Stress & Creativity
A Hormetic Relationship to Optimize the Social Adaption of the Phenotype?

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- Max Planck Human Ethology Institute
Prof. Dr. Karsten Müller,
- University of Mannheim
Agenda

Stress and Creativity?

Experimental Setting

First Results
STRESS & CREATIVITY – HOW DO THEY COME TOGETHER?

What should these two (stress and creativity) have to do with each other? And what is „hormesis“

HORMESIS?

“A generally-favorable biological response to low exposures to toxins and other stressors.”

Hackneyed, fuzzy term, potentially not scientifically usable

Even more hackneyed, fuzzy term, potentially unscientific, esoterical nonsense…
There are, certainly, many definitions of creativity. … most definitions, while using the creative product as the distinguishing sign of creativity, propose that the general qualities of novelty and appropriateness differentiate creative from uncreative products. … In other words, the product or response must be unusual … and it must also be correct in the context of the problem or audience to which it was addressed.

A product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are those familiar with the domain in which the product was created or the response articulated.”

Creativity is hard to grasp.

- Common ground among creativity researchers is very small: novelty & appropriateness as only “common denominators“.

- There is no universal definition of „appropriateness“, meaning, there is no context-free creativity-definition: Creativity is a „genuinely social phenomenon“.

- Not only the assessment of creativity but also its emergence is determined by social factors: extrinsic constraints (like rewards or external evaluation) can lead to decrements in creativity.

Stress is a biological term which refers to the response of a human or animal to emotional or physical demands, whether actual or imagined. It includes a state of alarm and adrenaline production, short-term resistance as a coping mechanism, and exhaustion.

Common stress symptoms include irritability, muscular tension, inability to concentrate and a variety of physical reactions, such as headaches and elevated heart rate.

When the body is under stress, the adrenal gland increases secretion of a hormone called cortisol. Short-term, this hormone can help aid in survival, for example by mobilizing energy reserves. Long-term elevation of cortisol, however, can have detrimental effects.

Stress is no easy cause-and-effect-relationship!

- Multiple influences determine style and intensity of the stress reaction.
- Multiple mediators are channeling the stress response with regard to bodily reactions.
- … and the psychological aspects and processes of stress are not yet factored in!

STRESS & CREATIVITY: WHERE IS THE CONNECTION?

There is no context-free creativity-definition: creativity is a “genuinely social phenomenon”.

Social constraints (like rewards, competition or external evaluation) can lead to decrements in creativity (Amabile, 1979, 1986).

As human intelligence is social, and creativity is part of it, creativity must also have a social quality (van Schaik, 2007; Jäger et.al. 1997).

Human neuroendocrine stress system is highly sensitive to social challenges (Flinn, 2007; Kirschbaum et.al. 1993)

Stressing life events are almost all social (Holmes & Masuda, 1967)

Early life exposure to stress via constrained maternal care may result in a vulnerable, chronically stressed phenotype (Bardi et.al. 2005).

Sources:
STRESS & CREATIVITY: WHERE IS THE CONNECTION?

SOCIAL INFLUENCE

Is it the same underlying mechanism?
STRESS & CREATIVITY: WHAT/HOW IS THE CONNECTION?

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STRESS & CREATIVITY: WHAT/HOW IS THE CONNECTION?

SOCIAL INFLUENCE

Is it the same underlying mechanism?

Creativity
[Index/Unit]

Stress
[Index/Unit]

Explicit Motives

Intrinsic Motives

Perceived Abilities

Explicit Motives

Intrinsic Motives

Perceived Abilities
STRESS & CREATIVITY: WHAT/HOW IS THE CONNECTION?

SOCIAL INFLUENCE

Is it the same underlying mechanism?

Creativity eliciting Sympathetic Distress

Internalization of extrinsic motivation → “autonomy”

Creativity
[Index/Unit]

Stress
[Index/Unit]

Sources:
STRESS & CREATIVITY: WHAT/HOW IS THE CONNECTION?

SOCIAL INFLUENCE

Is it the same underlying mechanism?

Creativity eliciting Sympathetic Distress

Internalization of extrinsic motivation \(\rightarrow\) “autonomy”

Sources:
STRESS & CREATIVITY: WHAT/HOW IS THE CONNECTION?

SOCIAL HOMEOSTASIS
Energetically optimal point of relationship self-others

Creativity eliciting Sympathetic Distress

Internalization of extrinsic motivation \(\rightarrow\) “autonomy”

Explicit Motives

Intrinsic Motives

Perceived Abilities

Sources:

Source:
THE HPA AXIS

What is the HPA axis?

It is the common mechanism for interactions among glands, hormones, and parts of the midbrain that mediate the general adaptation syndrome (GAS).

