mean=34.92 min, s.d.=22.45 min). To be eligible for analysis, we identified segments of usable data with less than 2mm/degrees of frame-to-frame displacement for (see Methods), resulting in 65 usable sessions (2.1-9.8 months, mean=5.3) from 53 unique individuals with 2.05-57.25 minutes of usable data per session (Figure 1d; mean=16.99, s.d.=12.82). Of these, 49 sessions from 46 unique individuals had enough data to be included in whole brain random effects analyses and 37 sessions from 33 unique individuals met the inclusion criteria for fROI analyses (see Methods for details of inclusion criteria).

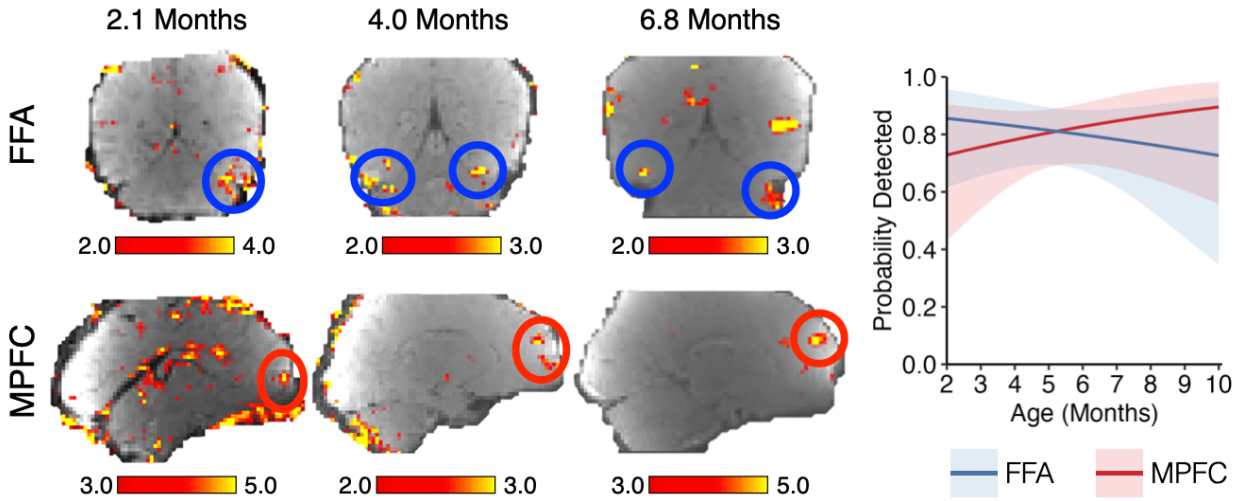

Figure 2. Face Responses in the Human Infant Brain. Whole brain voxel-wise analyses revealed face activations (faces>non-face) in individual infants (example 2.1-, 4.0-, and 6.8-month-old infants) around the fusiform face area (FFA; blue circle) and medial prefrontal cortex (MPFC; red circle). Images are overlaid on subject-specific T2*. Thresholds indicated in *z*-value heat scale for each image. Logistic regression results indicate that probability of detecting face activations in FFA and MPFC are not predicted by age.

Face Responses in Infants' Brains

Do infants have face-selective responses in both FFA and MPFC? To start, we compared responses to faces versus non-face control conditions (i.e., bodies, objects, and scenes) across the whole brain in individual infants, at lenient statistical thresholds (p<0.01, uncorrected). Visual inspection of contrast maps (faces>non-faces) from all sessions with enough usable data (n=65, all maps are shown in Figure S2-S10) revealed face activation in the approximate location of FFA in 52 individual subjects and in the approximate location of MPFC in 52 individual subjects (Figure 2). We observed face activations in FFA but not MPFC in 8 subjects (2.6-9.6 months), and in MPFC but not FFA in 8 subjects (3.8-8.8 months). The majority of individual subjects had activation in both FFA and MPFC (n=44, 2.6-9.6 months). In 5 infants (3.3-5.8 months) no activations were observed in either FFA or MPFC. Indeed, in a logistic regression the probability of detecting a face activation did not differ between regions (Figure 2; FFA or MPFC, β=1.29, SE=1.38, p=0.4), did not change with age (β=0.15, SE=0.18, p=0.4), and there was no interaction between age and region (β=-0.25, SE=0.25, p=0.3). Thus, visual inspection of face activations in individual contrast maps suggest that responses to faces arise early in infancy, in both FFA and MPFC.

Combining the individual maps in a whole brain group analysis posed a challenge because of the different distortions in the datasets from the two coils. As a result, we conducted separate whole-brain random effects analyses of the *Coil 2011* data and *Coil 2021* data (Figure S3). At lenient thresholds (p<0.05 voxelwise, uncorrected) activation was observed in the vicinity of FFA in the Coil 2021 group only, and in MPFC in both groups. Neither region survived correction for multiple comparisons.

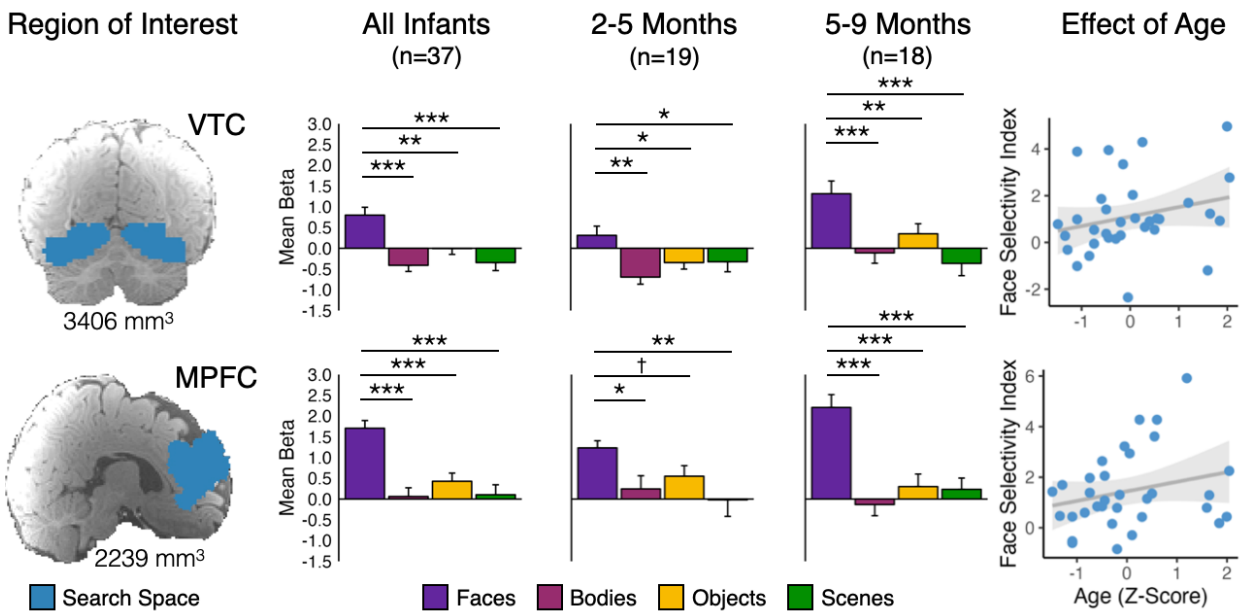

Figure 3. Face-selective responses in infant VTC and MPFC. In analyses collapsed across Coil 2011 and Coil 2021 datasets, we identified a face-selective fROI in each participant as the top 5% of voxels that responded more to faces than non-faces within a large anatomical search space (first column, blue, projected onto an infant anatomical image) of ventral temporal cortex (VTC, top) and medial prefrontal cortex (MPFC, bottom). Bar charts show the average response across participants in each fROI to faces (purple), bodies (pink), objects (yellow), and scenes (green) in data

independent of that used to define the fROI. Error bars indicate within-subject SE (69). Symbols indicate one-tailed statistics from linear mixed effects models: $^{\dagger}p<0.1$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$. Scatter plots show the face selectivity index (face β - μ(body β, object β, scene β)) as a function of z-scored age. Statistics reported in Tables 1 and 3.

Face-Selective Responses in Infant VTC and MPFC, but not Early Visual Cortex

To test whether face responses were significantly greater than the response to each control condition (i.e., face-selective), we used a functional region of interest (fROI) analysis. For all fROI analyses, we collapsed across Coil 2011 and Coil 2021 datasets. Previously, we reported that infants have face-selective responses in FFA in the Coil 2021 dataset (70). That analysis was done with a small anatomical constraint parcel localizing FFA. Here, to accommodate the lower resolution data obtained with Coil 2011, we used a larger VTC anatomical parcel. From each infant we used one subset of data to identify the top 5% of voxels in the VTC parcel that responded more to faces than non-face conditions. Then, from these voxels, we extracted the response to each of the four conditions from independent, left-out data. We iterated across data splits to obtain an average response to each condition in each parcel for each infant (see Methods). In VTC (Figure 3; Table 1), the face response was significantly greater than the response to bodies ($p<0.001$), objects ($p=0.003$), and scenes ($p<0.001$). Thus, using larger anatomical constraint parcels and combining Coil 2011 and Coil 2021 datasets, we confirmed that infants have face-selective responses in VTC. The overall magnitude of response in VTC, across all conditions, increased with age in this sample ($p=0.02$); there was no age by condition interaction ($p>0.1$, Table 2).

Given that infants have face-selective responses in VTC, the Serial Hypothesis predicts that infants may not yet have face-selective responses in MPFC. Using the same fROI cross-validation procedure described above, we selected the top 5% of voxels in MPFC that responded more to faces than the average response to non-face conditions. Then, in independent left-out data, we extracted the responses to all four conditions from these voxels. In MPFC (Figure 3; Table 1) the face response was significantly greater than the response to bodies ($p<0.001$), objects ($p<0.001$), and scenes ($p<0.001$). Additionally, the response in MPFC was just as face-selective as in VTC; when we directly compared responses in VTC versus MPFC, using a linear mixed-effects model, we found no region by condition interaction ($F(1,31)=0.006$, $p=0.9$; Table 2). Thus, 2- to 9-month-old infants have equally face-selective responses in VTC and MPFC.

