Assessing Quality Control of MRI-based Measurements of Iron for Adolescent Learning

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Abstract

- Adolescents must learn a lot throughout the transition from childhood to adulthood to navigate changing environments. Brain systems supporting learning through **dopamine signaling** also undergo changes during adolescence. Although research on adolescent development is growing, our knowledge about adolescent learning and behavior remains limited, as dopamine signaling is difficult to measure directly. Instead, tissue iron accumulation can act as a **proxy** for dopamine synthesis, a process known to have **connections to learning.**
- Our project aims to explore the relation between **iron concentrations** in brain regions involved in dopamine signaling and **adolescent learning behavior.** To understand this relationship, Magnetic Resonance Imaging (**MRI**) scans from participant studies were obtained to indirectly measure dopamine activity.
- We assessed the quality of MRI scans on **96** subjects and reviewed over **40,000** MRI slices to determine if distortions (**artifacts**) were introduced during **scanning** or MRI **processing**, and noted scans that required reprocessing or removal. Additionally, we assessed the distribution of iron concentrations in subcortical structures for any unusual results or potential patterns within these structures. Ultimately, we decided on the **removal/reprocessing** of **4230** MRI.

Background

- Adolescence is the **transition** from childhood to adulthood, characterized by **increased learning** and **cognitive development**
- The **basal ganglia** undergoes structural and neurochemical changes as a center for **cognitive** and **motivated behavior**

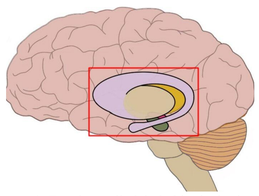

Figure 1: Basal ganglia labeled in the brain

- **Dopamine** is a neurotransmitter that is involved in reward-seeking behavior, motor control, and **learning**
- Iron accumulation serves as a **proxy** for past dopamine activity

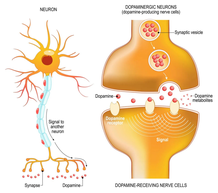

Figure 2: Dopamine neurotransmission

- Magnetic Resonance Imaging (MRI) is a noninvasive technique that can be used to quantify **iron levels** in different brain regions
- Distortions (**artifacts**) in these images result due to subject **motion** and MRI **processing** issues → reduced signal to noise ratio

Figure 3: Northeastern's 3T MRI Scanner

Our Contributions

1) **Literature review** to gain conceptual understanding of our research topics
2) **CITI training** (research ethics training) to handle human subject data ethically and protect privacy
3) MRI **Quality Control** (QC) **training** to learn how to identify different artifacts in the data set
4) Visual **quality control** checks of MRI data to **rate** scans and provide qualitative feedback, marking scans that need to be **removed** or **reprocessed**
5) Assessment of **iron** concentration data for **distribution** type and possible **patterns**

Artifact Documentation and Iron Analysis

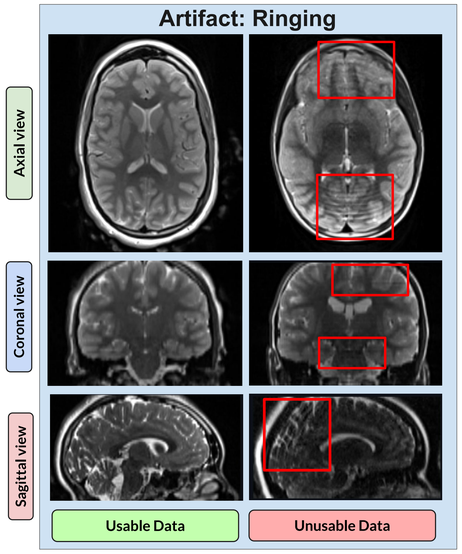

Figure 4: Ringing artifacts visualized

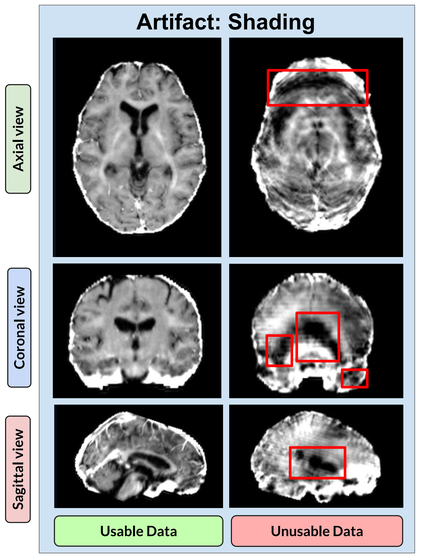

Figure 5: Shading artifacts visualized

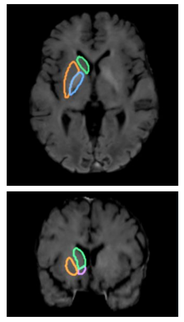

Figure 6: Regions of interest

Figure 7: Subcortical iron distributions

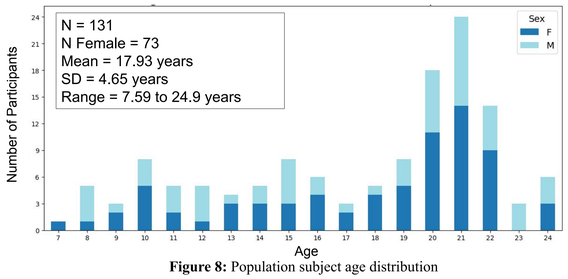

Figure 8: Population subject age distribution

Children (7-12) Count: 27
Adolescents (13-17) Count: 24
Young Adults (18-24) Count: 80

Our Total Subsample: 96 subjects
We Removed:
- 6 Child Subjects: 2538 slices
- 1 Adolescent Subject: 423 slices
- 3 Young Adult Subjects: 1269 slices

Total Removal: 4230 slices

Conclusion and Applications

- Brain tissue iron data will be used to determine patterns in iron distributions, as this novel research technique is mostly unexplored
- Our QC data will be used for future studies by our lab on:
  - **Peer influence** and **pro-social risk taking** in adolescents and its connection to dopamine function
  - **Reinforcement learning** and how reward-based learning changes across age groups
- Can **inform** us more broadly about adolescent **learning** and **behavior**:
  - Create better policies in **education**
  - Improve **juvenile** justice laws
  - Better understand **mental health** vulnerabilities

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