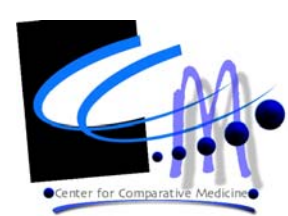


Benefit of Decreasing Noise Stimulation for Anesthetized Non-Human Primates Undergoing MRI Scans

Center for Comparative Medicine
Massachusetts General Hospital
Charlestown, MA

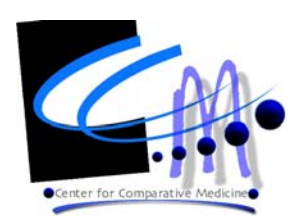
American Association for Laboratory Animal Science
60th Annual Meeting, Denver, CO
Session # PS85, November 11, 2009



MRI Acoustic Noise



- High-level sounds produced during magnetic resonance image mapping
- Various sources
 - Pump for liquid helium that cools magnet
 - Imaging room air-handling system
 - Fan in imaging bore to cool patient
 - Gradient noise produced by gradient coils during image acquisition, = highest-volume noise with tonal “beeps”, “banging”, and vibrations



The Bad News

- Human hearing range = 0-180 decibels (dB's)
- Continual exposure to >85 dB's is dangerous
- Gradient noises in most 3T magnets produce 123-138 dB's of peak noise levels
- Negative consequences
 - Temporary ↑ in hearing threshold
 - ↑ stress, even with light sedation
 - Avoiding motion artifact during imaging may require more sedatives, longer scanning time

Countermeasures

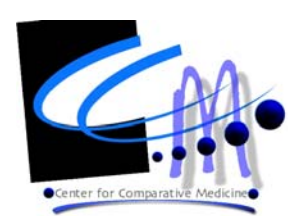
- Reduce the noise at its source
 - Modify image timing, sequencing, acquisition
- Reduce noise transmission from source→subject
 - Use sound-attenuating materials to reduce noise conduction through subject's ear canal
 - Reduce noise level conduction from source to subject's head/body via active noise reduction techniques



Observations and Questions

- NHP's exhibited \uparrow HR and RR during MRI scans while anesthetized
- Are these increases evidence of distress?
- Is the distress noise-related?
- Would reducing noise conduction at ear level help NHP's?





Materials and Methods



Eight 3½-year-old rhesus macaques

- Sedation induced with 15 mg/kg Ketamine HCl IM + 0.04 mg/kg Atropine IM. Propofol administered at 5 mg/kg IV to effect for intubation
- Animals underwent fMRI brain scans in a 3T magnet for a duration of 90 minutes each under propofol maintenance IV at 250-500 mcg/kg/min
- All scans performed under IACUC-approved protocols
- Routine veterinary support provided in the course of general anesthesia included IV fluid administration, monitoring and recording of vitals (HR, RR, SpO2%, ETCO2, NIBP), and providing circulating hot water pads for supplemental heat

Experimental Design

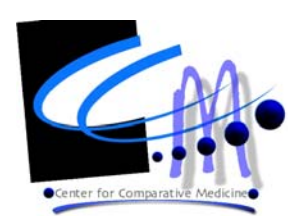


- **Group A:** All animals underwent 4 separate scans of 90 minutes each without noise reduction methods (control)
- **Group B:** Four animals were provided with pediatric BabyBlues ETY•Plugs™ during 4 additional scans each

Experimental Design (2)



- **Group C:** Four animals provided with pneumatic ScanSound™ headphones playing Baby Mozart™ classical music at 60-80 dB's during 4 additional scans each
- **Group D:** Two animals provided earplugs and ear-muffs together during 2 additional scans each