In addition to VTC and MPFC, we tested for face-selective responses in infant IOG and STS. Both regions had face-selective responses (Figure 4; Table 1). For details see supplemental materials.

At this point, one might be concerned that fROI analyses are so sensitive that any region could appear to have a face-selective response. To address this possibility, we conducted an fROI analysis in occipital areas, the predicted location of early visual cortex (EVC), where we do not expect to observe face-selective responses. We used the same procedure in the EVC parcel that we used in VTC and MPFC parcels – in each infant, we selected the top 5% of voxels that responded more to faces than non-faces, and then extracted the response to all four conditions in these voxels from independent, left-out data. Face responses in the selected voxels of EVC were significantly

greater than the response to objects (p=0.009) but were not statistically different than the response to bodies and scenes (ps>0.1; Table 1).

In particular, the response to faces in EVC should be substantially different from the response in genuinely face-selective regions. Thus, we directly compared the response in each proposed face-selective region to the response in EVC. Responses were more face-selective in VTC than in EVC (region by condition interaction, F(3,251)=2.86, p=0.04) and in MPFC than in EVC (region by condition interaction, F(3,254)=3.02, p=0.03; see Table 2). Thus, even in voxels selected for maximal responses to faces, we confirmed that voxels in infant EVC are not face selective and are significantly different from face-selective responses in VTC and MPFC.

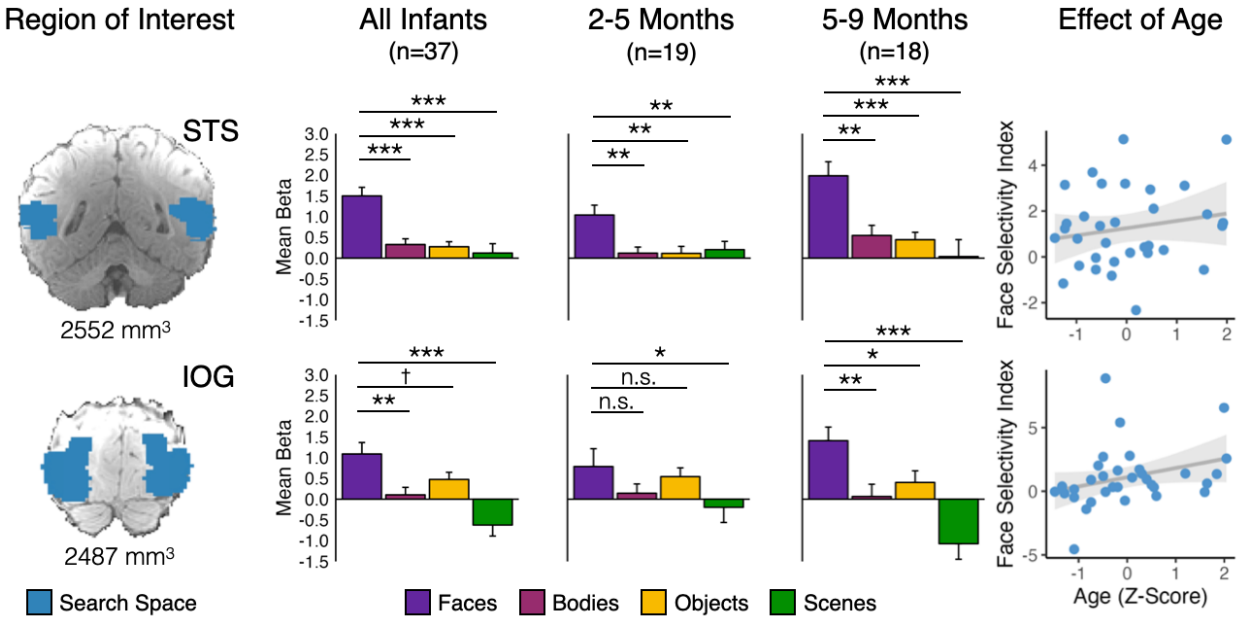

Figure 4. Face-selective responses in infant STS and IOG. In fROI analyses collapsed across Coil 2011 and Coil 2021 datasets, , we identified a face-selective fROI in each participant as the top 5% of voxels that responded more to faces than non-faces within large anatomical search spaces (first column, blue, projected onto an infant anatomical image) of superior temporal sulcus (STS, top) and inferior occipital gyrus (IOG, bottom). Bar charts show the average response across participants in each fROI to faces (purple), bodies (pink), objects (yellow), and scenes (green) in data independent of that used to define the fROI. Error bars indicate within-subject SE (69). Symbols used to report one-tailed statistics from linear mixed effects models: $^{\dagger}p$<0.1; $^{*}p$<0.05; $^{**}p$<0.01; $^{***}p$<0.001. Scatter plots show the face selectivity index (face β - μ(body β, object β, scene β)) as a function of z-scored age. Statistics reported in Tables 1 and 3.

No Evidence that Face Selectivity in FFA Emerges Earlier in Development than MPFC

The Serial Hypothesis distinctively predicts that the youngest infants should have face-selective responses in VTC, but not yet in MPFC. We tested this prediction in two complementary ways. First, we split the infants into two groups using a median split by age and asked if each group of infants had face-selective responses in VTC and MPFC. In the younger group of infants (n=19, 2.5-5.1 months) the face response in VTC was significantly greater than the response to bodies (p=0.001), objects (p=0.02), and scenes (p=0.03). In this same group of infants, the MPFC face

response was also greater than the response to each other condition (bodies p=0.02, objects p=0.08, scenes, p=0.005; all ps<0.03 in weighted LME, see Methods and Table S1). For both regions, older infants (n=18, 5.2-9.6 months) also had face selective responses (all ps<0.004). So, overall, responses in VTC and MPFC are face-selective in both the younger and the older half of the sample.

Next, we tested whether individual older infants have stronger face selectivity than younger infants. For each infant, in each region we calculated a face selectivity index (face β - μ(body β, object β, scene β)), and tested whether it was correlated with age. In both VTC and MPFC, age did not predict the selectivity index (ps>0.1; Table 2). Taken together, these results do not support the hypothesis that face-selective responses emerge in VTC prior to MPFC.

We conducted the same analyses in infant IOG and STS. The STS had face-selective responses in both younger and older infants that were not correlated with age (Figure 4; Table 1). The IOG, by contrast, showed a face-selective response only in the older babies (Figure 4; Table 1), and the overall response to all conditions increased with age, but there was no correlation between the face selectivity index and age (Figure 4; Table 2).

DISCUSSION

To test the Serial Hypothesis of cortical development, we asked: does the development of face responses in amodal associative regions, like medial prefrontal cortex (MPFC), require visual areas to first develop face selectivity? Here, we found that MPFC has face-selective responses in infants, from age 2 months on, the same age range in which we observed face-selective responses in FFA. Taken together, our results fail to support the Serial Hypothesis, and instead suggest that face-selective responses emerge in parallel across infant cortex.

FFA in infancy and through development

Here we show that not only do very young infants have face-selective responses in the approximate location of adult FFA (70), but that face selectivity (the difference between faces and other categories) does not change significantly across the age range tested here. The youngest infants are just as likely as the older infants to have a detectable FFA. How do these results fit in with the last few decades of research probing FFA development?

Considerable evidence indicates that the FFA plays a selective and causal role in face perception in adults. In particular, fMRI studies have shown that the FFA responds more to faces than any other stimulus yet tested (1, 71–74) (but see (75)). The FFA has been proposed to support face recognition by encoding face features, to hold information about identity, gender, and expression, and to be engaged both in face detection (i.e., distinguishing faces from other objects) and face identification (i.e. discriminating different faces from each other) (76–79). Intracranial recordings have further revealed that individual FFA neurons respond more to faces than non-faces objects (4, 80–83). Electrically stimulating this area leads patients to report distorted face (but not object) percepts (5, 84) and to perceive a face superimposed on non-face objects (4, 5, 82).

When in development does face selectivity emerge in FFA? In children, FFA responds more to faces than other non-face visual categories (16–25, 85–87). However, compared to adults, children have (1) a smaller volume of cortex with a significant face>non-face response and (2) a smaller magnitude response difference between face and non-face categories (16–25) (although see

(85–87)). These developmental differences are thought to correspond to face recognition and discrimination abilities that also change during this period (17, 21). But the question of when in development face selectivity initially emerges has remained elusive.

The first neuroimaging studies with human infants suggested an early preferential response to faces in the approximate location of FFA, without full face selectivity. An early PET study demonstrated that young infants have responses to faces in the approximate locations of FFA, STS, and MPFC (58). But this study was limited because infants saw only two kinds of stimuli, static images of female faces and one control condition, colorful diodes. Similarly, an initial fMRI study found face preferences, but not selectivity, in a small sample of human infants (88). Consistent with evidence in humans, face-selective responses were observed in infant macaques only late in the first year of life (89), which is thought to correspond to approximately age 3 years in human development. Thus, initial PET and fMRI investigations in infants and children suggested that face selectivity in FFA might initially arises in toddlers or young children, only after substantial visual experience.

However, other fMRI and EEG data challenge that view. Two recent fMRI studies in awake infants observed face-selective responses in FFA, using different stimuli and task procedures (70, 90). For the current paper, we re-analyzed the data reported in one of these papers (70), combining data collected with different coils to more sensitively look for age-related change in face-selective responses. To accommodate the different spatial distortions in the two coils, we used larger anatomical parcels, sacrificing spatial resolution, in exchange for a larger sample of younger infants. Using this strategy, we identified face-related activity, and measured face-selective responses, in VTC of infants 2- to 5-months-old. These results are consistent with EEG evidence of a distinctive response to faces, compared to other visual objects, in the brains of 4- to 6-month-old infants, with a source likely in the ventral visual stream (91). fMRI studies similarly have found early origins for retinotopic organization of visual cortex (92) and for responses to motion in MT (93, 94). Compared to these other visual regions, FFA development might be less dependent on visual experience. Adults born with cataracts that were removed by age two, have reduced motion-related responses in in MT but have preserved responses in FFA (95). Further, FFA responses are heritable (96, 97) and are partially preserved in congenitally blind adults (98, 99). In sum, the current results fit with a growing body of evidence that face selectivity in FFA initially arises within a few months after birth and requires little visual experience.

