DREAMIES T-M: A Novel Ear Protection Method in Infant Neuroimaging Research

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Introduction

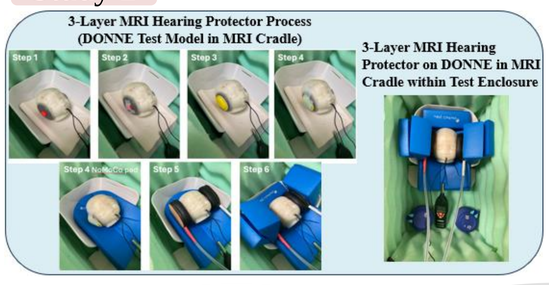
- Typical infant ear protection is a combination of putty earplugs, adhesive foam ear muffs (i.e., MiniMuffs or Neonatal Noise Guards) stabilized with adhesive tape, and headphones playing white noise. Soft foam padding is frequently added to stabilize the infant's head.
- DREAMIES T-M (NEATCap Medical, LLC, Bethlehem, PA), offers a new solution using soft foam, sealing ear cups and a soft, adjustable neoprene-nylon headband to ensure a snug seal providing a 27 dB overall sound attenuation that is less invasive.
- The use of DREAMIES T-M has yielded an overall success rate of 72% among infants and toddlers up to 48 months ($N_{3\text{-}9\ months}$ = 33/45, $N_{9\text{-}15\ months}$ = 2/4, $N_{15\text{-}30\ months}$ = 1/1).
- The present study aimed to evaluate sound attenuation of DREAMIES T-M compared to other ear protection methods to find optimal hearing protection for infant and toddler neuroimaging.

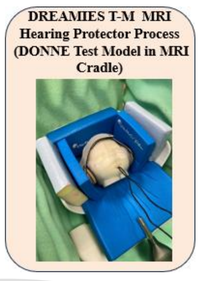
Methods

Study 1

- All testing were done at the University of Maryland Neuroimaging Center
- **Study 1** tested pink and rain noise as well as a mixed recording of MRI T1, T2, and DWI sounds.
- **Study 2** tested sound recordings of each MRI sequence from the HBCD study protocol.

Study 2





DREAMIES T-M

- Faster, less invasive application
- Resistance to moisture
- Often can be applied without waking up the child
- Reusable for subsequent visits
- Better sound attenuation at 2000 Hz

Provides sound attenuation for MRI sequences

3-Layer Method

- Invasive
- Time consuming application
- Comes off if the child sweats
- Silicone putty must be applied perfectly for sound attenuation to occur
- Child out-grows the MiniMuffs

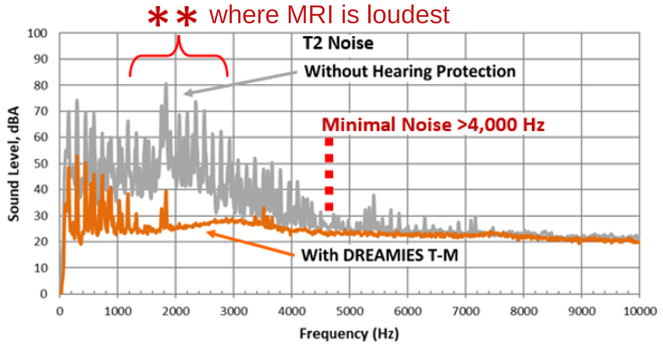
DREAMIES T-M provided higher sound attenuation (+4 dB) for T2 noise, and slightly higher sound attenuation for all other scans compared with the 3-layer method (best case scenario when a perfect seal with silicone putty was obtained). DREAMIES T-M's attributes of convenient and much faster application, ease of verifying a good seal by optical inspection, sweat resistance and position stability make it a preferred hearing protector for University of Maryland's HBCD scans.

Results

Study 1

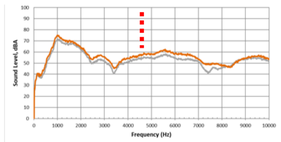
DREAMIES T-M Overall Sound Attenuation - T2 Noise (26 dB)

** where MRI is loudest



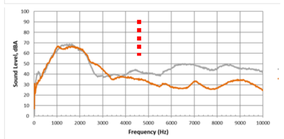
Overall Sound Attenuation of Rain Noise used for "Noise Masking"

Silicone Putty Incomplete Seal
0 dB Overall Attenuation
No Masking



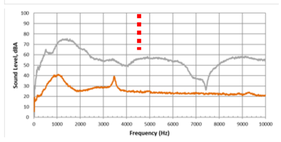
Gray – No Protector
Orange – Silicone Putty Incomplete Seal

Yellow Foam Earmuffs
1 dB Overall Attenuation
Almost No Masking
Some masking >4,000 Hz



Gray – No Protector
Orange – Yellow Earmuff Complete Seal

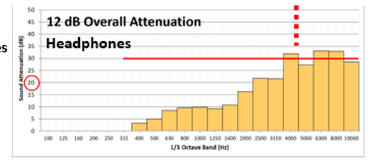
DREAMIES T-M
34 dB Overall Attenuation
Near-complete Masking

