Prescribed Psychostimulants and their Impacts on Brain Development

TACOMA

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Background

- This literature review aims to identify any notable differences in **anatomical structure and physiological functions** of the brain in those diagnosed with attention deficit hyperactivity disorder (**ADHD)** taking psychostimulants compared to those who do not.
  - ADHD is a neurodevelopmental disorder that affects impulse and motor control
  - Psychostimulants are class ll drugs used to treat ADHD that work by increasing the transmission of neurotransmitters.

Methods

- magnetic resonance imaging (**MRIs)** and positron emission tomography scans (**PET)** are used to capture **anatomical features and cellular activity of the brain**.
  - A patient is sent through a large magnet that causes protons in the body to align to produce images.
- CIVET-1.1.12 (Cortical Imaging via Surface Extraction) and MAGeT-Brain (Multi-atlas Grey Matter Segmentation) computer software tools are used for **neuroimaging analysis** to identify tissue and record cortical metrics

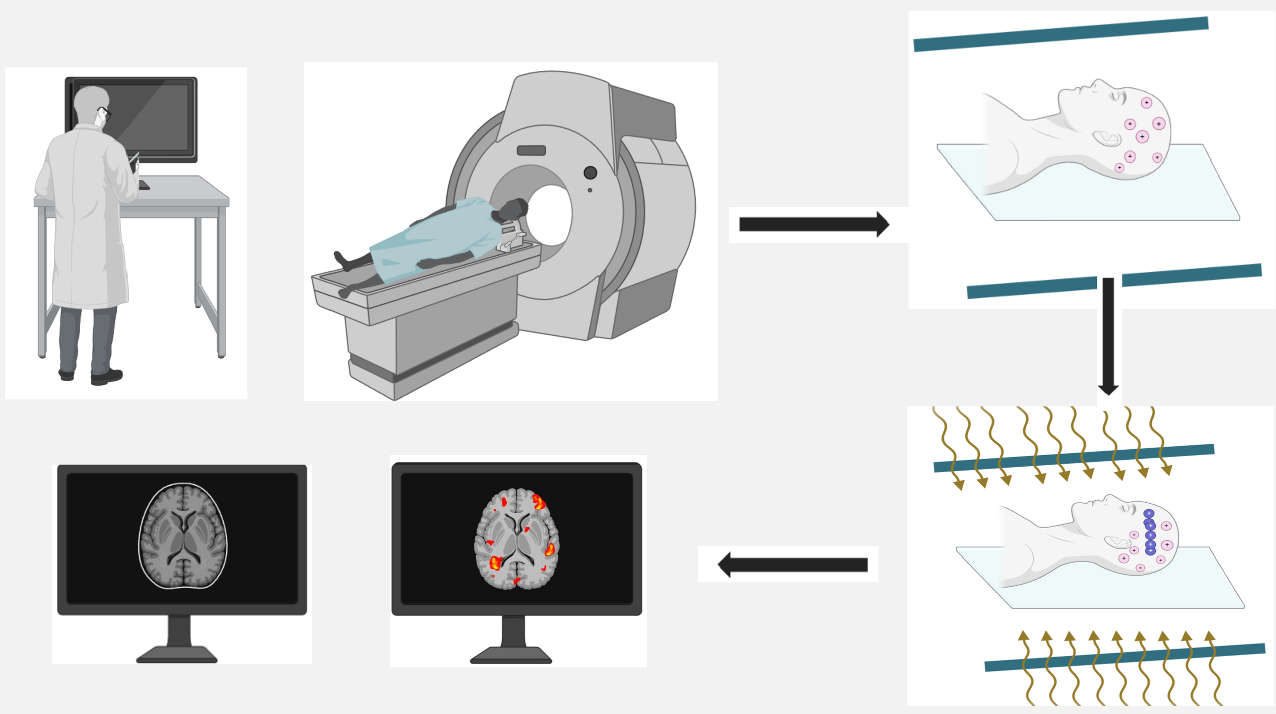


Fig. 1 Visual representation of how MRIs work (image created with BioRender).