Still, it is likely that many aspects of the FFA response change with both age and visual experience. The initial face-selective region in infants may be very small, and then expand to cover more of the fusiform gyrus during childhood (16–25); because of the spatial distortions we cannot confidently estimate the size of the region we observed in infants. In children, the extent of face selective cortex is correlated with face recognition and memory abilities (17), which continue to develop into adulthood (100–102). One important question for future research will be whether the size or selectivity of FFA in infants correspond to their face recognition abilities. Another interesting question is how the representation of face features, and face identities, in FFA changes during infancy and early childhood (90).

Face-Selective responses in IOS and STS of infants' brains

In addition to FFA, we also found that infants have face-selective responses in IOG and STS. Face-selective responses in IOG are in the approximate location of adult OFA. Like FFA, the

overall neural response to all visual categories in IOG increased with age, but face selectivity was not correlated with age. In initial models of the cortical face network, OFA was positioned as the source of face-specific input to FFA (2, 27). Consistent with a feedforward hierarchy, during online processing of faces, responses in OFA are faster than responses in FFA (103, 104). Yet damage to OFA in adulthood does not impair face selectivity in FFA (30, 105, 106). Thus, it is debated whether OFA is a necessary source of input to FFA, in a single hierarchy, or whether FFA receives sufficient face-specific input from other sources (30, 103, 107). Thus, the Serial Hypothesis does not predict whether development of OFA face selectivity would precede development of FFA face selectivity. The current results suggest that if anything, face selectivity in FFA developmentally precedes face selectivity in OFA. However, the weaker response in OFA should be interpreted with caution. Even in adults, OFA is small, variable and difficult to detect (108–111).

As with OFA, the hierarchical relationship between FFA and STS is disputed, so we do not use it here to test the Serial Hypothesis of cortical development. Nonetheless, we note that infants have face-selective responses in STS. In both infants and adults, face responses in STS are thought to be multi-modal – integrating across visual and auditory domains (112–115). At every age measured, there is a region in the STS responds more to faces than non-face object categories (116, 117). In both children and adults, the face region in STS responds more to dynamic faces than static faces (107, 116, 118, 119), more to point-light displays depicting two bodies interacting versus two bodies not interacting (120, 121), and more to speech than non-speech sounds (112). Further, in approximately the same location of adult STS, infants have a greater response to speech compared to non-speech sounds (122, 123), faces compared to non-faces (124, 125), and point-light displays depicting biological versus non-biological motion (126–128). Thus, while we did not measure multi-modal responses in this group of infants, it seems likely that the face response we observed in infants is related to multimodal face and voice responses previously observed across development.

MPFC in infancy and through development

In infants we find that a region in MPFC responds more to faces than to other visual categories. In adults, the MPFC is not classically considered a face perception region (2, 27). However, face activations have been observed in MPFC in response to images of faces compared to non-faces (110, 129), images of faces when judging attributes of those faces (130–132) and dynamic faces compared to objects (6, 133). Yet, while the FFA responds selectively to perceived faces, face-responsive regions in MPFC also respond to a variety of other social stimuli, including animations of social interactions and stories about people presented visually and aurally (6). Thus, face responses in MPFC are most likely related to the social and emotional meaning associated with faces.

Like adults, infants also have face responses in MPFC. A variety of studies have shown that infant MPFC responds more to dynamic faces than to dynamic non-face categories (53–55, 57, 58). Infants' MPFC face responses are greater for socially relevant faces (e.g., a parent, direct gaze, using infant-directed speech) than faces with less social relevance (e.g., a cartoon image, an averted gaze) (55, 56, 59–62, 64, 134). Consistent with this literature, we found face-selective responses in MPFC, relative to a variety of non-face object categories, in 5-9-month-olds and even in 2-5-month-olds, the youngest report to date of specialized responses in MPFC. These results provide strong constraints on the amount of visual and social experience required before MPFC acquires responses to faces and demonstrates that MPFC face responses do not emerge later in development than FFA.

In light of the fNIRS and behavioral research, one intriguing possibility is that infants' MPFC, like adult MPFC, is engaged in processing the social and emotional meaning associated with faces. However, the current evidence cannot exclude the possibility that initially infants' MPFC contains purely visual representations of faces and only later in infancy is used to ascribe social and emotional meaning to those faces.

Feedforward hierarchy is unlikely to drive cortical development

Our results may have implications for more general ideas concerning cortical functional development. One hypothesis is that the sequence of functional development follows the timing of cortical processing. Face responses in OFA are temporally earlier than face responses in FFA during online perception (103, 104), and both occur before responses in multimodal regions like STS and amodal regions like MPFC (3). A strictly serial model of cortical development should predict that cortical functions develop in the same sequence. Yet we find no evidence of a developmental sequence.

A second hypothesis is that functional development corresponds directly to anatomical maturation. By anatomical metrics like myelination and cortical thinning, prefrontal cortices are the slowest cortical areas to mature. Anatomical development of PFC is implicated in late-developing cognitive functions such as executive function and language (32, 33, 35, 44, 135–140). Thus, many researchers have assumed the prefrontal cortex is functionally immature or promiscuous during the earliest stages of development. In contrast, our results are consistent with mounting evidence that infant PFC has remarkably sophisticated function despite structural immaturity (141). Prior studies have reported activity in lateral PFC that corresponds to adult functional organization. For example, a region in lateral PFC in infants responds more to sequences with statistical regularity compared to unstructured input (142–144). Another area in infant PFC responds more to native language compared to foreign language or other non-speech sounds (145–149) and putative language areas have highly specific connections with orthographic-specific perceptual regions in VTC (150). Thus, our results are more consistent with an emerging view of PFC as a key player in infant cognitive development (150–152).

Summary

In sum, using fMRI in awake human infants, we find that in addition to FFA, the MPFC also has face-selective responses early in infancy. These findings are not consistent with the idea that perceptual regions necessarily develop functionally before amodal regions. An alternative hypothesis is that face responses across distinct regions of infant cortex emerge in parallel. Our findings about the origins of face selectivity accord with a broader theoretical view about the origins of the mind: infants are not passive statisticians accepting exogenous input (153), but very early in life have neural machinery supporting their ability to actively learn about their environment, and particularly, about other people.

Table 1. Functional Regions of Interest Analyses to test for Face Selective Responses.

fROI	Intercept	Bodies	Objects	Scenes	Motion	Age
All Infants						
VTC	**0.80** **(0.22)**	**-1.21** **(0.29)**	**-0.81** **(0.29)**	**-1.14** **(0.29)**	-0.15 (0.12)	**0.29** **(0.12)**
MPFC	**1.66** **(0.33)**	**-1.65** **(0.34)**	**-1.28** **(0.34)**	**-1.60** **(0.34)**	-0.06 (0.19)	0.12 (0.19)
EVC	-0.27 (0.30)	-0.32 (0.32)	**-0.74** **(0.32)**	-0.16 (0.32)	*-0.26* *(0.18)*	0.09 (0.17)
STS	**1.51** **(0.26)**	**-1.17** **(0.30)**	**-1.22** **(0.30)**	**-1.38** **(0.30)**	0.14 (0.15)	0.13 (0.15)
IOG	**1.02** **(0.39)**	**-0.98** **(0.38)**	*-0.61* *(0.38)*	**-1.71** **(0.38)**	*-0.36* *(0.23)*	**-0.63** **(0.22)**
Youngest Infants						
VTC	0.31 (0.29)	**-1.01** **(0.33)**	**-0.66** **(0.33)**	**-0.64** **(0.33)**	**-0.38** **(0.22)**	0.20 (0.22)
MPFC	**1.23** **(0.49)**	**-0.99** **(0.49)**	*-0.68* *(0.49)*	**-1.25** **(0.49)**	0.10 (0.42)	-0.24 (0.42)
STS	**1.04** **(0.31)**	**-0.92** **(0.31)**	**-0.93** **(0.31)**	**-0.84** **(0.31)**	**0.21** **(0.25)**	-0.34 (0.25)
IOG	**0.79** **(0.58)**	-0.64 (0.52)	-0.24 (0.52)	**-0.98** **(0.52)**	-0.29 (0.51)	0.50 (0.52)
Oldest Infants						
VTC	**1.34** **(0.33)**	**-1.39** **(0.43)**	**-1.17** **(0.43)**	**-1.73** **(0.46)**	0.02 (0.19)	-0.01 (0.19)
MPFC	**2.13** **(0.41)**	**-2.26** **(0.46)**	**-2.04** **(0.46)**	**-1.84** **(0.50)**	0.11 (0.29)	0.32 (0.25)
STS	**1.98** **(0.39)**	**-1.44** **(0.48)**	**-1.62** **(0.48)**	**-1.92** **(0.52)**	0.31 (0.26)	0.14 (0.24)
IOG	**1.34** **(0.45)**	**-1.24** **(0.52)**	**-1.12** **(0.52)**	**-2.41** **(0.56)**	-0.25 (0.31)	**-0.58** **(0.28)**

Parameter estimates from linear mixed effects models with beta values for each condition as predictors. Indicator-coded vectors used to test if body, object, and scene responses are each significantly less than the response to faces. Sex and z-scored age were coded as fixed effects and subject was coded as a random effect. Standard error is indicated in paratheses; $p<0.05$ is indicated in bold; $p<0.10$ is indicated in italics. Thus, a negative number in bold indicates a significantly lower response to that condition to faces. The intercept indicates the magnitude of the face response relative to baseline.

Table 2. Tests for Region Interactions.

