Woodpecker Pecking

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Why it is that woodpeckers do not get brain injury from pecking?

- People get brain injury if the brain decelerates at about 100g over about 5 millisecond (the time of a typical impact in a car crash)

- Measurements on woodpeckers indicate that they tolerate decelerations of up to 1500g over about 0.5 milliseconds during pecking
- (g is the acceleration of gravity)

  (millisecond = 1/1000 second)

May PRA Fuster JM, Habe J and Hirschman A (1979)Woodpecker Drilling Behavior Arch Nerol 36, 370-373

Woodpecker Pecking

- High speed video images taken at 2000 frames per second
- Get one image every 0.5 milliseconds
- Declerations of 600-1500g during impact

May PRA Fuster JM, Habe J and Hirschman A (1979)Arch Nerol 36, 370-373

Scaling

- The stress on the brain in an impact is the force/area
- The force is the brain mass times the deceleration

$$stress = \frac{force}{area} = \frac{mass \times deceleration}{area}$$

Scaling

- Assuming that the brain tissue of humans and woodpeckers can tolerate the same stress:

$$\frac{m_h d_h}{A_h} = \frac{m_w d_w}{A_w}$$

- m = mass
- d = deceleration
- A = area = πr^2

h = human

w = woodpecker

Scaling

- Rearranging,

$$d_w = \frac{m_h}{m_w} \frac{A_w}{A_h} d_h = \frac{m_h}{m_w} \frac{r_w^2}{r_h^2} d_h$$

- m = mass
- d = deceleration
- A = area = πr^2

h = human

w = woodpecker

Scaling

Photos of human head and woodpecker head, showing relative size, removed for copyright reasons.

$m_h = 1400$ grams
$r_h = 60$mm
$m_w = 2$ grams
$r_w = 7$mm

giving: $d_w \sim 10\ d_h$

The woodpecker brain can withstand about 10 times the deceleration that a human brain can.

Scaling

- The deceleration that the human brain can tolerate depends on the duration of the deceleration:

Goldsmith W (2001) The state of head injury biomechanics: past, present and future: Part 1 Critical Reviews in Biomedical Engineering 29, 441-600.

Scaling

- The duration of the woodpecker deceleration during pecking has been measured to be 0.5 milliseconds
- For this duration, the human brain can withstand about 500g deceleration
- The woodpecker can withstand about 10 times this, or 5000g
- Maximum measured decelerations of 1500g are well below this