→ The HPA axis is the endocrine core of the stress regulation system.

As such, it links the individual to its social surrounding, setting the stage for the individual’s behavioral as well as creative options!

Source: Netherlands Institute for Neuroscience, http://www.nin.knaw.nl/Portals/0/Department/Huitinga/hypothalmus%20zijknat%20jeroen.jpg
Cortisol is the body’s primary stress hormone. When the brain stimulates its release in response to physical or emotional stress, the adrenal glands secrete cortisol into the blood. Cortisol helps the body regulate blood sugar levels and blood pressure. It also is an anti-inflammatory, an anti-allergic agent and reduces the actions of the immune system.

It is known that in normal people the level of cortisol in the bloodstream peaks in the morning, then decreases as the day progresses. In depressed people, however, cortisol peaks earlier in the morning and does not level off or decrease in the afternoon or evening. Chronically elevated cortisol may potentially contribute to the emergence of clinical depression by affecting the serotonergic neurotransmission.

Agenda

Stress and Creativity?

Experimental Setting

First Results
EXPERIMENTAL SETTING

Group 1: Reward
- Saliva Cortisol 1st sample
- Announcement Reward
- Creativity Task
- Reward
- Perceived Stress Questionnaire
- Saliva Cortisol 2nd sample
- Intrinsic Motivation Inventory

Group 2: Stressful Task
- Saliva Cortisol 1st sample
- Stressful Task
- Creativity Task
- -
- Perceived Stress Questionnaire
- Saliva Cortisol 2nd sample
- Intrinsic Motivation Inventory

Group 3: Stressful Task + Reward
- Saliva Cortisol 1st sample
- Stressful Task
- Creativity Task
- Reward
- Perceived Stress Questionnaire
- Saliva Cortisol 2nd sample
- Intrinsic Motivation Inventory

Group 4: Control Group
- Saliva Cortisol 1st sample
- -
- -
- -
- Perceived Stress Questionnaire
- Saliva Cortisol 2nd sample
- Intrinsic Motivation Inventory
EXPERIMENTAL SETTING – Saliva Cortisol

Saliva Cortisol Samples:

Pre- and post experimental sample using „Salivette“ system:

A: Complete Salivette

B: Parts:

1: Stopper
2: Swab
3: Suspended Insert
4: Centrifuge Vessel
EXPERIMENTAL SETTING – measuring creativity

Sample „drawing task“ (task 1)

Task 1

Please draw in the boxes below as many different pictures on the subject „mobility“.

Please start only after the lab supervisor tells you to!
EXPERIMENTAL SETTING – measuring psychological aspect of stress

The **Perceived Stress Questionnaire** (Fliege et al., 2005; Levenstein et al. 1993)

For each sentence, mark the number that describes how often it applies to you during the last 4 weeks. There are no right or wrong answers. Please work quickly, without bothering to check your answers, and do not skip any question.

<table>
<thead>
<tr>
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<td></td>
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<tr>
<td>02</td>
<td>You feel that too many demands are being made on you</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>03</td>
<td>You have too many things to do</td>
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<td>04</td>
<td>You feel you’re doing things you really like</td>
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<tr>
<td>05</td>
<td>You fear you may not manage to attain your goals</td>
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<td></td>
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<tr>
<td>06</td>
<td>You feel calm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>You feel frustrated</td>
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</table>
EXPERIMENTAL SETTING – measuring intrinsic motivation

The Intrinsic Motivation Inventory (Ryan, 1982)

The following is a 22 item version of the scale that has been used in some lab studies on intrinsic motivation. It has four subscales: interest/enjoyment, perceived choice, perceived competence, and pressure/tension. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; perceived choice and perceived competence are theorized to be positive predictors of both self-report and behavioral measures of intrinsic motivation. Pressure tension is theorized to be a negative predictor of intrinsic motivation. Scoring information is presented after the questionnaire itself.

TASK EVALUATION QUESTIONNAIRE

For each of the following statements, please indicate how true it is for you, using the following scale:

1. not at all true  2. somewhat true  3. very true

1. While I was working on the task I was thinking about how much I enjoyed it.
2. I did not feel at all nervous about doing the task.
3. I felt that it was my choice to do the task.
4. I think I am pretty good at this task.
5. I found the task very interesting.
6. I felt tense while doing the task.
Structure

Stress and Creativity?