Variable	Sum Sq.	Num DF	Den DF	F	P
Condition & Age in VTC					
Condition	34.27	3	104.00	**7.55**	**0.0001**
Z-Scored Age	8.37	1	57.12	**5.53**	**0.02**
Z-Scored Motion	2.18	3	54.11	1.44	0.23
Condition * Age	7.74	3	104.00	1.70	0.17
EVC & VTC					
Condition	30.35	3	250.96	**5.71**	**0.0009**
fROI	25.32	1	250.96	**14.29**	**0.0002**
Z-Scored Motion	1.55	1	105.71	0.88	0.35
Z-Scored Age	4.66	1	111.63	2.63	0.11
Condition * fROI	15.21	3	250.96	**2.86**	**0.04**
EVC & MPFC					
Condition	51.71	3	254.45	**6.07**	**0.0005**
fROI	97.88	1	254.45	**34.45**	**0.0000001**
Z-Scored Motion	3.34	1	82.90	1.17	0.28
Z-Scored Age	2.41	1	87.43	0.85	0.36
Condition * fROI	25.78	3	254.45	**3.02**	**0.03**
VTC & MPFC					
Condition	97.56	3	254.63	**14.10**	**0.0000002**
fROI	23.64	1	254.63	**10.25**	**0.002**
Z-Scored Motion	0.18	1	83.934	0.08	0.78
Z-Scored Age	6.15	1	88.50	2.67	0.11
Condition * fROI	2.89	3	254.63	0.42	0.74
Contrast Values in MPFC, VTC & Age					
fROI	1.85	1	31	0.85	0.36
Z-Scored Age	7.82	1	30	*3.60*	*0.07*
Z-Scored Motion	1.09	1	30	0.50	0.49
fROI * Age	0.01	1	31	0.01	0.94

All results from linear mixed effects models converted to ANOVA with R function anova; $p<0.05$ is indicated in bold, $p<0.10$ is indicated in italics.

Table 3. Effect of Age and Sex on Selectivity Index*.

fROI	Intercept†	Age†	Sex†	Motion†
VTC	**0.87** **(0.41)**	0.39 (0.29)	0.46 (0.57)	-0.10 (0.29)
MPFC	**1.35** **(0.39)**	0.37 (0.27)	0.18 (0.55)	-0.14 (0.28)
STS	*0.75* *(0.42)*	0.40 (0.30)	0.98 (0.59)	-0.08 (0.30)
IOG	0.91 (0.58)	0.69 (0.41)	0.38 (0.81)	-0.43 (0.41)

Face selectivity index for each subject is the face beta minus the average response to non-face conditions (μ(Body ß, Object ß, Scene ß)). Parameter estimates from linear models with face selectivity index as the dependent variable and z-scored age, sex, and z-scored motion as predictors. Standard error is indicated in paratheses. $p<0.05$ is indicated in bold, $p<0.10$ is indicated in italics.

METHODS

Participants

Infants were recruited from the Boston metro area through word-of-mouth, fliers, and social media. Parents of participants were provided parking or reimbursed travel expenses. Participants received a small compensation for each visit and, when possible, printed images of their brain. We recruited 86 infants (2.0-11.9 months; mean=5.4 months; 41 female; 42 Coil 2021) and recovered usable data (see data selection) from 65 infants (2.6-11.9 months, 24 female, 31 Coil 2021). Data were previously used to test if infants have category-selective responses to faces, bodies and scenes the FFA, extrastriate body area, and parahippocampal place area, respectively (70).

Experimental paradigms

Paradigm 1. Infants watched videos of faces (Figure 1b), bodies, objects, and scenes (Figure 1c) (116), and a colorful, curvy, abstract baseline was used to maintain infants' attention during baseline blocks. Videos were selected to be categorically homogeneous within blocks and heterogeneous between blocks. Each block was 18s and was composed of six 3s videos from the same category. Face videos showed one child's face on a black background. Object videos show toys moving. Body videos showed children's hands or feet on a black background. Scene videos showed natural environments. Baseline blocks were also 18s and consisted of six 3s videos that featured abstract color scenes such as liquid bubbles or tie-dyed patterns. Block order was pseudo-random such that all blocks played once prior to playing again. Videos played continuously for as long as the infant was content, paying attention, and awake.

Paradigm 2. Infants watched videos from the same five conditions as in *Paradigm 1*. However, the videos were shortened to 2.7s and interleaved with still images from the same category (but not drawn from the videos) presented for 300ms. All blocks were 18s and included 6 videos and 6 images. Video and image order were randomized within blocks and block order was pseudorandom by category. *Paradigm 2* contained one additional block depicting hand-object interactions which was not included in the present analysis.

Data collection

Infants were swaddled if possible (Figure 1a). A parent or researcher went into the scanner with the infant while a second adult stood outside the bore of the scanner. Infants heard lullabies (https://store.jammyjams.net/products/pop-goes-lullaby-10) for the duration of the scan. For data collected with *Coil 2011*, lullabies were played over a loudspeaker into the scanning room. For data collected with *Coil 2021*, lullabies were played through custom infant headphones (Figure 1a).

Coil 2011. For data collected with *Coil 2011* we used a custom 32-channel infant coil designed for a Siemens Trio 3T scanner (66). We used a quiet EPI with sinusoidal trajectory (67) with 22 near-axial slices (repetition time, TR=3s, echo time, TE=43 ms, flip angle=90º, field of view, FOV=192 mm, matrix=64x64, slice thickness=3 mm, slice gap=0.6 mm). The sinusoidal acquisition sequence caused substantial distortions in the functional images (Figure S2a).

Coil 2021. Infants wore custom infant MR-safe headphones. Infant headphones attenuated scanner noises and allowed infants to hear the lullabies. An adjustable coil design (68) increased infant comfort and accommodated headphones as well as a variety of head sizes (Figure 1a). The new infant coil and infant headphones designed for a Siemens Prisma 3T scanner enabled the use of an EPI with standard trajectory with 44 near-axial slices (repetition time, TR=3s, echo time, TE=30ms, flip angle=90°, field of view, FOV=160 mm, matrix=80x80, slice thickness=2 mm, slice gap=0 mm). Six infants had data collected using a different EPI with standard trajectory with 52 near-axial slices (repetition time, TR=2s, echo time, TE=30ms, flip angle=90°, field of view, FOV=208 mm, matrix=104x104, slice thickness=2 mm, slice gap=0 mm). Functional data collected with *Coil 2021* were less distorted than data collected with *Coil 2011* (Figure S1).

Data selection (subrun creation)

To be included in the analysis, data had to meet criteria for low head motion. Motion criteria are the same as our two previous studies (70, 88). Data were cleaved between consecutive timepoints having more than 2 degrees or mm of frame-to-frame displacement, creating *subruns*, which contained at least 24 consecutive low-motion volumes. All volumes included in a subrun were extracted from the original run data and combined to create a new Nifti file for each subrun. Paradigm files were similarly updated for each subrun. Volumes with greater than 0.5 degrees or mm of frame-to-frame displacement were removed from all analyses.

Data collected within a 30-day window from a single subject were analyzed as one session. Subjects had to have at least 5 minutes of low-motion data to be included in the whole brain analysis. For each individual infant, only one image was included in each RFX (Coil 2011 or Coil 2021) analysis. To be included in the fROI analysis, subjects had to have at least two novo-subruns with at least 96 volumes (often by combining or splitting subruns) in each novo-subrun (one to choose voxels and the other to independently extract response magnitudes from the selected voxels).

fMRI data preprocessing

Each subrun was processed individually. First, an individual functional image was extracted from the middle of the subrun to be used for registering the subruns to one another for further analysis. Then, each subrun was motion corrected using FSL MCFLIRT. If more than 3 consecutive images had more than 0.5 mm or 0.5 degrees of motion, there had to be at least 7 consecutive low-motion volumes following the last high-motion volume for those volumes to be included in the analysis. Additionally, each subrun had to have at least 24 volumes after accounting for motion and sleep TRs. Functional data were skull-stripped (FSL BET2), intensity normalized, and spatially smoothed with a 3mm FWHM Gaussian kernel (FSL SUSAN).

Data registration

All subruns were registered within subjects and then each subject was registered to a standard template. First, the middle image of each subrun was extracted and used as an example image for registration. If the middle image was corrupted by motion or distortion, a better image was selected to be the example image. The example image from the middle subrun of the first visit was used as the target image. All other subruns from each subject were registered to that subject's target image using FSL FLIRT. The target image for each subject was then registered to a template

image using FSL FLIRT. For data collected with *Coil 2011*, the template image was the same one used previously (88). For data collected with *Coil 2021*, a template image was selected from a single subject from whom we had a high-resolution anatomical image on which to display functional data. Given the distortion of the images and the lack of an anatomical image for each subject, traditional registration tools do not effectively register infant data. As such, we attempted to register each image using a rigid, an affine, and a partial affine registration with FSL FLIRT. The best image registration was selected by eye from the three options and manually tuned using the Freesurfer GUI for the best possible data alignment. Each image took between 2 and 8 hours of human labor to register. Images collected with *Coil 2021* were transformed to the anatomical space of the template image for visualization.

Subject-level beta and contrast maps

Functional data were analyzed with a whole-brain voxel-wise general linear model (GLM) using custom MATLAB scripts. The GLM included 4 condition regressors (faces, scenes, bodies, and objects), 6 motion regressors, a linear trend regressor, and 5 PCA noise regressors. PCA noise regressors are analogous to GLMDenoise (154). Condition regressors were defined as a boxcar function for the duration of each condition block (18s). Infant inattention or sleep was accounted for using a single nuisance ('sleep') regressor. The sleep regressor was defined as a boxcar function with a 1 for each TR the infant was not looking at the stimuli, and the corresponding TR was set to 0 for all condition regressors. Boxcar condition and sleep regressors were convolved with an infant hemodynamic response function (HRF) that is characterized by a longer time to peak and deeper undershoot compared to the standard adult HRF (155). Next, data and all regressors except PCA noise regressors were concatenated across subruns. PCA noise regressors were computed across concatenated data and beta values were computed for each condition in a whole-brain voxel-wise GLM. Subject-level contrast maps were computed as the difference between the face beta and the average of all non-face (i.e., bodies, objects, and scenes) betas for each voxel using in-house MATLAB code.