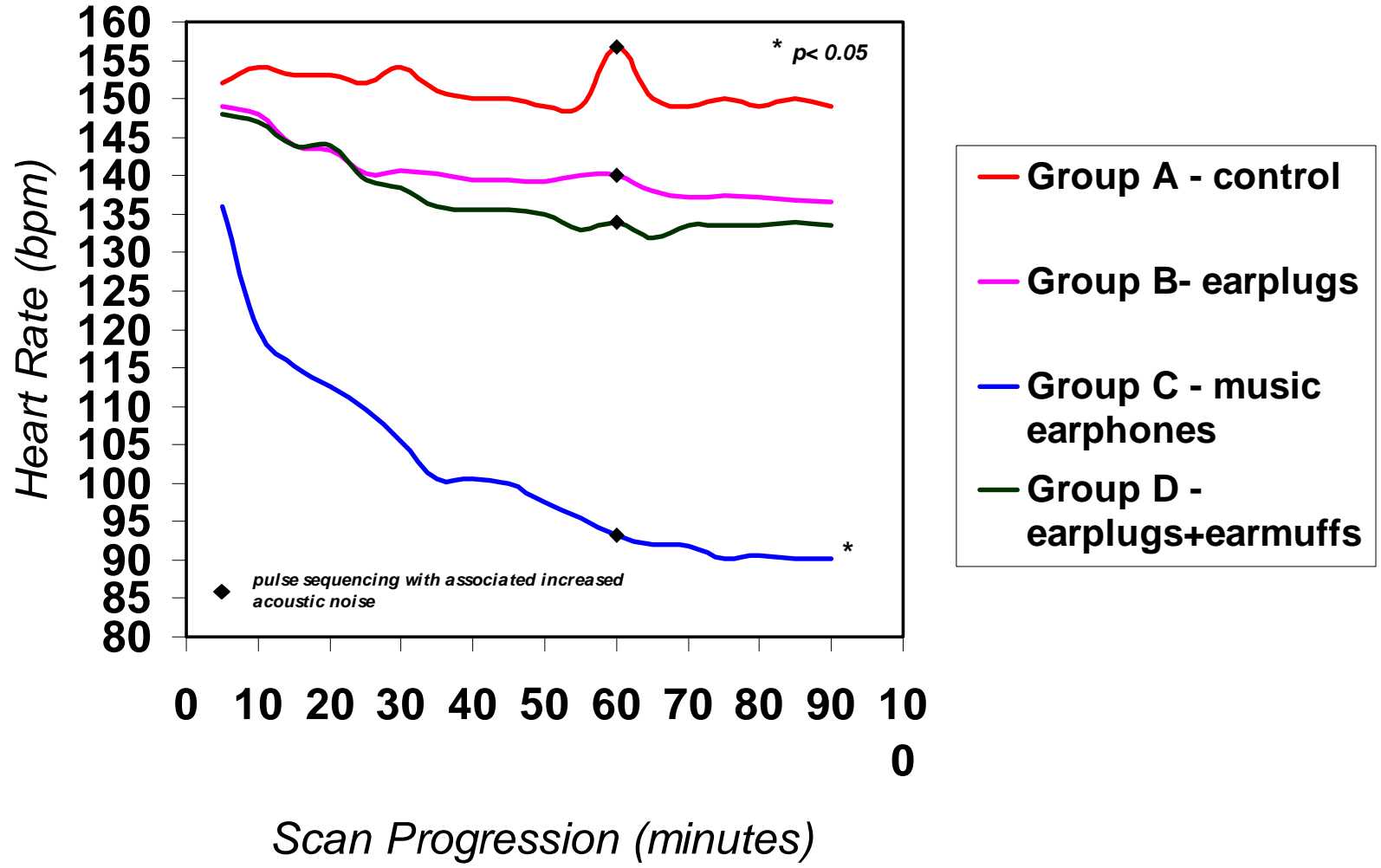


Experimental Design (3)