Experimental Setting

First Results
### Descriptive Statistics

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<th>Statistic</th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Std. Error</th>
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<td>4</td>
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<td>17</td>
<td>18</td>
<td>35</td>
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<td>4.233</td>
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<td>0.388</td>
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<td>366</td>
<td>28</td>
<td>394</td>
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<td>000</td>
<td>283</td>
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<td>-155</td>
<td>080</td>
<td>-0.004949</td>
<td>0.048564</td>
<td>-0.893</td>
<td>0.378</td>
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<td>129.7</td>
<td>4010</td>
<td>0.396798</td>
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<td>0.378</td>
<td>1.617</td>
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<td>Q2 Avg Creativity</td>
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<td>3.58</td>
<td>8.84</td>
<td>5.4814</td>
<td>1.00496</td>
<td>0.627</td>
<td>0.357</td>
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<td>75.0</td>
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<td>83.3</td>
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<td>0.357</td>
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<td>39</td>
<td>96.2</td>
<td>39.7</td>
<td>135.9</td>
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<td>PSQ + Cortisol Index Reversed</td>
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<td>106.0</td>
<td>2.6</td>
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</table>
### FIRST RESULTS – Did the “stressing” work?

#### Analysis of variance: „Condition“ as Independent Variable

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<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
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<th>Maximum</th>
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<td><strong>Cortisol Delta (2 minus 1)</strong></td>
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<tr>
<td>Reward</td>
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<td>0.036911</td>
<td>0.012304</td>
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<td>0.052990</td>
<td>0.020028</td>
<td>-0.06244</td>
<td>0.03558</td>
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<td><strong>Q3 Total Score</strong></td>
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<td>Reward</td>
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<tr>
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<td>15,3140</td>
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<td>47,399</td>
<td>18,3</td>
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<td>Total</td>
<td>44</td>
<td>42,832</td>
<td>17,6628</td>
<td>2,6628</td>
<td>37,462</td>
<td>48,202</td>
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<td>37,492</td>
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<td>52,218</td>
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*a. Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.*
FIRST RESULTS – How does the relation stress & creativity look like?

Regression – curve fit: Perceived stress as independent, average creativity as dependent variable

<table>
<thead>
<tr>
<th>Equation</th>
<th>Model Summary</th>
<th>Parameter Estimates</th>
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<td>F</td>
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<td>Compound</td>
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Dependent Variable: Q2 Avg Creativity

![Graph showing Q2 Avg Creativity vs Q3 Total Score](graph.png)
FIRST RESULTS – How does the relation stress & creativity look like?

Regression – curve fit: **Cortisol delta** as independent, average creativity as dependent variable

Dependent Variable: Q2 Avg Creativity

<table>
<thead>
<tr>
<th>Equation</th>
<th>R Square</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
<th>Constant</th>
<th>b1</th>
<th>b2</th>
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<td>0.179</td>
<td>5.208</td>
<td>5.584</td>
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Q2 Avg Creativity

- **Observed**
- **Linear**
- **Quadratic**
FIRST RESULTS – How does the relation stress & creativity look like?

Regression – curve fit: **Cortisol delta %** as independent, average creativity as dependent variable

Dependent Variable: Q2 Avg Creativity

<table>
<thead>
<tr>
<th>Equation</th>
<th>R Square</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
<th>Constant</th>
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<th>b2</th>
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Q2 Avg Creativity

- **Observed**
- **Linear**
- **Quadratic**

Cortisol Delta in Percent
FIRST RESULTS – Does stress always feel bad?

Validation of **self-rated wellbeing**: Correlation between PSQ „joy“ and IMI „interest & enjoyment“

<table>
<thead>
<tr>
<th></th>
<th>Q3 Joy Scale</th>
<th>Q4 Interest/Enjoyment Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q3 Joy Scale</strong></td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>16588.619</td>
<td>368.762</td>
</tr>
<tr>
<td>Covariance</td>
<td>385.782</td>
<td>8.576</td>
</tr>
<tr>
<td>N</td>
<td>44</td>
<td>44</td>
</tr>
</tbody>
</table>

| **Q4 Interest/Enjoyment Scale** | Pearson Correlation | 0.419** | 1 |
|                               | Sig. (2-tailed)     | 0.005   |   |
|                               | Sum of Squares and Cross-products | 368.762 | 46.684 |
|                               | Covariance          | 8.576   | 1.086 |
|                               | N                   | 44      | 44   |

**. Correlation is significant at the 0.01 level (2-tailed).
FIRST RESULTS – Does stress always feel bad? Yes?

Regression – curve fit: **Cortisol delta %** as independent, self-rated wellbeing as dependent variable

**Dependent Variable:** Joy-Index

<table>
<thead>
<tr>
<th>Equation</th>
<th>Model Summary</th>
<th>Parameter Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R Square</td>
<td>F</td>
</tr>
<tr>
<td>Linear</td>
<td>,035</td>
<td>1,322</td>
</tr>
<tr>
<td>Quadratic</td>
<td>,052</td>
<td>,977</td>
</tr>
</tbody>
</table>

Joy-Index

Q3 Joy Scale

[Graphs showing scatter plots and regression lines for cortisol delta in percent vs. joy-index with linear and quadratic models.]
FIRST RESULTS – Does stress always feel bad? NO! Not if is of interest!

