Is the Pigeon Brain Robust to Age-Related Atrophy? Revisiting Coppola and Bingman (2020)

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ABSTRACT

A previous study (Coppola and Bingman, 2019) reported age-related increase in forebrain volume in pigeons (contrasting with mammals). However, pigeons used may not have been old enough to detect age-related atrophy. Using similar methods to the previous study, the current study will measure even older pigeon brains to confirm their conclusions.

BACKGROUND

- In mammals, aging is often associated with atrophy of the forebrain, which is believed to result in learning, memory, and cognitive deficits (Samson & Barnes, 2013).
- In pigeons, aging is also associated with deficits in learning, memory, and cognition (e.g., Coppola et al., 2014), but their brain appears to be robust to age-related atrophy (Coppola & Bingman, 2019).
  - Coppola and Bingman (2019) found the brain of older pigeons (10-15 years; $M = 12.86$, $SD = 1.46$) to be *heavier* and *larger* than that of younger pigeons (2-3 years).
- The purpose of the current study was to reexamine the conclusions of Coppola and Bingman (2019) by measuring the brain of even older pigeons (18-20 years).

METHODS

- *Subjects:*
  - 10 white carneau pigeons: 5 young (1-5 years); 5 old (17 – 20 years; $M = 18.20$, $SD = 1.30$).
- *Procedures*
  - Each brain was measured on a balance (mass in g).
  - Each forebrain was measured five times along the maximal extent of the dorsal-ventral, medial-lateral, and anterior-posterior planes (Figure 1) using a digital caliper with a resolution of 0.01 mm. Averaged values were then multiplied together, yielding the volume (mm^3) of the smallest possible box in which the forebrain could fit.
- *Data Analysis*
  - An independent-samples *t*-test was used to compare the body mass (g) of young and old pigeons.
  - Two ANCOVAs (body mass as covariate) were used to analyze the effects of age on brain mass and forebrain volume.
  - Analyses were conducted in SPSS (v. 26); criterion for significance was $p < .05$.

RESULTS

- Younger pigeons ($M = 555.00$g, $SEM = 29.07$g) had a significantly lighter body mass than older pigeons ($M = 639.20$g, $SEM = 12.39$g), $t(8) = 2.67$, $p < .03$.
- Younger pigeons had a significantly greater brain mass ($M = 2.76$g, $SEM = 0.03$g) than older pigeons ($M = 2.42$g, $SEM = 0.08$g), $F(1,7) = 8.56$, $p < .03$, $\eta_p^2 = .55$ (Figure 2).
- The forebrain volume of younger pigeons ($M = 1480.44$mm, $SEM = 25.03$mm) was significantly larger than that of older pigeons ($M = 1236.57$mm, $SEM = 39.56$mm), $F(1,7) = 16.27$, $p < .01$, $\eta_p^2 = .70$ (Figure 2).

FIGURES

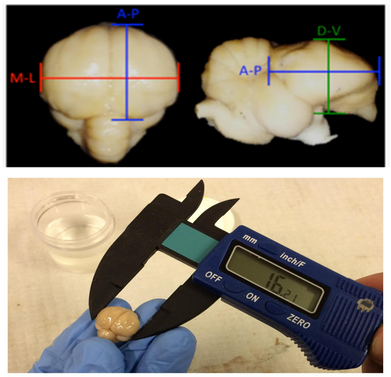

Figure 1. Top: orthogonal planes measured of the forebrain. Bottom: measuring example.

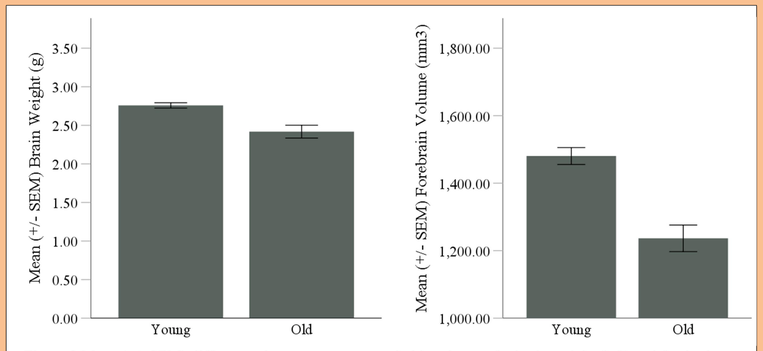

Figure 2. Mean (+/- SEM) differences between younger and older pigeons for brain weight (left) and forebrain volume (right). Younger pigeons had significantly heavier brains and larger forebrains than older pigeons.

DISCUSSION

- Contrary to Coppola and Bingman (2019), the current study found age-related atrophy of the pigeon forebrain.
  - Younger pigeons had heavier brains and larger forebrains than older pigeons, despite having a lighter body weight.
  - This is perhaps because the average age of the current sample of older pigeons was 5.34 years older than the average age of the older pigeons in Coppola and Bingman (2019).
- *Limitations and considerations*
  - Coppola and Bingman (2019) used homing pigeons, while the current study used white carneaus (different breeds of the same species).
  - The amount of time in post-fixative differed between young and old pigeons, though maximum shrinkage should have occurred in all brains. Brains will be remeasured in the fall semester to confirm findings.
- *Future directions*
  - The cerebellum and tecta need to be measured in the current sample (as in Coppola & Bingman, 2019) to determine if age-related atrophy is specific to the forebrain.
    - Although Coppola and Bingman (2019) found the forebrain of older pigeons to be larger than that of younger pigeons, they detected no effect of age on the size of the cerebellum or tecta.
  - Coppola et al.'s (2016) findings of an age-related increase in hippocampal volume should be visited as their sample of older pigeons may not have been old enough to detect age-related hippocampal atrophy.
  - Previous attempts have failed to identify age-related neuropathology (amyloid-beta plaques) in older pigeons between 12 and 15 years of age. The current sample will be assessed for histological markers of neuropathological aging in fall 2022.

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