Jumping to Conclusions: Younger Adults Show Stronger Lévy Flight Patterns Than Older Adults During Fast Binary Decisions

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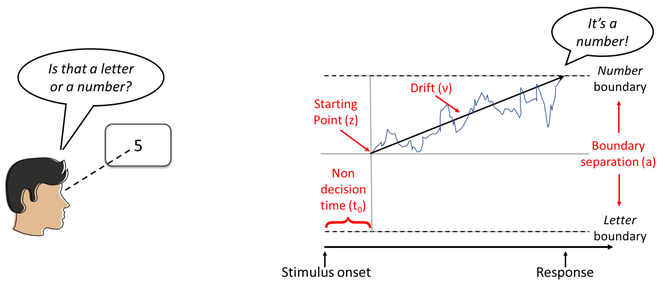
Background

- Over the past 20 years, the **Diffusion Model (DM)**[1] has gained popularity as a neurocomputational framework of speeded decision making[2]
  - The DM assumes that simple decisions (e.g., is that shape a person or a tree?) reflect the accumulation of noisy information until a threshold of evidence is reached
- The DM has also advanced research in **cognitive aging**, by identifying age differences in cognitive processes underlying speeded decisions[3,4,5]
- Recent research in aging has increasingly focused on **age-related changes in the intra-individual variability** of neurocognitive processes[6]
- The standard DM assumes that fast binary decisions are based on an evidence-accumulation process with Gaussian noise. However, recent research suggests that young-adult data are sometimes better characterized by so-called **Lévy-flight models with heavy-tailed noise distributions**. Lévy flights produce occasional extreme jumps in the accumulation process[7,8] which may be adaptive in certain contexts (e.g., exploration, foraging).

Research Questions

1. Do younger and older adults differ with respect to the "jumpiness" of the information accumulation process that guides their decisions?
2. How does "jumpy" information accumulation relate to other features of decision processes in younger and older adults?

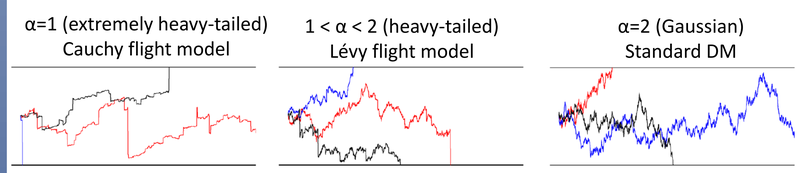
Diffusion Model (DM) vs. Lévy Flight Model



Parameters of the Standard DM

- **Non-decision time (t_0):** Time needed for stimulus encoding and motor response
- **Starting point (z)**: Located between the 2 boundaries; exact location determines bias
- **Drift rate (v)**: Average rate of information accumulation process; higher means more efficient (accurate and fast)
- **Boundary separation (a)**: Threshold of evidence needed for a decision; wider means more cautious (accurate and slow)

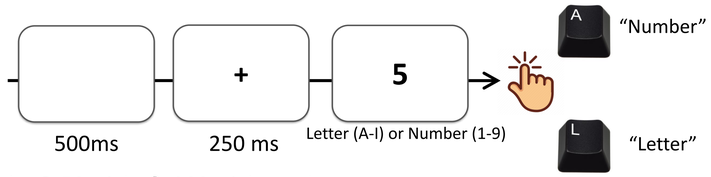
The **Lévy Flight Model** has an additional free **Stability Parameter α** which determines the shape of the noise distribution:



Sample path figures from Voss et al. (2019)

Method

Letter-Number Discrimination Task

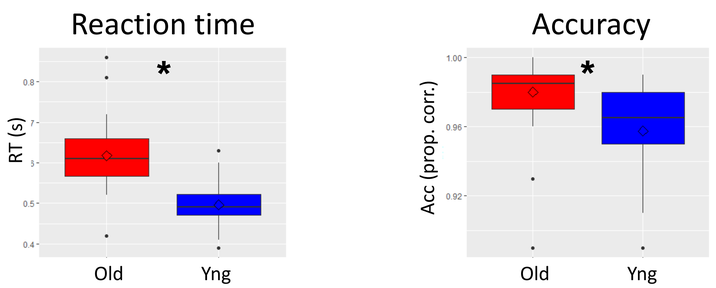


4 blocks @ 50 trials → 200 trials total

Participants: 40 healthy Younger Adults (Age 18-35, Mean = 23.95; 27 Female)
40 healthy Older Adults (Age 63-80, Mean = 69.95; 26 Female)

Model parameters estimated for each participant using deep probabilistic modeling approach for likelihood-free parameter estimation[8]

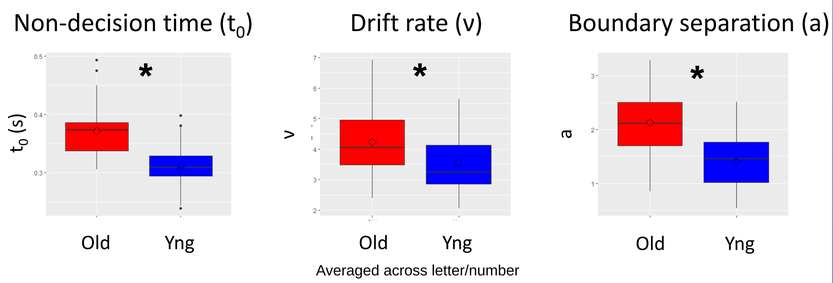
Behavioral Results



Based on median RT for correct responses

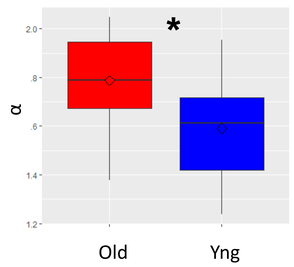
* indicates $p < .01$

Model Parameters



Averaged across letter/number

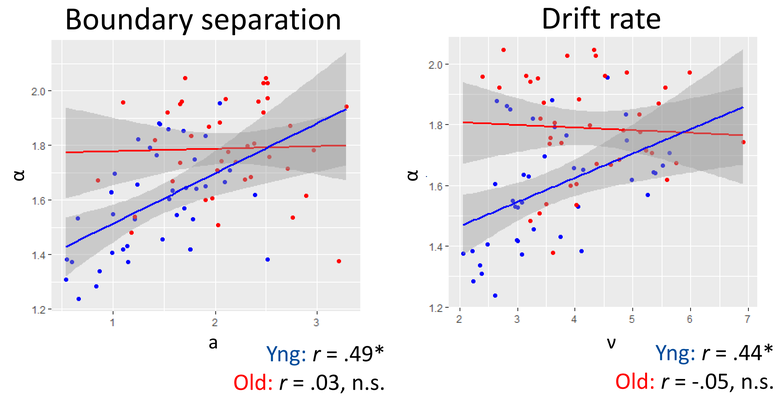
Stability parameter (α)



Key finding #1
Higher value of α in older adults: less "jumpy" information accumulation in aging.

* indicates $p < .01$

Relationship between α and other model parameters



Key finding #2
Younger adults with wider decision boundaries and higher drift rates also had higher α ("less jumpy"). This pattern was absent in older adults.

Conclusions

This study offers novel evidence of age differences in the intra-individual variability of information accumulation processes in decision making

→ **"Jumping to conclusions" more typical of younger adults than of older adults**

Open questions: functional significance and physiological basis of Levy flights; stability across decision domains; relationship to other measures of intra-individual variability (e.g., fMRI signal variability)

References & Funding

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