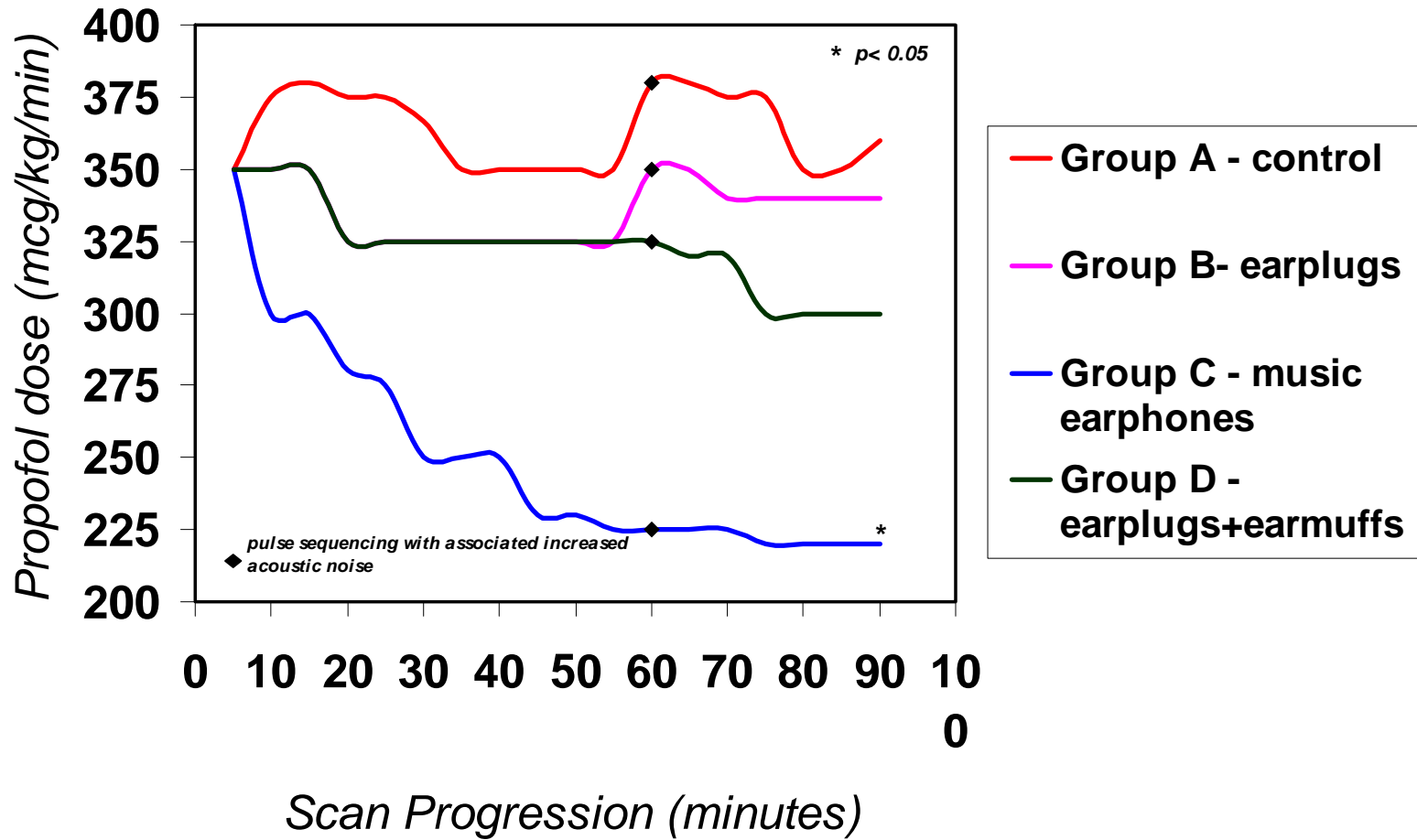


- Means were calculated from each animal's individual data over their entire scans/group
- Data from all animals in each group were then combined and used to calculate means for:
 - Heart rate over duration of entire scan
 - Propofol maintenance dose
 - Recovery time between final propofol dose and sitting up without assistance in home cage
- Means of each group were compared against the control group using a two-tailed Student's t test (significance at $p < 0.05$)