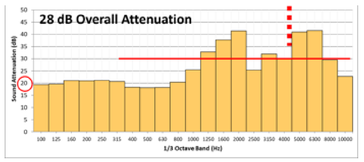


Gray – No Protector
Orange – DREAMIES T-M Complete Seal

Pink Noise Test Data Suggest Benefit of DREAMIES T-M with Padding

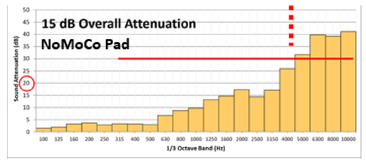
Headphones are not great earmuffs

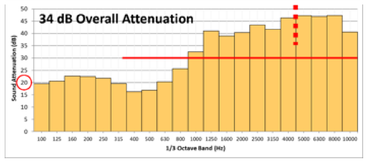




DREAMIES T-M

Pad blocks more sound than Headphones

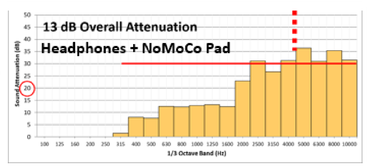


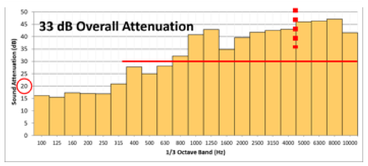


DREAMIES T-M + NoMoCo Pad

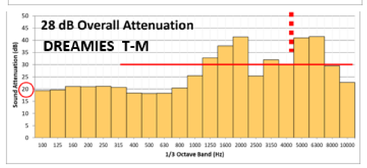
** Simplest Combination

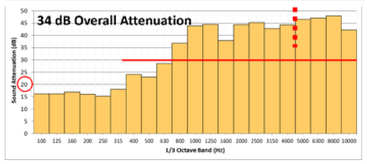
Headphones + Pad combo not significantly better





DREAMIES T-M + Headphones





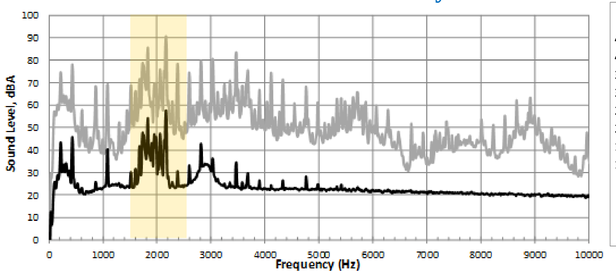
DREAMIES T-M + Headphones + 2 NoMoCo Pads

Study 1 and Study 2 found the overall sound attenuation achieved by applying multiple layers of sound protection is not simply the numerical sum of the sound attenuation of the individual layers. Adding more layers of hearing protection does not always result in more sound attenuation.

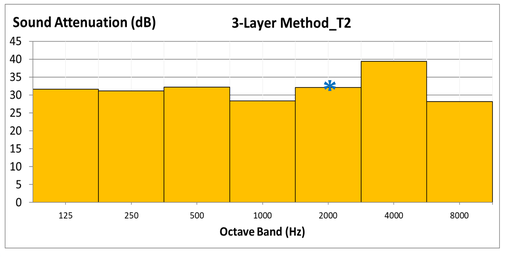
Study 2

	Silicone Putty + Tape + MiniMuffs + Tape + Headphones plus NoMoCo Foam Pad - L&R Avg							
	Sound Attenuation (dB)							
Scan	Overall (dBA)	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
T2	**32.6**	27.8	27.9	29.3	32.6	32.4	38.5	27.8
Resting-state fMRI (fieldmaps)	**30.7**	26.6	27.1	28.7	34.8	26.5	26.0	24.9
Resting-state fMRI	**29.4**	27.3	27.3	29.2	33.1	25.0	25.8	26.2
DWI	**33.6**	26.2	27.4	29.1	17.1	26.9	21.3	19.2
Ojalas	**28.4**	28.2	28.5	26.9	29.7	26.9	24.4	16.8
fmap_TB1TFL	**31.1**	27.5	28.0	32.7	23.7	24.9	21.5	19.1
MRS-LocAX	**29.0**	27.7	28.2	29.5	28.3	25.9	29.8	22.9
MRS-LocCor	**31.0**	27.9	28.0	29.2	21.3	25.3	30.0	20.6
MRS (shimming)	**30.5**	25.2	28.0	26.1	25.4	25.3	32.5	17.1
MRS	**29.2**	28.6	27.8	28.0	30.4	25.4	29.2	24.1
T1	**31.5**	28.5	28.9	31.8	28.2	26.9	31.3	23.8
Average	**30.6**	27.4	27.9	29.1	27.7	26.5	28.2	22.0

T2 Scan Sound with and w/o 3-Layer Method



Measured Attenuation of T2 Scan Sound



* Note: Our test shows the greatest sound blocking difference between DREAMIES T-M and the 3-layer method occurs at 2000 Hz where T2 Noise is loudest.

	DREAMIES T-M plus NoMoCo Foam Pad - L&R Avg							
	Sound Attenuation (dB)							
Scan	Overall (dBA)	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
T2	**36.9**	26.3	27.3	27.5	35.7	41.3	39.0	28.0
Resting-state fMRI (fieldmaps)	**31.4**	24.5	27.2	24.7	29.0	32.3	26.3	25.3
Resting-state fMRI	**30.4**	24.1	27.8	24.9	30.4	31.7	26.1	26.6
DWI	**34.3**	23.1	27.5	25.7	17.4	31.9	21.8	19.6
Ojalas	**30.1**	26.8	26.6	23.8	31.1	37.1	24.9	17.3
fmap_TB1TFL	**29.9**	24.5	26.9	25.3	24.0	33.2	22.0	19.6
MRS-LocAX	**30.8**	25.4	26.6	25.5	28.5	36.6	30.7	23.5
MRS-LocCor	**32.1**	25.5	28.0	25.5	21.6	31.6	30.8	21.1
MRS (shimming)	**32.9**	23.8	28.6	23.0	25.8	32.8	33.3	17.6
MRS	**28.6**	25.6	27.7	24.1	31.1	35.1	29.9	24.6
T1	**32.5**	24.9	29.7	24.2	28.9	35.2	32.2	24.4
Average	**31.8**	25.0	27.6	24.9	27.6	34.4	28.8	22.5

T2 Scan Sound with and w/o DREAMIES T-M