Infant fNIRS brain responses at participant level

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Aims:

1. Present participant-level analysis of infant fNIRS data from the Habituation and Novelty Detection (HaND) task[1], one of the fNIRS tasks from the Brain Imaging for Global Health (BRIGHT) study.
2. Highlight the importance of understanding the data at participant level when studying brain function and correlations with potential modulating factors.

Background:

fNIRS applications on brain development have increased exponentially in recent years

More complex research questions to be answered by
- Larger cohorts [1-3]
- Multi-modality data acquisition[1]
- Modelling of interactions between metrics of development [1-3]

There is a need to define reliable metrics of brain function at individual level

These metrics can be used to build models that correlate brain function with other measures of development

It is **imperative** to use reliable and meaningful data at participant level

Methods:

- fNIRS data collected with NTS system (Gowerlabs) at 780 and 850 nm
- 17-channels per hemisphere, with 2cm source-detector separation
- fNIRs arrays covering inferior frontal and temporal regions (See Fig. 1)
- Data collection was longitudinal at 1,5,8,12,18 and 24mo
- **Habituation** = Fam1-Fam3; **Novelty Detection** = Novel-Fam3 (Fig. 2)

Fig. 1 12mo-old participant wearing the fNIRS headgear.

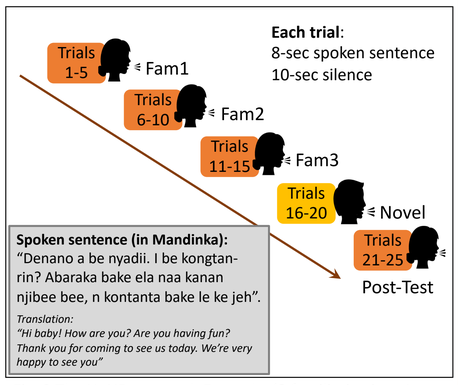


Fig. 2 The HaND protocol: 5 epochs (3 familiarization, 1 novel, 1 pos-test) with 5 trials each epoch.

Results:

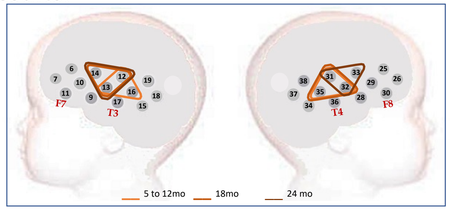


Fig. 3 Representation of lateral channel positions on the infant head. Superimposed triangular Regions of Interest (ROI) were calculated with Cluster Permutation analysis[3,4] at group level, for Fam1 epoch at 5, 8, 12, 18 and 24mo.

LH	ch2	ch3	ch5	ch6	ch7	ch8	ch9	ch10	ch11	ch12	ch13	ch14	ch15	ch16	ch17	ch18	ch19
5mo	2.9	4.3	2.2	2.2	3.6	2.2	2.9	4.3	3.6	13.8	13.8	5.8	3.6	8.7	5.1	2.2	6.5
8mo	3.0	2.0	1.0	3.0	2.0	1.0	4.0	2.0	2.0	16.2	13.1	8.1	0.0	10.1	10.1	2.0	4.0
12mo	1.6	0.8	0.8	3.3	0.8	0.8	7.3	4.9	3.3	17.1	18.7	2.4	4.9	15.4	11.4	0.8	4.9
18mo	2.6	1.8	4.4	7.9	2.6	3.5	8.8	14.9	1.8	15.8	21.1	16.7	3.5	10.5	7.9	3.5	3.5
24mo	1.7	5.2	3.5	8.7	5.2	1.7	7.0	20.0	4.3	18.3	16.5	31.3	1.7	13.0	7.8	0.0	3.5

ch20	ch22	ch23	ch25	ch26	ch27	ch28	ch29	ch30	ch31	ch32	ch33	ch34	ch35	ch36	ch37	ch38	RH
3.6	2.2	2.2	3.6	0.7	2.9	8.7	0.7	3.6	5.8	14.5	3.6	2.9	6.5	8.0	3.6	2.9	5mo
2.0	7.1	7.1	0.0	4.0	1.0	4.0	1.0	3.0	6.1	16.2	5.1	1.0	7.1	6.1	2.0	0.0	8mo
0.0	1.6	2.4	0.8	1.6	3.3	5.7	3.3	1.6	15.4	22.8	7.3	1.6	14.6	9.8	5.7	6.5	12mo
1.8	4.4	3.5	6.1	6.1	4.4	7.0	7.0	0.0	23.7	24.6	14.9	4.4	7.9	12.3	1.8	5.3	18mo
0.9	0.9	2.6	2.6	2.6	0.9	10.4	10.4	2.6	15.7	23.5	19.1	0.9	4.3	5.2	0.9	2.6	24mo

Table 1. Participants with significant activation at Fam1 epoch, per channel and time point, in % of total participants included in the analysis at each time point. Highlighted cells indicate channels included in the ROI (See Fig. 32). Upper panel: left hemisphere; lower panel: right hemisphere.

