Cortisol in Hair
Novel Way(s) to Assess Chronic Stress
(and Animal Welfare??)

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What is the best (or appropriate) measure of adrenal cortex activity?

How can we obtain a long-term marker of HPA function?
Time Scales for Measuring Stress Hormones

Different Time Windows...

Minutes to Hours
Saliva / Blood

Days
Urine

Weeks/Months/Years
Hair ?!!
Cortisol in Hair
The Individual’s History Book of Steroid Production?

Stalder & Kirschbaum, Brain Behavior and Immunity 2012
Rhesus Monkeys (n = 16)

$\rho = .80, p < .001$

Davenport et al., 2006
Hair Cortisol: Reflection of Total Adrenal Output?

Rhesus Monkeys (n = 16)

\[ r = .80, \ p < .001 \]

Davenport et al., 2006

Domestic Cats (n = 27)

\[ r = .90, \ p < .001 \]

Accorsi et al., 2007

Dogs (n = 29)

\[ r = .67, \ p < .001 \]

Pragst et al., 2006
Cortisol in Hair
The Individual’s History Book of Steroid Production

Figure 3: Hair as a retrospective calendar. Each datapoint represents the mean cortisol concentration of around 3 month's period (or one year).

Carlitz et al., 2014
Cortisol in Hair
The Individual’s History Book of Steroid Production

Carlitz et al., 2014
Also the aggressor pays a toll...
Wash-Out Effect
no effect in non-human primates

Figure 2: Cortisol development along hair shaft of 10 representative orangutan hair samples. Black squares show mean cortisol level of 20 animals.

Carlitz, 2014
Cortisol in Hair
A Retrospective Measure of Cumulative Cortisol Exposure

Non-invasive

Minute amounts needed (5-10 mg)

Apparently very stable

Reflection of adrenal output over prolonged periods
Collecting a Hair Sample
Cortisol in Hair
A Retrospective Measure of Cumulative Cortisol Exposure

Non-invasive

Minute amounts needed (5-10 mg)

Apparently very stable

Reflection of adrenal output over prolonged periods
Cortisol in Hair
A Retrospective Measure of Cumulative Cortisol Exposure

Apparently VERY stable:
Cortisol-like immunoreactivity in 4000-year-old mummy hair (pretty normal levels!)

Foto: Staatliches Museum Ägyptischer Kunst München
Cortisol in Hair

A Retrospective Measure of Cumulative Cortisol Exposure
Trait of State?

Apparently very stable:
Comparable values over 1-year period individual trait measure?

Stalder et al., 2011
Intraindividual stability: results, correlation

Stalder et al., 2011
Potential sociodemographic and hair-related confounders

Study samples:

- **Main study sample**
  
  N = 360, age: 1 to 91 years
  173 women (48.1 %)
  variability in natural hair colours

- **Confirmatory sample: extreme natural hair colours**
  
  N = 78, age: 18 to 35 years
  - n = 35 natural blonds (17 w, 18 m)
  - n = 43 dark brown haired (19 w, 24 m)

- **Confirmatory sample: young children**
  
  - children: N = 31
    age: mean (range) = 3.6 yrs (1 to 9 yrs)
  - adults: N = 34 (mean age: 24.2 yrs)

*Dettenborn et al., 2012*
Potential confounders: natural hair colour

Results – natural hair colour

Main study sample:

No significant main effect of hair colour (in adults controlling for sex)

\[ F_{(2, 232)} = 2.54, \ p = .08, \ \eta_p^2 = .02 \]

Dettenborn et al., 2012
Potential confounders: hair washing

Results – self-reported frequency of hair washing

Main study sample:

1st (and 2nd) hair segment:
No association with self-reported frequency of hair washes (adults 18–49 yrs)

\[ r = -0.06, \, p = 0.34 \]

Dettenborn et al., 2012
Potential confounders: age & sex

**Results – age**

**Main study sample:**

\[
\text{adj. } R^2 = .035 \quad p < .001
\]

**Confirmatory sample**

– young children:

\[F_{(1, 64)} = 20.65 \quad p < .001 \quad \eta_p^2 = .25\]

**Results – sex**

**Main study sample**

(adults, 18-49 yrs):  

\[F_{(1, 251)} = 9.57 \quad p = .002 \quad \eta_p^2 = .037\]

*Dettenborn et al., 2012*
# HPA Hyper and Hypoactivity Reflection in Hair Cortisol?

## Box 3 | Conditions with altered HPA axis activity

### Increased activity of the HPA axis
- Cushing syndrome
- Chronic stress
- Melancholic depression
- Anorexia nervosa
- Obsessive–compulsive disorder
- Panic disorder
- Excessive exercise (obligate athleticism)
- Chronic, active alcoholism
- Alcohol and narcotic withdrawal
- Diabetes mellitus
- Central obesity (metabolic syndrome)
- Post-traumatic stress disorder in children
- Hyperthyroidism
- Pregnancy

### Decreased activity of HPA axis
- Adrenal insufficiency
- Atypical/seasonal depression
- Chronic fatigue syndrome
- Fibromyalgia
- Premenstrual tension syndrome
- Climacteric depression
- Nicotine withdrawal
- Following cessation of glucocorticoid therapy
- Following Cushing syndrome cure
- Following chronic stress
- Postpartum period
- Adult post-traumatic stress disorder
- Hypothyroidism
- Rheumatoid arthritis
- Asthma, eczema

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## HPA Hyper and Hypoactivity Reflection in Hair Cortisol

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<thead>
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Dresden Marathon 2009 Study
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Skoluda et al., 2011
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Chronic Stress: Unemployment
Chronic Stress: Long-Term Unemployment

Dettenborn et al. 2010
# HPA Hyper and Hypoactivity Reflection in Hair Cortisol

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Participants: 10 PTSD-patients and 17 traumatised controls from a civil war area of Northern Uganda

Clinical and psychological measures

- Semi-structured diagnostic interview (CAPS; Blake et al., 1995)
- Sociodemographic information, hair-specific characteristics, participant health
- Number of different life-time traumatic events (self-developed checklist)
- Chronic Stress (PSS-4; Cohen, 1994)
- Depressiveness (HSCL; Derogatis et al., 1974)
- Suicide ideation (M.I.N.I.; Sheehan et al., 1998)
Hair Cortisol in Trauma Patients

PTSD in Victims of War – acutely traumatized

Steudte et al., 2011
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Some unresolved issues

- Origin of hair cortisol
- Hair cortisol and total adrenal output
- Wash-out effect
- High or low – what’s good or bad?
Cortisol in Hair
The Individual’s History Book of Steroid Production?

Stalder & Kirschbaum, *Brain Behavior and Immunity* 2012
Where does it come from??

Ito et al., 2005
Limitations
Obvious Limitation...

...but we are working hard to get a handle on this little problem, too.