Diverging development

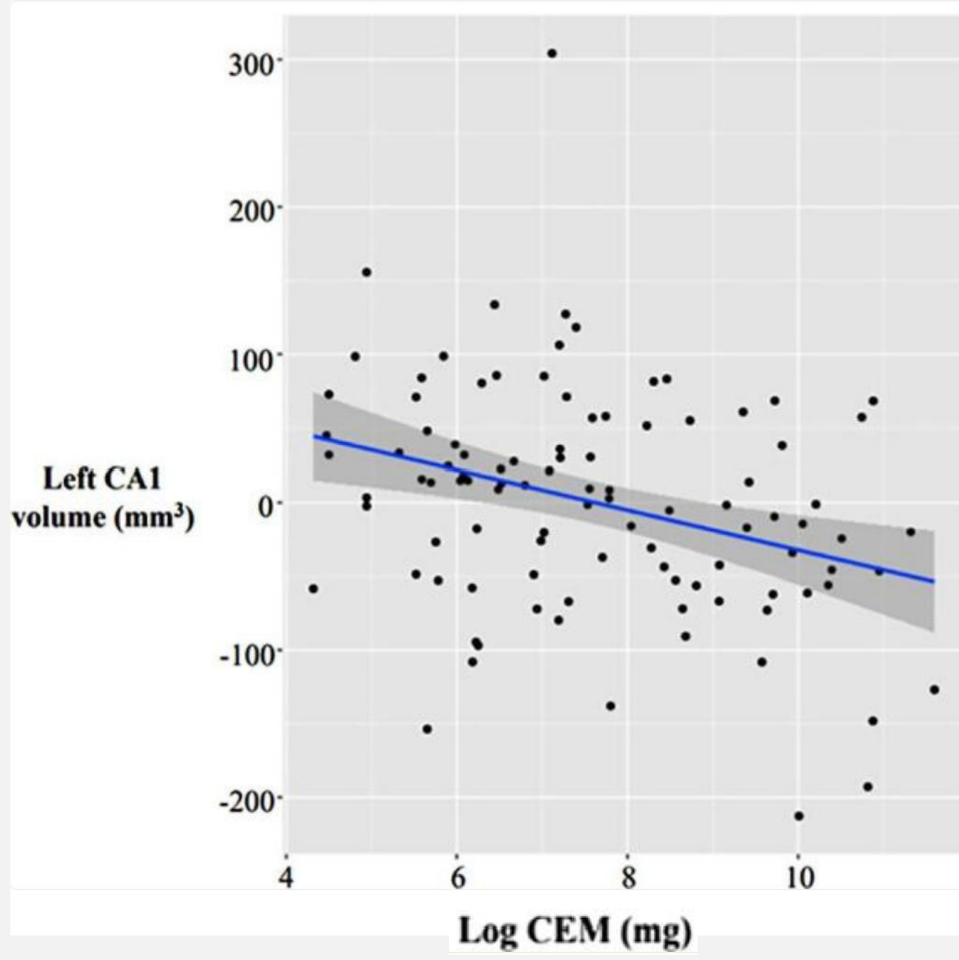


Fig 4 Graph characterizing the relationship between chronic exposure to ADHD medication and hippocampal CA1 volume (Fotopoulos et al., 2021).

- In a durational study conducted, spanning from a week to about 4.5 years, research of **chronic exposure** to ADHD medication (CEM) showed that continuous stimulant use at higher doses to treat ADHD was associated with a **decreased left CA1 hippocampus volume**
- The hippocampus which is involved in memory consolidation and learning aspects was divided into regions; (CA1, CA2/CA3, CA4/DG, SR/SL/SM, and subiculum) imaging scans show that the subregion affected was CA1.
- Implications surrounding the **dose-dependent relationship** between development and functional **abnormalities** in ADHD have been noted.