For each subject that had sufficient data, we hand-coded whether there were face activations in the approximate location of FFA and MPFC. We used logistic regression to determine whether the probability of detecting face responses in each region increased with age or differed by region. Specifically, we fit a model in R using the lme4 package (https://github.com/lme4/) with the expression:

```
glm(count ~ region * age + dataQuantity, family="binomial")
```

where count is a binomial true/false vector, region is FFA or MPFC, age is in months, and dataQuantity is the number of total volumes collected in that session.

Group random effects analysis

Because the sequences used with each coil created very different patterns of spatial distortion, we conducted one group random effects analysis for data collected with each coil. First, subject-level contrast difference (faces – non-face) maps were transformed to coil-specific template space. Group random effects analyses were performed using Freesurfer mri_concat and Freesurfer mri_glmfit.

Functional region of interest (fROI) analysis

To determine if cortical responses are face-specific, we utilized a functional region of interest (fROI) approach. Due to the variable amount of data in each subrun for each subject and the impact this could have on reliable parameter estimates from the GLM, we first combined or split subruns to approximately equate the amount of data across novo-subruns within subjects. For example, if a subject had three subruns and the first was 30 volumes, the second was 75 volumes and third was 325 volumes, then we concatenated the first two subruns to create one novo-subrun and we split the third subrun into 3 resulting in a total of four novo-subruns with approximately 100 volumes each.

To constrain search areas for voxel selection, we used anatomically defined parcels transformed to subject-specific space. Due to the distortions in the *Coil 2011* dataset, we opted to used larger parcels than the standard FFA parcel we used previously (70). We created VTC, MPFC, IOG, STS, and subcortical parcels using the Glasser atlas (156). The ventral parcel included Glasser areas VMV1, VMV2, VMV3, VVC, PHA1, PHA2, PHA3, and FFC. For the MPFC parcel we used Glasser areas p24, d32, 9m, and p32. The IOG parcel included Glasser areas LO1, LO2, LO3, V4, V4t and PIT. For the STS parcel, we used Glasser areas STSvp, STSva, STSdp, STSda, STV. We also used the anatomically defined thalamus, brainstem, and amygdala from MNI space. All parcels were transformed to infant-specific functional space by concatenating the subrun-to-infant template registration matrix with the infant template-to-MNI registration matrix and inverting those transformations.

We used an iterative leave-one-novo-subrun-out procedure such that data were concatenated across all novo-subruns except one prior to the whole-brain voxel-wise GLM and contrast were computed. The top 5% of voxels that had a greater response to faces than the average response to non-face conditions within an anatomical constraint parcel were selected as the fROI for that subject. Then, the parameter estimates (i.e., beta values) for all four conditions were extracted from the left-out novo-subrun. For all bar plots, beta values were averaged across participants.

To determine whether a region's response was category-selective, we fit the beta-values using a linear mixed effects model. In each model, we dummy-coded the three control conditions, to test the hypotheses that the response to each control condition was significantly lower than the response to the face condition. Specifically, we fit a model in R using the lme4 package (https://github.com/lme4/) with the expression:

```
lmer( betas ~ c1 + c2 + c3 + motion + age + (1|subject))
```

where the three dummy-coded condition regressors are c1 (bodies), c2 (objects) and c3 (scenes). Motion was computed as the proportion of scrubbed volumes. Age and motion were z-scored. Motion was a fixed effects parameters of no interest and subject was coded as a random effect for all models. Four individual infants contributed more than one session of data, which was treated as within-subjects variance through the random effect and the age regressor separated the two datapoints. The response in a parcel was deemed selective if the fixed effect coefficient for each of the three control conditions was significantly negative. Because predictions were unidirectional, reported *p*-values were one-tailed. We also computed weighted LME models to account for the variable amount of data each subject contributed to each condition and the results were similar (Table S1).

To test for an interaction between EVC and VTC/MPFC, we fit a model in R using the lme4 package (https://github.com/lme4/) with the expression:

```
anova( lmer( betas ~ condName * region + motion + age + (1|subject)))
```

where condName was the condition label for each beta and region was the ROI for each beta. Motion and age were z-scored. When a weight was added, it was added as a vector of the total volumes that contributed to a condition estimate divided by the total number of volumes collected from all infants in the analysis.

Effects of infant age

To determine if the contrast difference between faces and all non-face conditions changed as a function of infant age, we used a linear model for each parcel. In this model, we only included one session per infant. For infants (n=2) that had a session collected with Coil 2011 and a separate session using Coil 2021, we used the higher-resolution Coil 2021 session. For infants who had two sessions collected with the same coil (n=2), we included the session with more data. In all, n=33 infants contributed data to this analysis. To test for age effects, contrast values (i.e., face beta – average beta for all non-face conditions) were the dependent variable. The predictors of interest were age and sex. Motion was a fixed effect of non-interest. Age and motion were z-scored.

