# The Effect of Sleeping Routines on Infant MRI Acquisitions

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## INTRODUCTION

Infant imaging is integral to making strides in research that is concerned with neurodevelopmental changes in infancy. Magnetic resonance imaging (MRI) is a technique that is used to track the development of brain structures over time (Singh et al., 2023). Due to the precision of this technique, which captures fine details of the brain structure, body movements can cause a great loss of signal. Lying still during the acquisition can be a major challenge for very young participants, such as newborns, infants, and toddlers. Sedation is not an option that most researchers will visit because its known risks (Templeton et al., 2020).

This leads to the interest in quantifying the factors that can improve the likelihood of performing a successful MRI scan with infants. **Previous research has identified the procedures to improve MRI acquisition with infants.** The developing ear is more sensitive to the sound pressure levels that are produced by the MRI. Devices such as earplugs paired with headphones are recommended for both active noise protection (i.e., the sound is being emitted to cancel out the frequency of the MRI) and passive noise protection (i.e., a barrier from the MRI noise). Whisper MRI sequences are also used to create a more conducive sleep environment and reduce movement during the scan (Akbar et al., 2023). All these factors represent adjustments to the environment or experience for the infant, rather than analyzing the infants' own habits in relation to MRI success.

**The goal of the current study is to determine impact of sleeping habits**, such as position and consistency as well as environmental factors, such as breastfeeding and noise, **on the success of the MRI**. Infants were divided into two groups based on the MRI scan outcome – successful vs. unsuccessful. Group comparisons were performed on these variables and classification tree models were conducted to identify the factors predicting the MRI outcome. **Determining what factors will increase success in scanning non-sedated infants will increase efficiency of MRI acquisition procedures.**

## METHODS

### Procedure

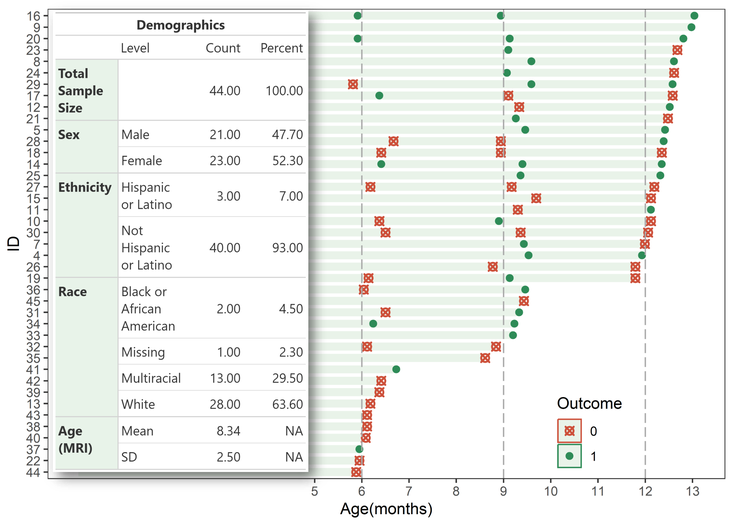
Parents filled out a survey on their infants' sleeping routine prior to the MRI visit. The survey included questions from the Brief **Infant Sleep Questionnaire – Revised** (BISQ-R, Mindell et al., 2019), aimed at assessing the infant's recent sleep patterns over the prior two weeks. We considered **demographic characteristics** (i.e., age and sex), along with factors related to **sleep patterns** (i.e., sleep consistency, onset latency, sleep-MRI gap, posture, and feeding) and **visit time** (i.e., sleep-MRI time gap) to determine their impact on MRI scan outcome. The MRI scans could only be collected between 2:00 pm and 8:00 pm. Appointments were scheduled within the time period of MRI machine availability and around the baby's sleep schedule. All variables are considered in relation to the MRI outcome at each visit.

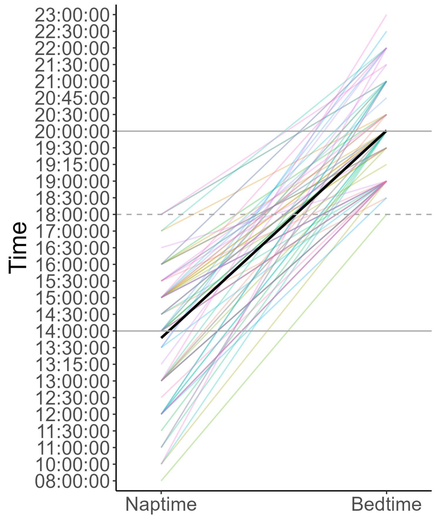
## SAMPLE

Data for a total of 44 participants was considered in the current study. Each participant contributed with up to 3 MRI visits. Scans were scheduled when participants were 6, 9, or 12 months of age. **Based on all the participants there was an overall MRI success rate of about 47%.** On average participants took their afternoon naps around 2 pm, whereas their bedtime was around 8 pm. Many naptimes fell in a time when the MRI machine was not available, **36% of the sample (16 participants) had bedtimes that were after the time when the MRI machine would be available**.

