‘Fetal reactions to face-like and non-face-like light stimuli controlling for maternal mental health: a study with reference to research methodologies’

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1 - INTRODUCTION & AIMS

My 6-week Laidlaw project concerned fetal behavioural research. The aims were:

- Investigate the impact of a variety of face-like and non-face-like light stimuli on fetal eye movement and head turn behaviours
- Examine the relationship between fetal behaviours and maternal mental health
- Introduction to research on the topic of fetal responses to light stimuli
- Critically discuss AI methodologies for fetal ultrasound coding.

Figure 1 – 4D ultrasound image of eye opening

2 - BACKGROUND: FETAL BEHAVIOURAL RESPONSES TO LIGHT STIMULI

- Reid et al. (2017) found statistically significant differences between fetal head turning behaviour towards ‘top-heavy’ and ‘bottom-heavy’ light stimuli. However, a critique of study methodology by Scheel et al. (2018) limits the reliability of conclusions.
- Reissland et al. (2018, 2020) found statistically significant correlations between maternal anxiety and depression, and fetal behaviour.
- Reissland et al. (2020) found statistically significant differences in rate of fetal head turns when exposed to face-like stimuli (both top-heavy and bottom-heavy) in comparison to control non-face-like stimuli, controlling for maternal mental health.

Gaps in existing research include:

- Impact of different patterns of control light stimuli upon fetal behaviours.
- Eye blink rate in response to face-like light stimuli, building upon Reissland et al. (2020) findings on head turn behaviours.

3 - CODING SYSTEMS AND AI IN FETAL ULTRASOUND RESEARCH

Manual coding systems:

- Qualitative coding systems using ‘emotionally charged language’ (Reissland, 2014) to describe fetal facial movements (eg ‘smiling’ or ‘grimacing’) risks coding discrepancies between individual coders.
- Anatomically based coding systems are more objective. These included the Fetal Observable Movement System (FOMS) used in the current study, which anatomically defines 17 fetal facial movements (Reissland et al., 2016).

AI coding systems:

- AI is increasingly being used in fetal ultrasound research, particularly in clinical settings (for example to identify fetal facial anomalies).

Current benefits of AI	Current limitations of AI
• Potential to improve 4D ultrasound clarity. • Reduce time cost of manual coding techniques. • If refined, potential to reduce risk of human coding error.	• Large confidence intervals in AI fetal facial movement coding in Miyagi et al. (2021) paper. • Concerns over whether AI-altered videos are generalisable. • Concerns over impact of ‘smoothing’ ultrasound image.

4 - STUDY METHODOLOGY

- Ultrasound videos of five fetuses were used.
- Each fetus at each scan point was exposed to six different stationary light stimuli, as below:

Face-like stimuli	Non-face-like stimuli	
RU – right side up smiley face	DS – diagonal stripes	ES – extended stripes
UD – upside down (inverted) smiley face	VS – vertical stripes	SQ – square

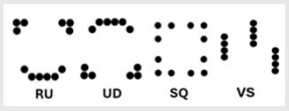

Figure 2 – example of light stimuli patterns used for the study

Figure 3 - modelling (by Durham University Department of Physics) of how light stimuli appears to the fetus in utero

- Stimuli also presented as moving. Analysis was conducted of fetal responses to RU and UD stimuli between moving and static presentations.
- Mothers completed validated mental health questionnaires on attachment, stress, anxiety and depression.
- FOMS coding system was used on Observer 12.
- Eyes open/closed and head turns (left/right/up/down) coded.
- 56 videos coded in total.

Methodology factors to be considered:

- Small sample size
- Some ultrasound videos had large sections where behaviour was not codable.

5 - ANALYSIS AND DISCUSSION

Regression analysis conducted of maternal mental health as correlated with each type of light stimuli (see Figure 4).

- No statistically significant results found. Small sample size meant perfect R^2 values and NaN p-values.

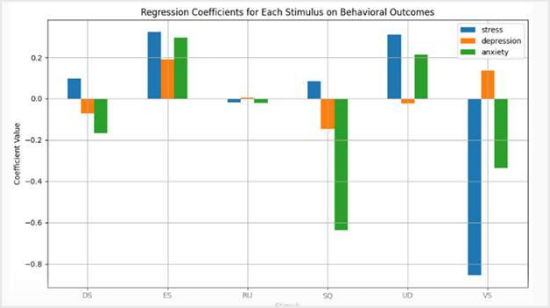

Figure 4 - Regression analysis of maternal mental health in relation to eye blink behaviours

Summarised answers to research sub-questions:

- No statistically significant correlations between maternal mental health and specific behavioural responses were found.
- No statistically significant difference between the average rate of eye movement and head turn behaviours at ~32-weeks versus ~36-weeks.
- No consistent relationship between frequency of movement and type of light stimulus.
- No significant differences between behavioural responses to the static and moving RU and UD stimuli.
- Two trends observed warranting further research (see below).

6 - CONCLUSION AND IMPLICATIONS

- Research indicates that including maternal mental health as a variable impacting fetal behaviour is essential to obtain valid results (Reissland et al. 2018, 2020).
- Existing research has shown differential fetal responses to different orientations of light stimuli (Reid et al. (2017), Reissland et al., (2020)).
- There are relative benefits and limitations of both manual and AI coding techniques within fetal ultrasound research, however AI has the potential to improve ultrasound research and clinical application.
- No statistically significant results were obtained in the current hypothesis-generating study; however, some trends were observed.
- Further research on why fetuses respond differently to different orientation of light stimuli could have important implications for infant development.

Trends warranting further research include:

- Trend between increasing maternal stress and average relative frequency of eye movements at 36 weeks.
- One mother had a statistically significant change in eye movement frequency between ~32 and ~36 weeks.

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