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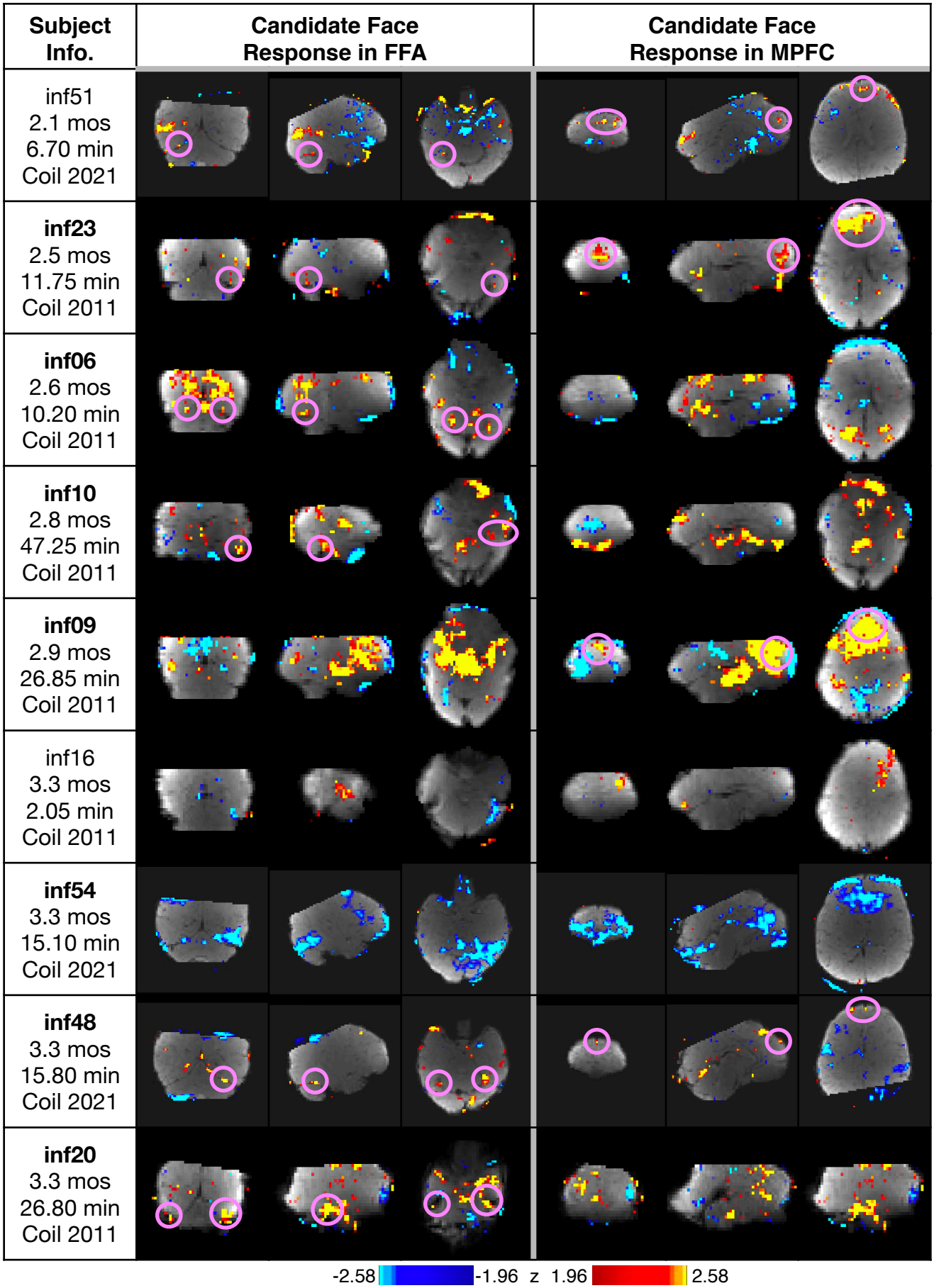
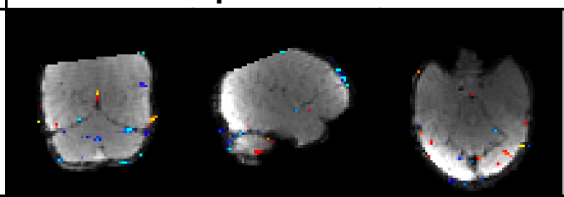
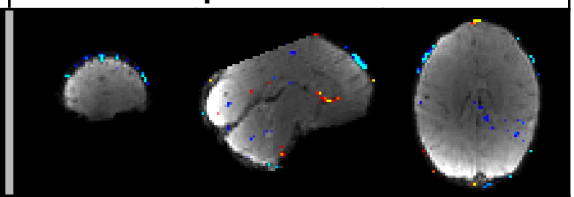
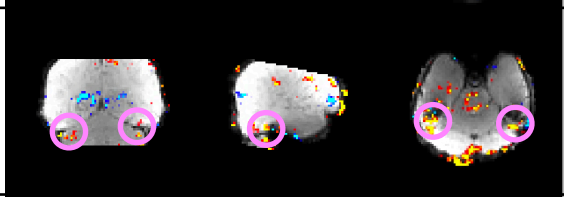
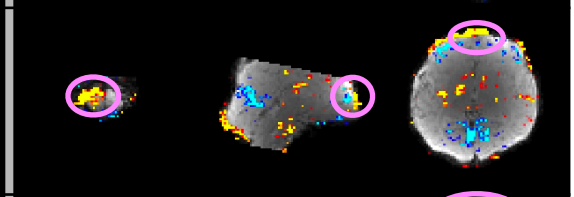
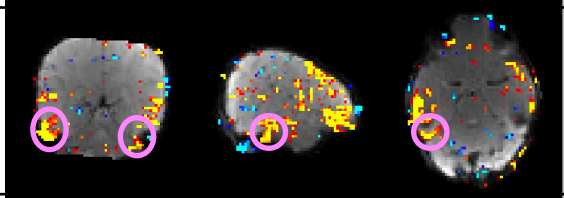
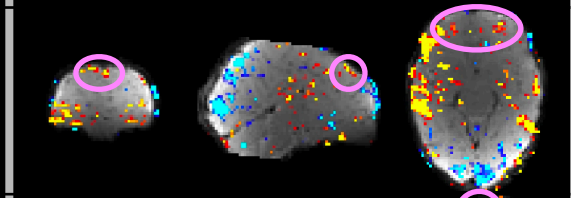
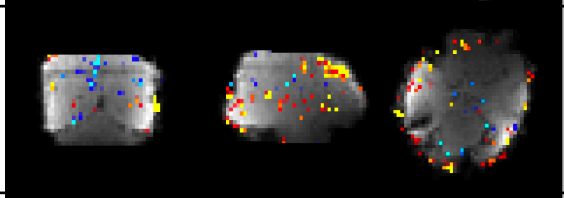
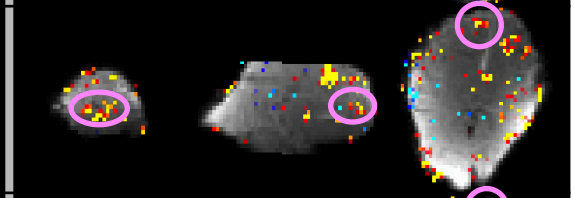
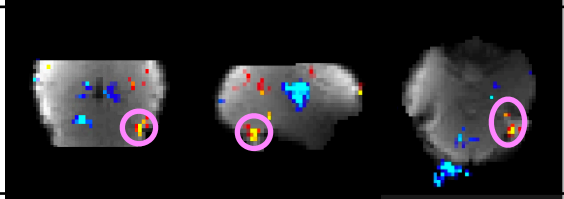
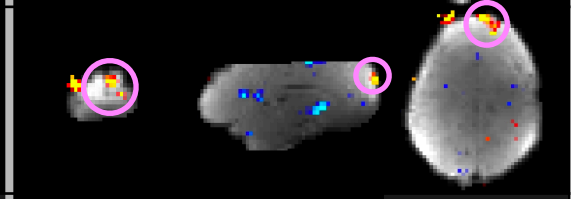
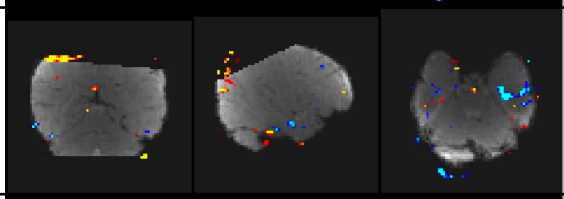
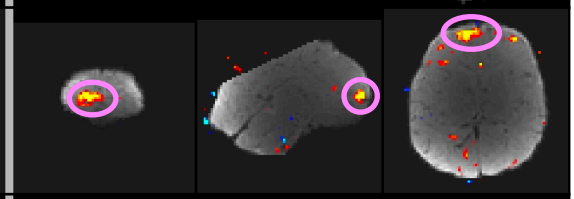
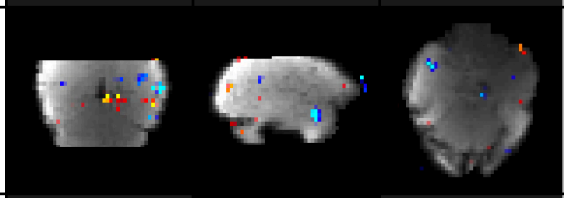
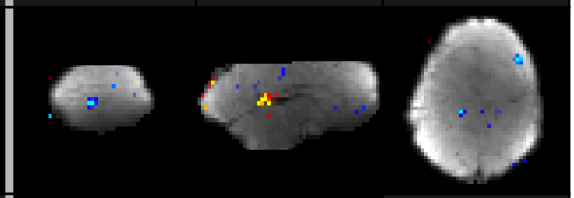
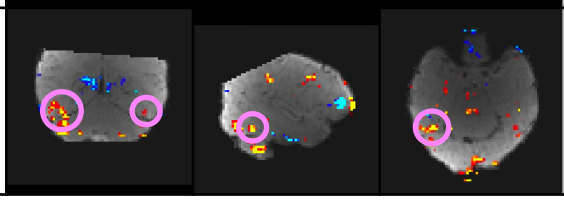
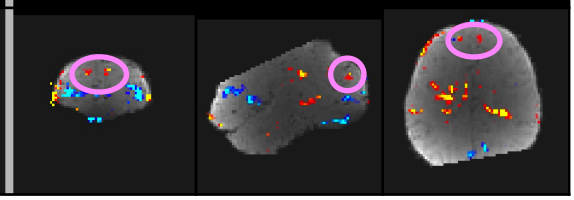
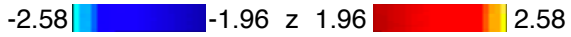
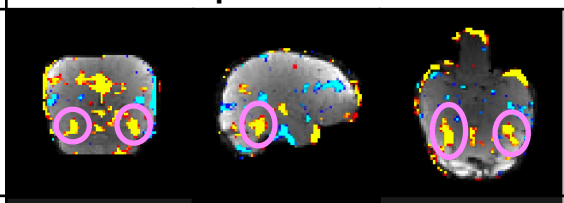
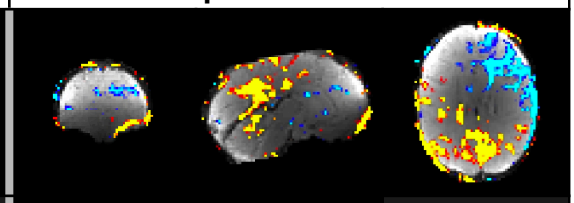
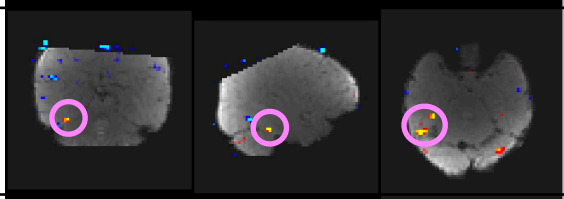
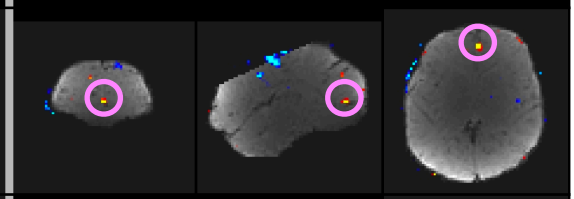
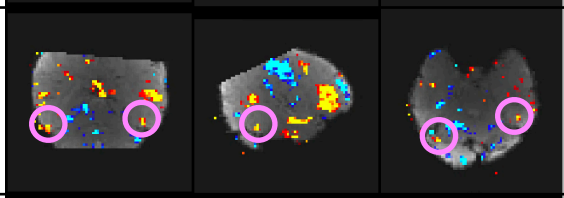
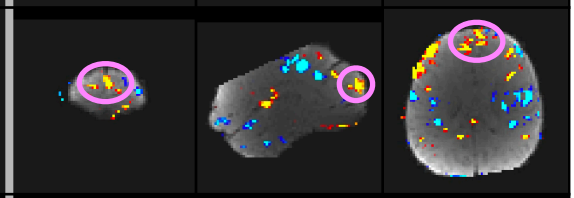
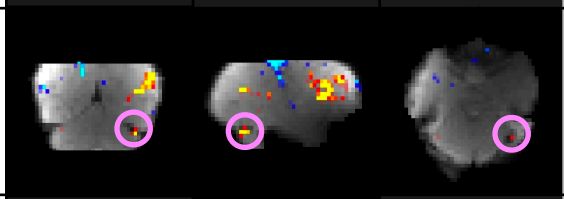
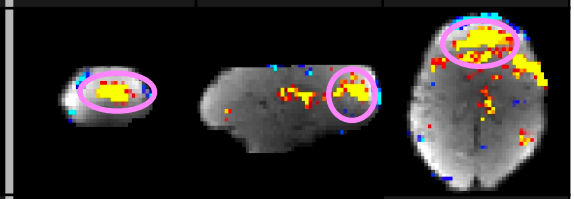
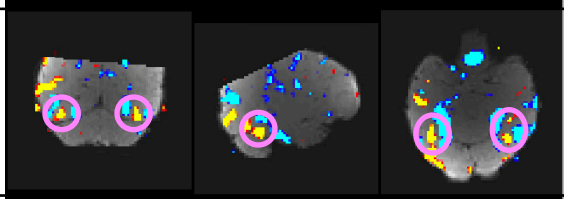
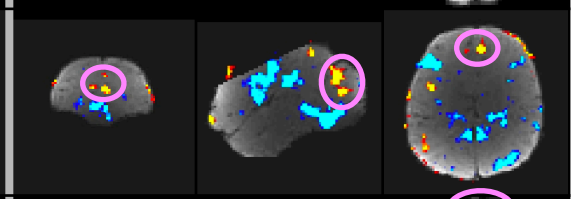
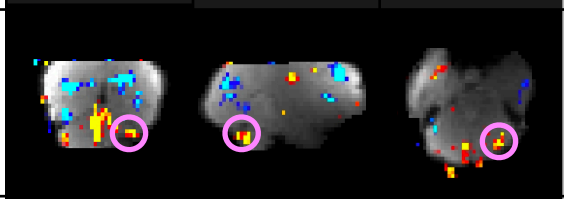
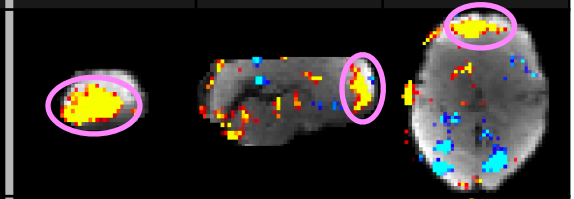
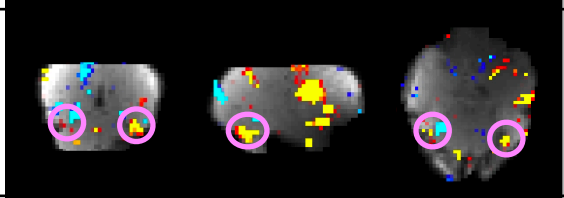
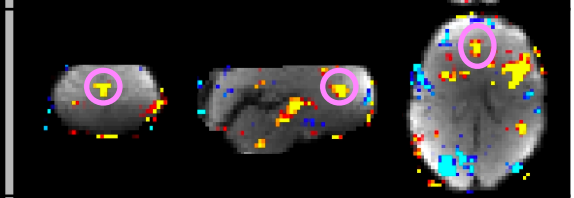
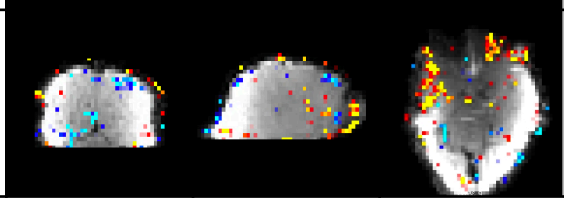
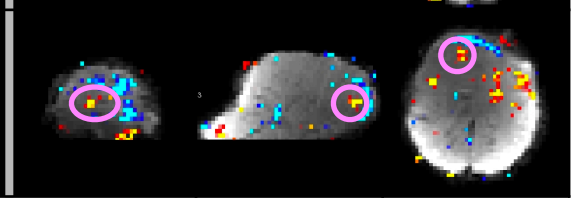