Normalization patterns

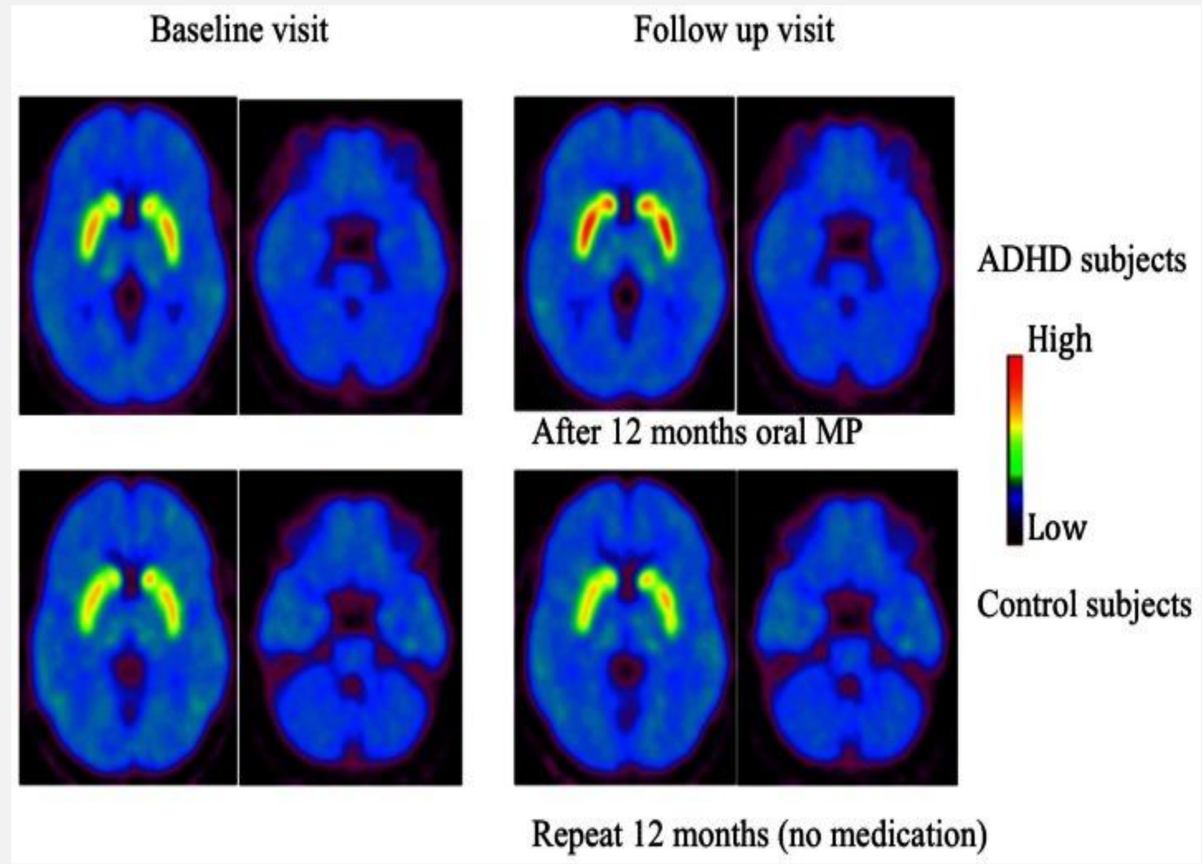
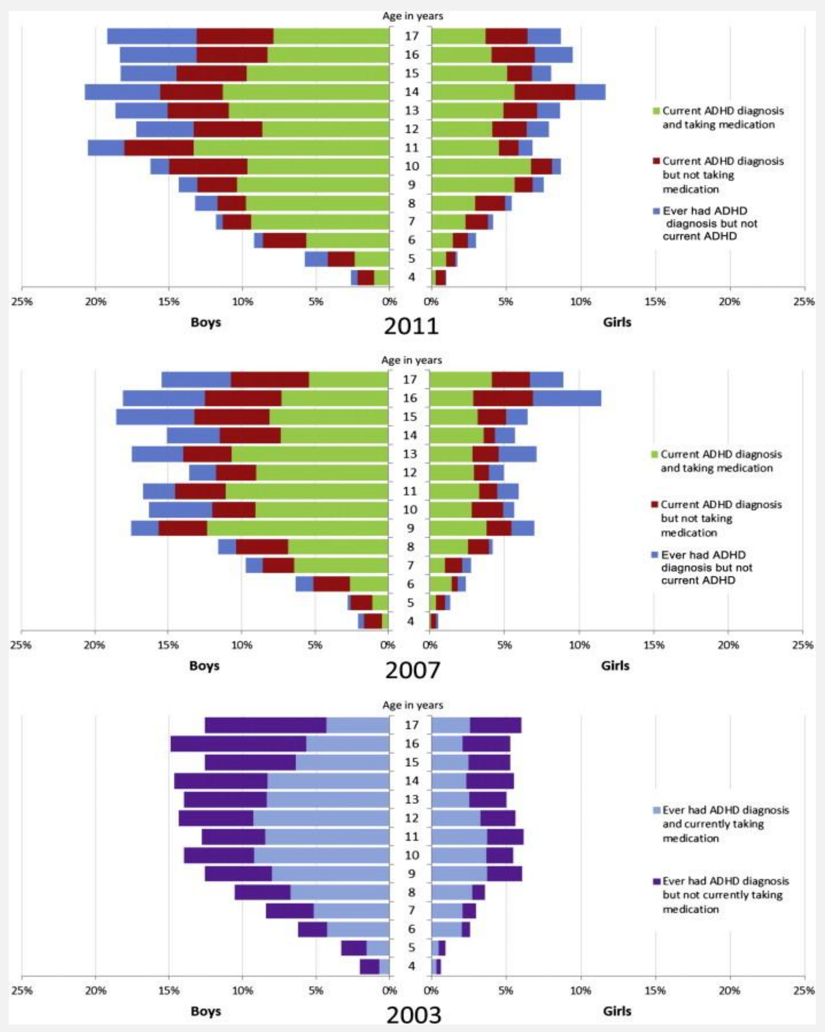