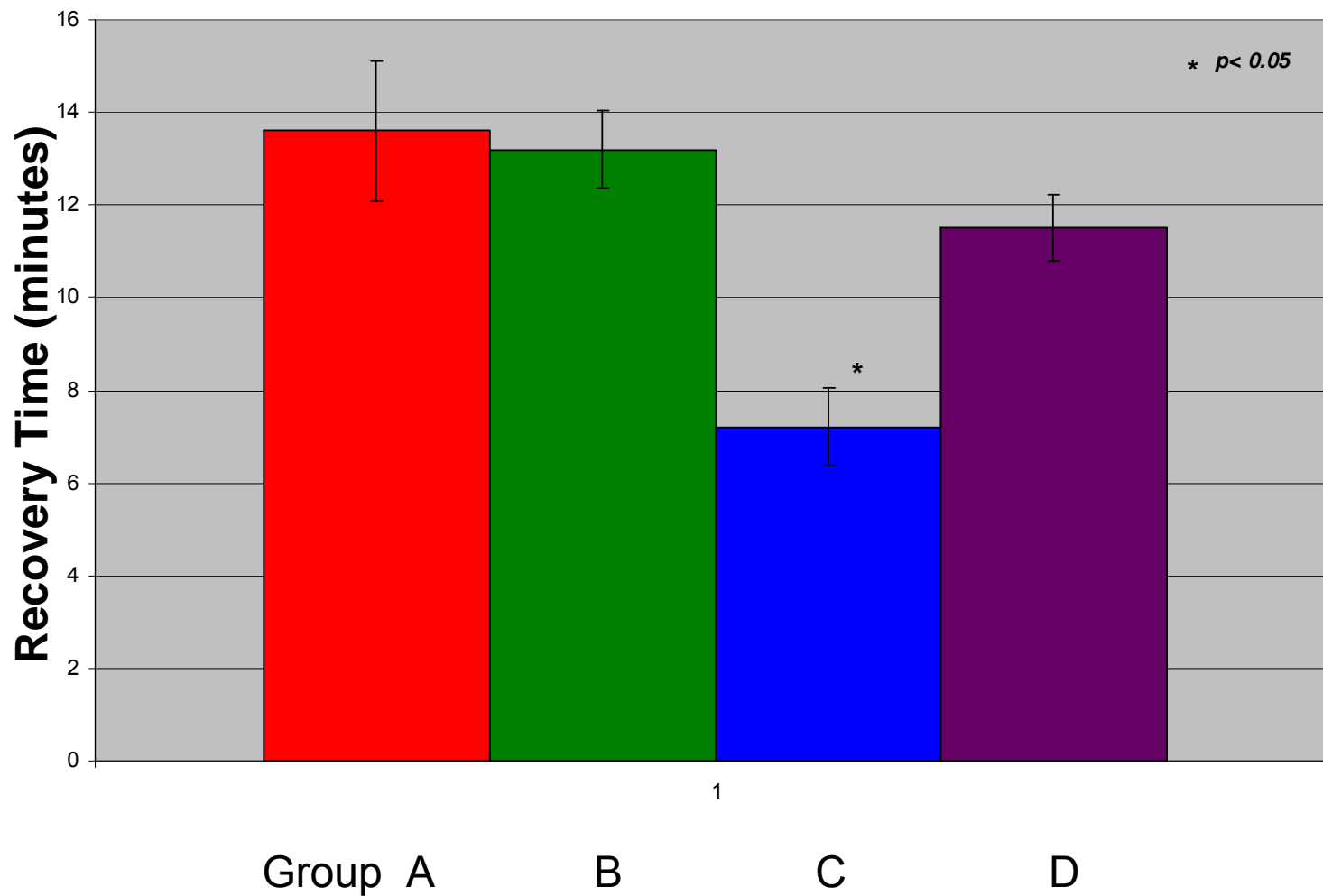
Heart Rate Results

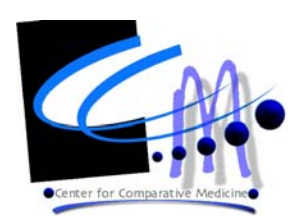


Propofol Results



Recovery Time Results

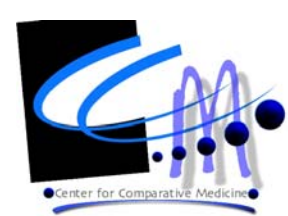




Results



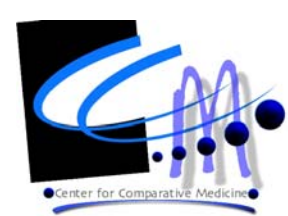
- Animals in the control group and Groups B and D maintained level heart rates and required more anesthesia to remain still when exposed to MRI noise
- Animals provided with musical headphones (Group C) required 30% less anesthetic and had heart rates 41% lower than controls (Group A)
- Recovery times (time to sitting up) between Group A and Group C improved by 7 minutes (47% sooner vs. control)
- Unlike Group A, no animals in the other 3 groups awoke or showed movement during the loudest sequencing phase



Discussion



- Less anesthetic is better
 - Better medicine (safer physiological state)
 - Better welfare (faster recovery time)
 - Better science (more data via more frequent sessions)
- Continuous MRI noise requires more anesthetic
 - Strategies to ↓ anesthetic dose should be encouraged
- Group C strategy was safe for the animal, easy to use for personnel, and effective in this pilot study



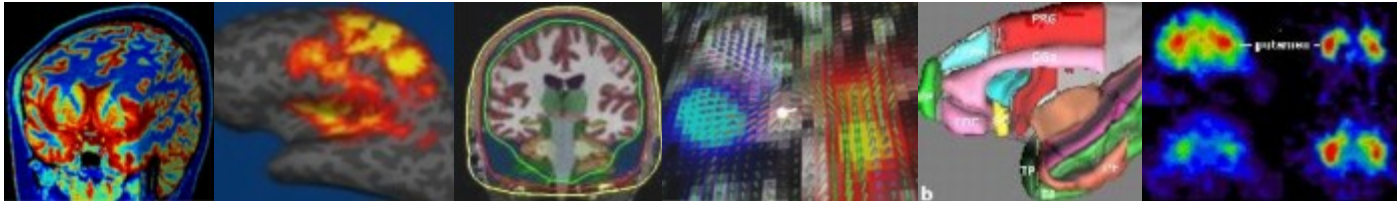
Next Steps



- Larger n values for Groups B, C, D
- Consider anatomy of NHP ear canals
 - Earplugs found on market not ideal for shape and size of most laboratory animal ear canals
 - Difficulty keeping BabyBlue[®] ear plugs in place (only during prep phase pre-scan)
- Compare effects of different animal positions in MRI bore as well as other magnet strengths
- Consider behavior/conditioning training to detect and quantify NHP hearing damage from overexposure to acoustic noise levels
- Investigate additional species (NHP and otherwise)

Acknowledgements

- Athinoula A. Martinos Center for Biomedical Imaging (<http://www.nmr.mgh.harvard.edu/martinos>)



- All of the many CCM Research Animal Specialists who assisted in anesthesia monitoring support

Questions?

