Background

- Real world decisions involve integrating rewards with other discounting factors such as time delays, probability, or physical effort.
- Discounting benefits by such factors generates a subjective value (SV) - or common currency - to maximize utility.
- A recent meta-analysis supports the common currency hypothesis, showing subjective values are represented in:
  - medial prefrontal cortex (mPFC)
  - posterior parietal cortex (PCC)
  - ventral striatum (vStr).
- However, these meta-analytic approaches focused on healthy young adults.
- Using tasks that integrate monetary rewards with either time delays, probability, or physical effort, we examined adult age differences in:
  - discount rates
  - subjective SV representations
  - neural representation of reward and discounting factors.

Method

Participants
77 healthy participants completed the study at Vanderbilt University Mean Age (SD) = 49.86 (17.94), Age Range = 22 – 83, 44 Female, 33 Male

Procedures
- **Effort**: choices between a smaller reward with a lower level of physical effort and a larger reward with a higher level of physical effort.
- **Probability**: choices between a smaller reward with a higher probability and a larger reward with a lower probability.
- **Time**: choices between a smaller reward with a shorter time delay and a larger reward with a longer time delay.

Computational Modeling
Subjective values were modeled using a hyperbolic discount function:

\[ SV = \frac{1}{1 + e^{-k \cdot t}} \]

For each task, C represents either:
- **Effort**: Proportion of maximum ability
- **Probability**: Odds against winning (1-Pwin)/Pwin
- **Time**: Time delay in days

Data was fit with three decision rules:
- Softmax with free decision slope
- Softmax with decision slope = 1
- Hardmax + e

Best fitting models were determined using Akaike Weights.

Neural Subjective Value Representation

Best fitting k was used to generate trial-by-trial parametric modulators of SV tailored to each individual. \( p < .005 \)

Neural Reward Magnitude and Discounting Factor Representation

Raw reward and discount factors were used to generate trial-by-trial parametric modulators. \( p < .005 \)

Discount Rates and Age

There were no relationships between discount rates (k) and age:

- Reduced/reward magnitude with age in a network of regions, including:
  - bilateral inferior frontal gyrus (IFG)
  - caudate
  - thalamus.

- Reduced probability of reward with age in a network of regions, including:
  - left superior parietal lobule
  - caudate.

- Increased representation of time delay with age in inferior parietal lobule.
- Reduced representation of time delay with age in supplementary motor area.

Conclusions and Future Directions

- **Age differences only appeared when SV was decomposed into reward magnitude and each individual discounting factor.**
  - **Most effects were a reduction in representation with age.**
  - These effects differed for each discounting factor.
  - Consistent with prior studies in young adults, a network of regions including the mPFC and vStr correlated with SV.
  - Despite age differences in the representations of reward magnitude and each discounting factor, the lack of age differences in the representation of SV and behavior suggest that these value-related signals are integrated similarly across adulthood.
  - It is possible that age differences exist, but this study design was not sensitive enough to detect these age differences.
  - Monetary rewards may not be as salient for older adults.
  - Other, more relevant rewards (social or health) have been shown to elicit age differences in behavior.
- Future studies should use these other reward domains.

In this sample, we will also examine:
- distributed representations of SV using MVPA
- the relationship between SV representations and dopamine D2 receptor availability.

References

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