Subject Info.
Candidate Face Response in FFA
Candidate Face Response in MPFC
inf51
2.1 mos
6.70 min
Coil 2021
inf23
2.5 mos
11.75 min
Coil 2011
inf06
2.6 mos
10.20 min
Coil 2011
inf10
2.8 mos
47.25 min
Coil 2011
inf09
2.9 mos
26.85 min
Coil 2011
inf16
3.3 mos
2.05 min
Coil 2011
inf54
3.3 mos
15.10 min
Coil 2021
inf48
3.3 mos
15.80 min
Coil 2021
inf20
3.3 mos
26.80 min
Coil 2011
-2.58
-1.96
z
1.96
2.58

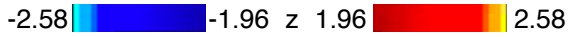
Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf47 3.5 mos 4.05 min Coil 2021		
inf34 5.00 mos 22.37 min Coil 2021*		
inf53 3.7 mos 3.30 min Coil 2021		
inf18 3.7 mos 4.45 min Coil 2011		
inf04 3.7 mos 8.15 min Coil 2011		
inf49 3.8 mos 30.20 min Coil 2021		
inf22 3.9 mos 6.20 min Coil 2011		
inf35 3.9 mos 7.85 min Coil 2021		

-2.58 -1.96 z 1.96 2.58

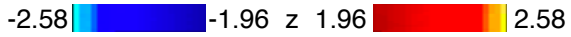
Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf08 3.9 mos 12.45 min Coil 2011		
inf07 4.0 mos 18.60 min Coil 2011		
inf42 4.0 mos 20.80 min Coil 2021		
inf26 4.2 mos 16.95 min Coil 2011		
inf11 4.3 mos 5.75 min Coil 2011		
inf02 4.3 mos 24.50 min Coil 2011		
inf45 4.3 mos 31.80 min Coil 2021		
inf03 4.4 mos 9.30 min Coil 2011		

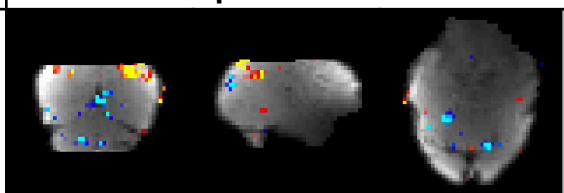
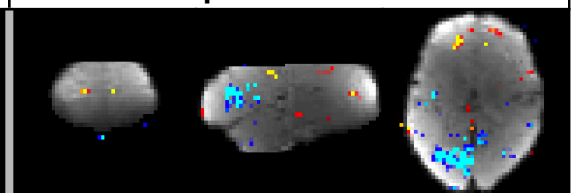
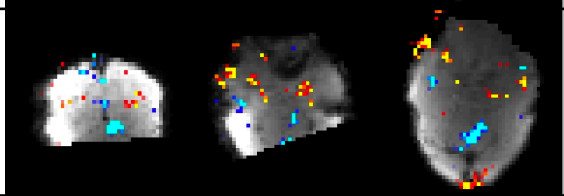
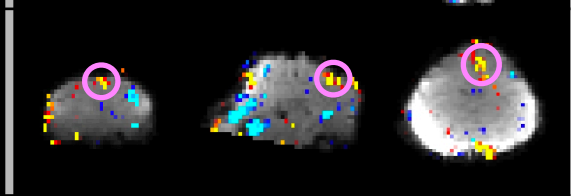
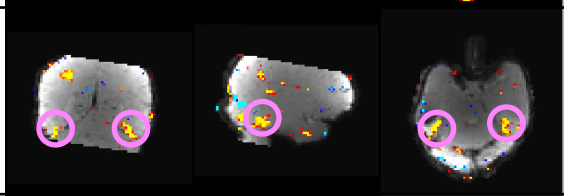
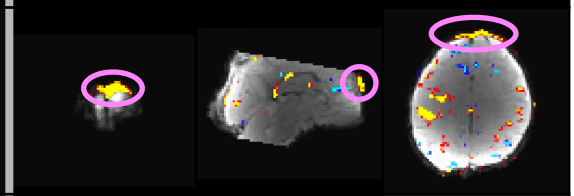
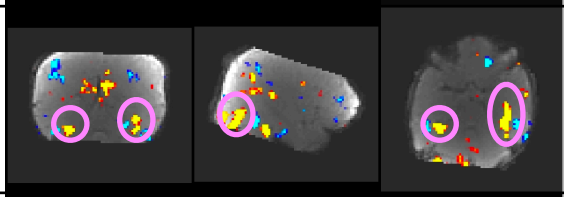
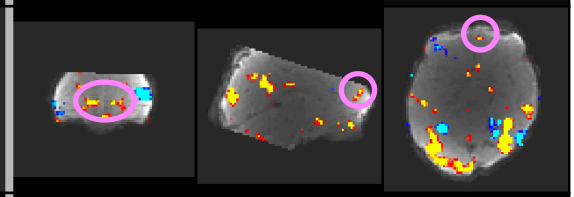
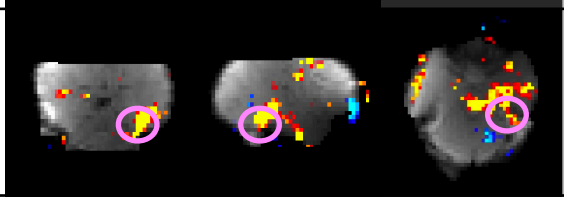
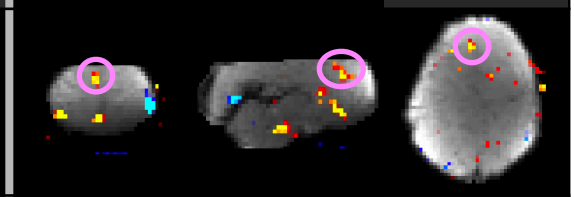
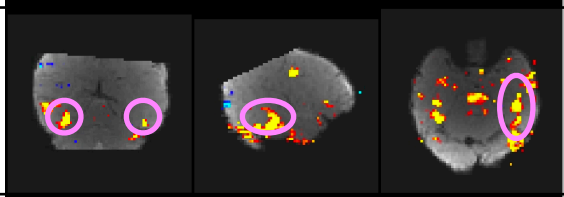
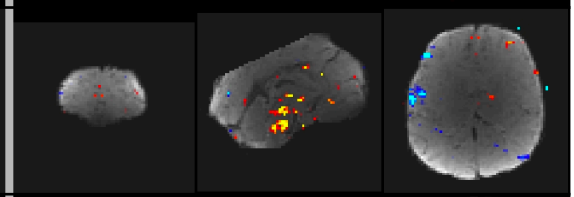
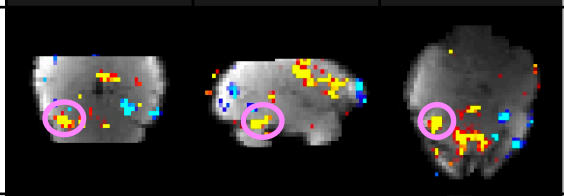
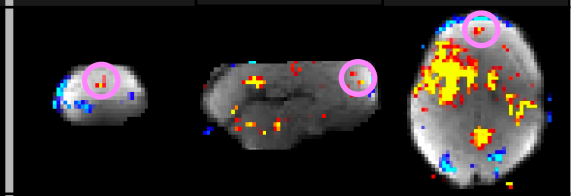
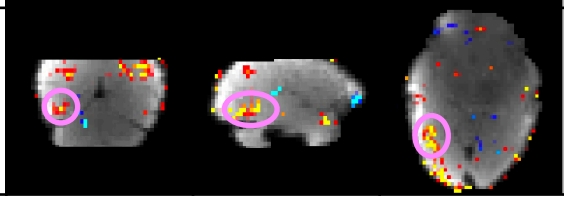
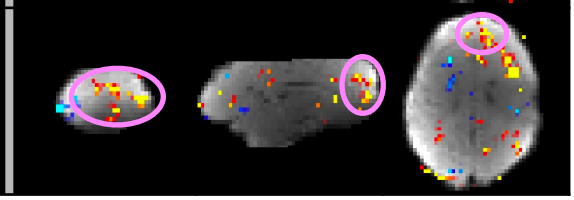


Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf43 4.5 mos 13.75 min Coil 2021		
inf52 4.5 mos 26.00 min Coil 2021		
inf39 4.6 mos 9.30 min Coil 2021		
inf12 4.6 mos 16.85 min Coil 2011		
inf37 4.6 mos 52.45 min Coil 2021		
inf13 4.9 mos 34.70 min Coil 2011		
inf28 5.1 mos 15.00 min Coil 2011		
inf36 5.1 mos 18.65 min Coil 2011		



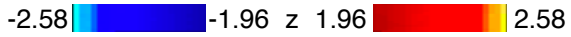
Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf36 5.2 mos 36.55 min Coil 2021		
inf50 5.4 mos 4.70 min Coil 2021		
inf24 5.4 mos 16.20 min Coil 2011		
inf30 5.6 mos 4.33 min Coil 2021*		
inf01 5.6 mos 8.05 min Coil 2011		
inf41 5.6 mos 15.90 min Coil 2021		
inf25 5.6 mos 33.05 min Coil 2011		
inf21 5.7 mos 57.25 min Coil 2011		

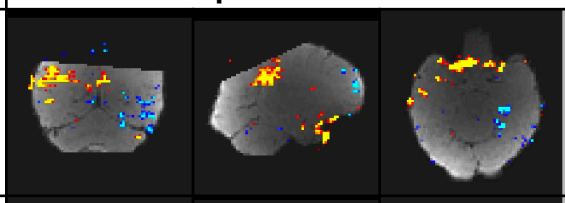
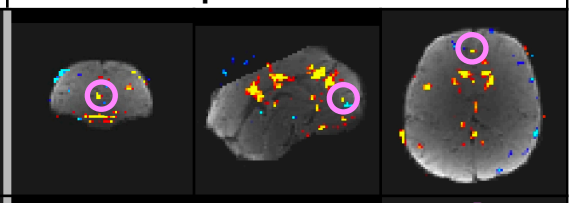
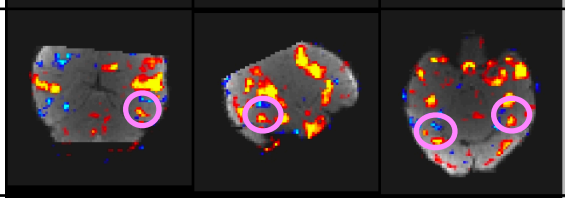
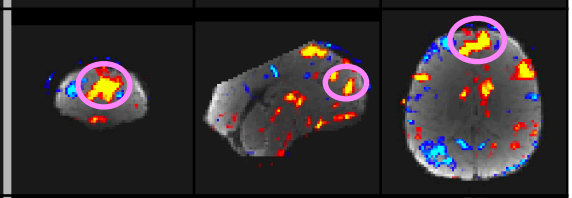
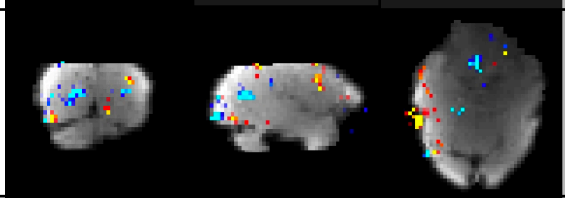
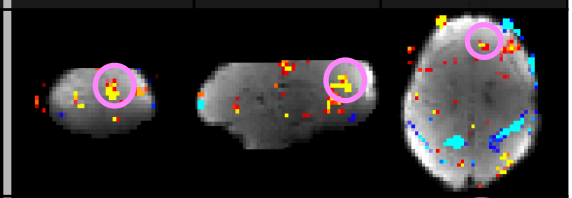
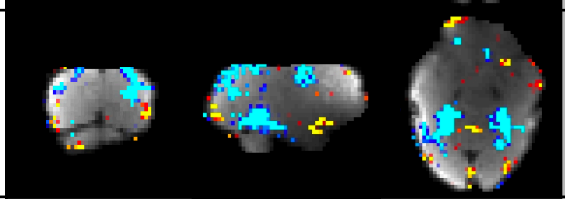
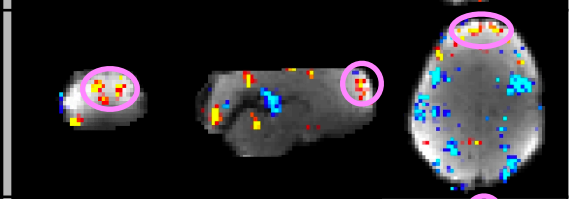
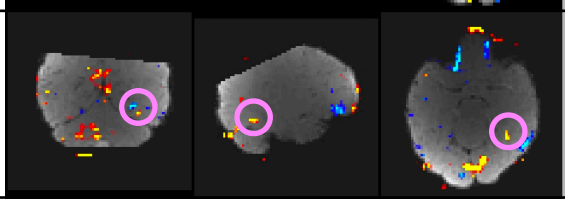
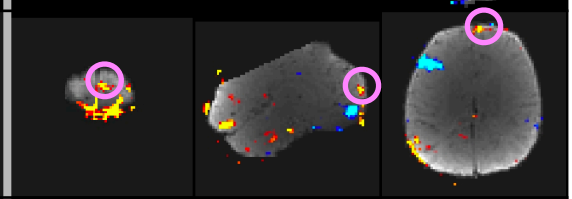
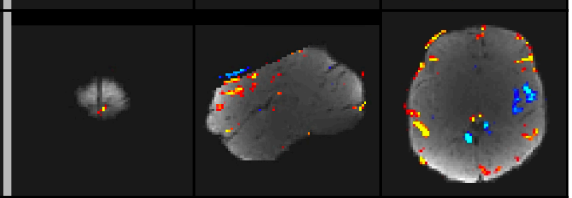
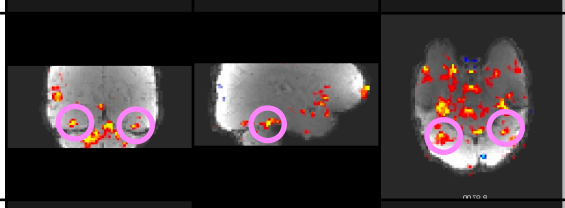
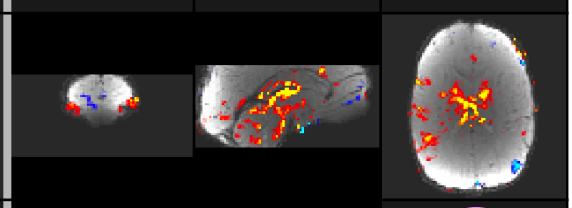
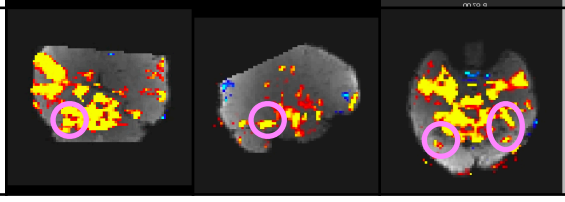
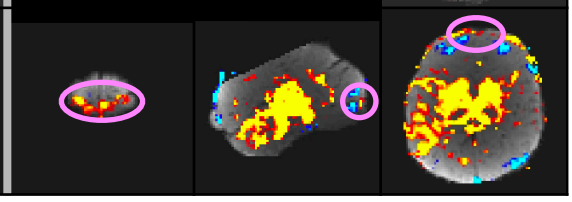
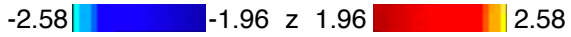


Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf14 5.8 mos 2.25 min Coil 2011		
inf03 5.8 mos 7.05 min Coil 2011		
inf32 6.0 mos 3.60 min Coil 2021*		
inf31 6.0 mos 9.03 min Coil 2021*		
inf19 6.1 mos 20.10 min Coil 2011		
inf30 6.2 mos 8.65 min Coil 2021		
inf27 6.3 mos 30.05 min Coil 2011		
inf05 6.5 mos 11.45 min Coil 2011		

-2.58 -1.96 z 1.96 2.58

Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf40 6.5 mos 19.00 min Coil 2021		
inf17 6.6 mos 23.35 min Coil 2011		
inf33 6.7 mos 2.07 min Coil 2021*		
inf13 6.7 mos 5.55 min Coil 2011		
inf46 6.7 mos 17.10 min Coil 2021		
inf44 6.8 mos 9.15 min Coil 2021		
inf09 6.8 mos 15.35 min Coil 2011		
inf07 7.6 mos 2.35 min Coil 2011		



Subject Info.	Candidate Face Response in FFA	Candidate Face Response in MPFC
inf27 7.7 mos 13.80 min Coil 2021		
inf26 7.9 mos 47.70 min Coil 2021		
inf02 8.7 mos 32.10 min Coil 2011		
inf06 8.8 mos 13.05 min Coil 2021		
inf25 9.2 mos 22.35 min Coil 2021		
inf38 9.5 mos 30.65 min Coil 2021		
inf29 9.6 mos 16.33 min Coil 2021*		
Inf29 9.8 mos 7.90 min Coil 2021