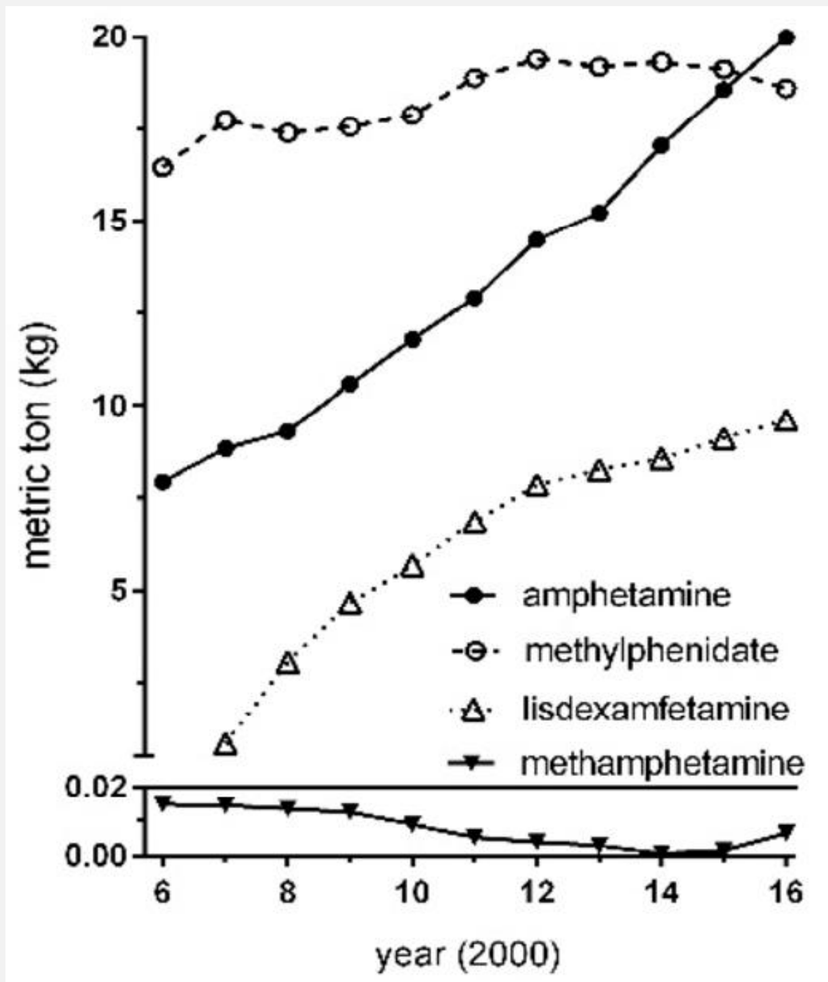
Fig. 5 Averaged dopamine transporter availability for ADHD (n=18) and control (n=11) subjects prior and concluding 12 months of oral MP treatment, along with baseline and 12-month follow-up for control group (Wang et al., 2013).

- Typically, in ADHD patients, there is **decreased transportation** of **Neurotransmitters** such as dopamine, norepinephrine, and epinephrine. These chemical messengers play important roles in **proper motor and impulse control**.
- 18 participants with ADHD were treated with methylphenidate (MP) and 11 control subjects with ADHD remained unmedicated throughout the experiment
- Concluding a twelve-month treatment of MP, PETS scans show increased striatal dopamine-transporter availability in structures of the caudate, putamen, and ventral striatum was observed in medicated ADHD patients (Wang et al. 2013).

Prevalence of ADHD and stimulant use



- Increased diagnoses and psychostimulant use have been observed, not seen prior to the 2000s
- From 2003-2011 trends in ADHD diagnoses have reported a 42% increase (Visser et al. 2014).
- **26.5 million children** ages 5-17 years old were **diagnosed** with ADHD **from 2020-2022** in the United States (Reuben 2024).



- From 2007—2011, 28% increase in medicated children aged 4-17 years old using prescription stimulants
- Common psychostimulants used to treat ADHD include amphetamine, methylphenidate, and methamphetamine.
- Estimated that about 3 million children diagnosed with ADHD will take prescribed stimulants to manage symptoms (Lakhan and Kirchgessner 2012)

Fig. 2 Estimated prevalence of parent reported ADHD incidences diagnosed by health care provider among children by age, sex, and medication status-United states 2003,2007, and 2011 (Visser et al., 2014).

Fig. 3 Time course of weighted of amphetamine, methylphenidate, methamphetamine, and lisdexamfetamine dispensed in the U.S. and its territories from 2006-2016 (Piper et al., 2018).

Conclusions

- Overall results show that the use of psychostimulants in cases to treat ADHD has both **normalizing and diverging developmental differences.**
- Additional research needs to be done to adequately represent the developmental effects, few studies truly depict the long-term effect of pharmaceuticals and their impact on the development of the brain.
- Future studies should increase the number **of longitudinal studies** to accurately determine any effects the medication may have on **brain maturation**, expand the scope of research on the **relationship between dosage** of prescribed stimulants and observed developmental differences in **anatomical or physiological functions**, as well as an investigation into whether these noted differences have **adverse effects** on the quality of life for an individuals

Acknowledgments

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