- Complete overlap in ROIs from 5 to 12 mo, and a minimal change in channel configuration of the ROIs at 18 and 24 mo (Fig. 3).
- Channels with the highest % of participants with significant activation at Fam1 are consistent with the ROI definitions (Table 1).

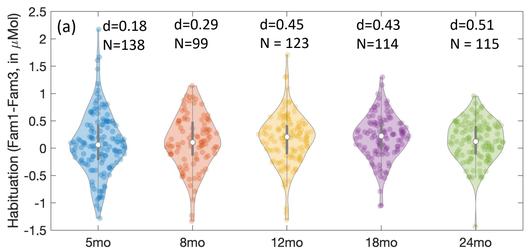
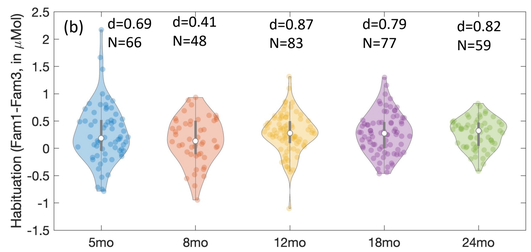


Fig. 4 **Habituation** at 5 age points. (a) including participants with valid fNIRS data; (b) including only participants with activation at Fam1 epoch. All age groups show significant habituation in (a) and (b). Cohen's *d* measures effect size.



- **Habituation** is significant at group with all available datasets and when excluding those with no significant Fam1 (Fig. 4).
- When datasets with no significant Fam1 are excluded, effect sizes increase considerably at all time points (Fig. 4b)

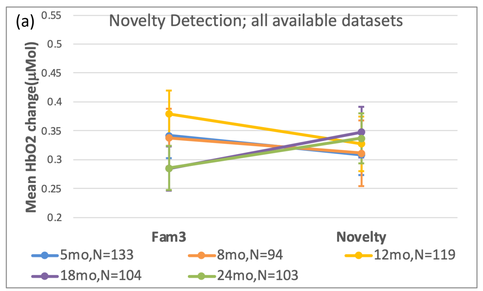
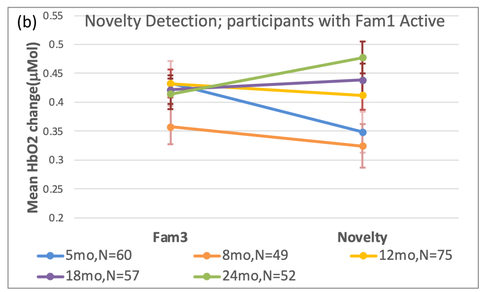


Fig. 5 **Novelty Detection** (Novelty-Fam3) at 5,8,12,18 and 24 mo. (a) including all participants with valid fNIRS data; (b) including only participants with activation at Fam1 epoch. Vertical bars indicate one Standard Error of the Mean (SEM). N = number of participants included.



- **Novelty Detection** is not significant when considering all available datasets (Fig. 5a) or when selecting Fam1 active (Fig. 5b).
- The trend of increasing Novelty Detection with age is only visible when considering participants with Fam1 active (Fig. 5b).

References: [1] Lloyd-Fox et al, Developmental Science (2019); [2] Perdue et al, Developmental Science (2019); [3] Wijeakumar et al, Developmental Science (2019); [4] Abboub et al., Brain and Language.(2016).

Discussion:

- Regions with the strongest Fam1 activation at group level are defined by channels that show the highest % of participants in table 1.
- All channels have > 0% participants, albeit most are very small compared with ROI channels.
  - ➡ Consistency in headgear placement, and strong spatial localization of activation.
- 14 participants (of 191) had no activation at any channel at any time point.
  - ➡ Exclude from the analysis due to poor sensitivity with fNIRS.

Imposing activation at Fam1 for group and participant level analysis ensures that, for the HaND protocol, the condition contrasts will inform about change from initial stimulation:
- Enhances significance of group results.
- Unmasks trends present in the data.
- Improves interpretation of condition contrasts at group and at participant level.
  - ➡ The data can be exported as a measure of brain function for correlations with other measures.

Conclusion:

In order to ensure meaningful interpretation and use of fNIRS responses as a measure of brain function it is imperative to
(1) include analysis at participant level;
(2) impose conditions that guide condition contrasts.

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BRIGHT Brain Imaging For Global Health

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