Regression – curve fit: Cortisol delta % as independent, self-rated wellbeing as dependent variable

<table>
<thead>
<tr>
<th>Equation</th>
<th>R Square</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
<th>Constant</th>
<th>b1</th>
<th>b2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>0.001</td>
<td>0.036</td>
<td>1</td>
<td>37</td>
<td>0.851</td>
<td>4.427</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.014</td>
<td>0.250</td>
<td>2</td>
<td>36</td>
<td>0.780</td>
<td>4.495</td>
<td>0.003</td>
<td>-4.918E-5</td>
</tr>
</tbody>
</table>

Dependent Variable: Q4 Interest/Enjoyment Scale
FIRST RESULTS – Is there a connection between group size and stress?

Anova: Factor group size, cortisol delta % and creativity as dependent variables

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cortisol Delta in Percent</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>1892,877</td>
<td>4</td>
<td>473,219</td>
<td>,278</td>
<td>,890</td>
</tr>
<tr>
<td>Within Groups</td>
<td>57937,719</td>
<td>34</td>
<td>1704,051</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59830,596</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Q2 Avg Creativity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>8,072</td>
<td>4</td>
<td>2,018</td>
<td>2,226</td>
<td>,084</td>
</tr>
<tr>
<td>Within Groups</td>
<td>35,355</td>
<td>39</td>
<td>,907</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>43,428</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Q3 Total Score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>3623,356</td>
<td>4</td>
<td>905,839</td>
<td>3,608</td>
<td>,014</td>
</tr>
<tr>
<td>Within Groups</td>
<td>9791,499</td>
<td>39</td>
<td>251,064</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13414,855</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mediation of creativity-decreasing effect of lowered intrinsic motivation?

Mediation model – revised

Step 1: Calculate correlations

Step 2: Calculating regression analysis (regressing creativity to intrinsic motivation and stress)

Problem: Due to small sample size (still) not significant?

\[ a = -0.493^{**} \]
\[ b = -0.229 \]
\[ c = 0.479^{**} \]
Mediation of creativity-decreasing effect of lowered intrinsic motivation?

Mediation model – revised

Step 1: Calculate correlations

Step 2: Calculating regression analysis (regressing creativity to intrinsic motivation and stress)


<table>
<thead>
<tr>
<th>Value</th>
<th>s.e.</th>
<th>LL 95 CI</th>
<th>UL 95 CI</th>
<th>Z</th>
<th>Sig(two)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.0050</td>
<td>0.0853</td>
<td>-1.723</td>
<td>1.622</td>
<td>-0.0588</td>
<td>0.9531</td>
</tr>
</tbody>
</table>

BOOTSTRAP RESULTS For INDIRECT EFFECT

<table>
<thead>
<tr>
<th>Data</th>
<th>Mean</th>
<th>s.e.</th>
<th>LL 95 CI</th>
<th>UL 95 CI</th>
<th>LL 99 CI</th>
<th>UL 99 CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect</td>
<td>-0.0050</td>
<td>0.002</td>
<td>0.0851</td>
<td>-1.555</td>
<td>1.895</td>
<td>-2.190</td>
</tr>
</tbody>
</table>

NUMBER OF BOOTSTRAP RESAMPLES

5000

FAIRCHILD ET AL. (2009) VARIANCE IN Y ACCOUNTED FOR BY INDIRECT EFFECT:

0.0524

→ No significant reduction of path Creativity-Intr.Mot. by Stress!
Discussion

So, what do YOU think about the relation between stress and creativity, after all?
Discussion

What does the results imply for the creative potential of chronically stressed people?
Discussion

What does the results imply for allday creativity?
Discussion

Interesting Questions:

- What is the relation between cortisol and the conditions? Did the „stressing“ work?
- How do people „feel“ stress – is there something like „eustess“? (relation between cortisol values and joy-scale of PSQ / interest enjoyment-scale of IMI?)
- How about the correlation between Cortisol and PSQ?
- Does an overall stress-index constituted from cortisol- and PSQ-values make sense? Would it more clearly reflect an actual stress-level? **From current data rather not!**
- What does the change in cortisol say about the stress system of the respective person?
- Is there a connection between groupsize and stress-level (in terms of psychosocial stress / stress mediated via group pressure)?
- Does stress better explain the crowding effect within creativity research?