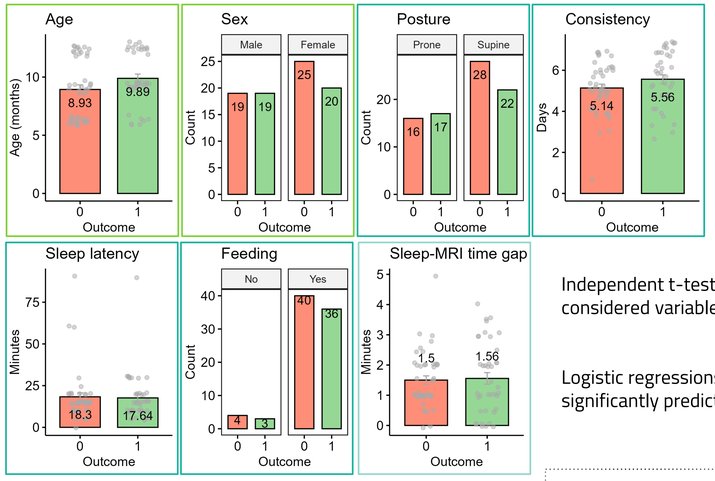
**Demographics**

| | Level | Count | Percent |
|---|---|---|---|
| **Total Sample Size** | | 44.00 | 100.00 |
| **Sex** | Male | 21.00 | 47.70 |
| | Female | 23.00 | 52.30 |
| **Ethnicity** | Hispanic or Latino | 3.00 | 7.00 |
| | Not Hispanic or Latino | 40.00 | 93.00 |
| **Race** | Black or African American | 2.00 | 4.50 |
| | Missing | 1.00 | 2.30 |
| | Multiracial | 13.00 | 29.50 |
| | White | 28.00 | 63.60 |
| **Age (MRI)** | Mean | 8.34 | NA |
| | SD | 2.50 | NA |




## RESULTS




**Demographic variables**
- Age
- Sex

**Visit variable**
- Sleep-MRI time gap

**Sleep variables**
- Posture
- Consistency
- Latency
- Feeding

Independent t-tests showed non-significant differences between groups for all considered variables, ts (81) <-1.76, p > 0.08

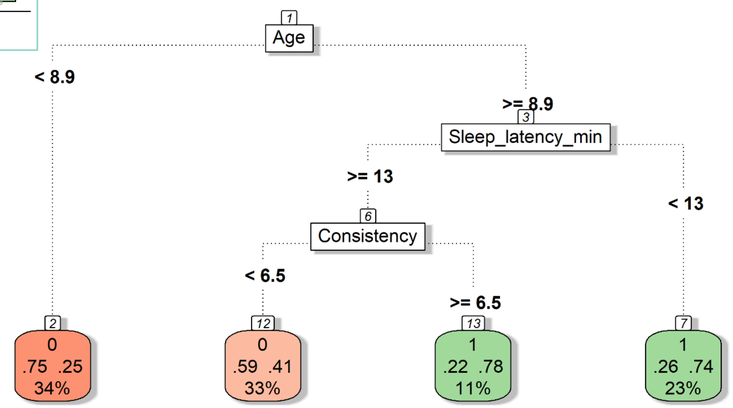
Logistic regressions showed that none of the considered variables were significantly predicting the MRI outcome (ps > .172)

Decision tree models were performed in three consecutive steps starting with demographic variables (tree1), and adding sleep (tree2) and visit variables (tree3).

A repeated cross-validations approach was used to train the model, considering 5 folds repeated 2 times.

The tree2 was the best model (accuracy = .58, Kappa = .15), with age, sleep latency, and consistency as final nodes.

**Successful MRI scans were more likely to be performed with older infants with short sleep latencies and more sleep consistency .**




## CONCLUSION

The current study investigated the effect of infants' sleeping habits on the success rate of MRI acquisitions collected during natural sleep.

There were non-significant differences between groups for the seven measures under investigation.

Decision tree models suggested that **younger infants (i.e., age less than 8.9 months) were more likely to be unsuccessfully scanned**. Sleep latency and sleep consistency also showed to be terminal nodes of the model. Specifically, **infants who usually take less than 13 minutes to fall asleep have 74% chance of being scanned successfully**. Furthermore, **infants who have consistent sleep habits (i.e., more the 6 days a week) have 78% chance to be successfully scanned**.

**Future Directions**
- Use larger and more diverse samples
- Utilize quantifiable sleep measure devices
- Manipulate sleep environments and routines experimentally
  - Investigate and apply non-sedative strategies to improve scan success

**Machine learning decision tree can be implemented to predict the outcome of imaging procedures. These results can be utilized to implement improvements on imaging protocols.**

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