

Background

General theories of inconsistency-compensation propose a link between inconsistency detection, and subsequent fluid compensation towards unrelated schema, such as affirming alternative beliefs, or abstracting unrelated environmental patterns (Proulx & Heine, 2009). Extant models propose that inconsistency-induced arousal mediates such compensatory action (Proulx et al., 2012), but there is limited direct evidence for this. Moreover, the role of personality variables in impacting inconsistency-compensation processes, specifically those traits that may be associated with increased arousal states (e.g., mindfulness), remains untested.

The link between inconsistency and arousal has been reliably demonstrated (Randles et al., 2013), as has the utility of pupillometry to assess this arousal as a proxy of tonic locus-coeruleus noradrenaline (LC-NA) activity and associated exploratory attentional states (Gilzenrat et al., 2010).

Accordingly, through the lens of adaptive gain theory (AGT; Aston-Jones & Cohen, 2005), which accounts for the link between inconsistency detection and tonic LC-NA activation / exploratory attention conducive to “learning” states, we utilised PD as a proxy of inconsistency-induced arousal during a task of diminishing utility (DUT; cost:reward ratio inconsistency) and examined PD relationships with subsequent compensatory abstraction (AGL; artificial grammar detection). Moreover, we included a measure of trait mindfulness (MAAS) to examine personality variables in impacting this process.

We predicted that (H1) greater magnitudes of inconsistency-induced PD would be associated with improved AGL performance, and (H2) dispositional mindfulness would moderate this relationship, insofar as higher MAAS scorers would exhibit larger PD and improved AGL performance.

Methods and Materials

We utilised a within-subjects design to assess inconsistency-induced arousal and subsequent compensatory abstraction capabilities. Participants ($N = 65$) first completed the DUT (Figure 1), whereby pre-trial pupil diameter (PD) was recorded amid epochs of increasing task difficulty / reduced utility. This provided a vector of PD change leading up to task disengagement (escape trials), which was used as a proxy for increased tonic LC-NA activity.

Participants subsequently completed the AGL (Figure 2), whereby they were implicitly “trained” on an artificial grammar rule, and subsequently “tested” by being asked to detect novel grammars adhering to this rule.

Trait mindfulness was assessed using the Mindful Attention and Awareness Scale (MAAS) as a potential mediatory mechanism.

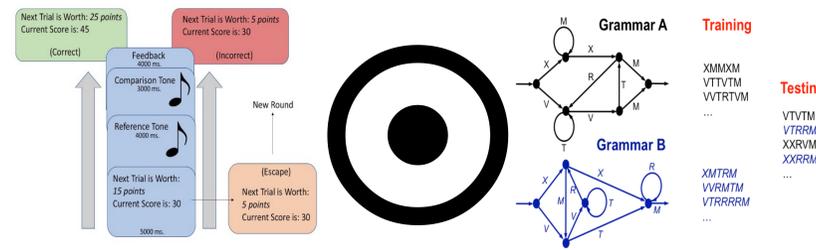


Figure 1. Diminishing Utility Task (DUT) as inconsistency induction.

Figure 2. Artificial Grammar Learning Task (AGL) as test of abstraction (1).

Results

In line with our first prediction (H1), we found that greater magnitudes of inconsistency-induced PD were associated with improved AGL performance in the form of higher AGL scores (hits – false alarms / total responses) (Figure 3, top panel, $p < .01$). Moreover, we found that dispositional mindfulness moderated this relationship, insofar as higher MAAS scorers exhibited greater PD and higher AGL scores (Figure 3, bottom panel, $p = .03$).

Signal Detection Theory (SDT) indices of target detection / signal abstraction further supported these findings, whereby elevated PD was also associated with higher d' -prime scores (z-scored hits minus z-scored false alarms) (Figure 4, top panel, $p = .07$), a relationship which was again moderated by MAAS (Figure 4, bottom panel, $p = .03$).

Figure 3. Greater magnitudes of PD change associated with enhanced AGL performance (top panel), which was moderated by MAAS (bottom panel)

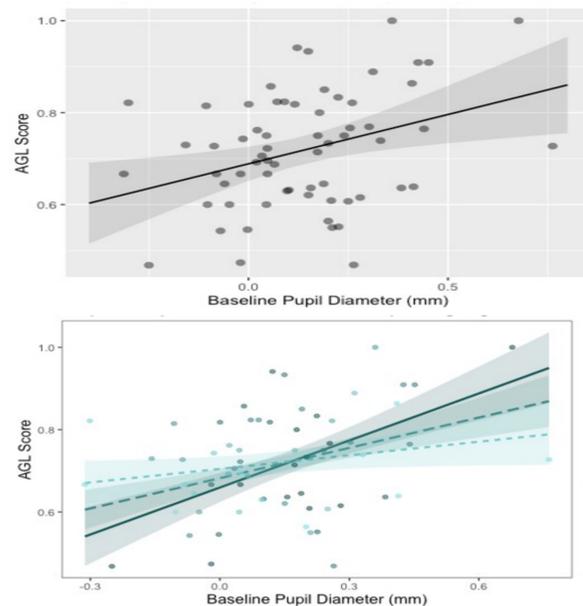
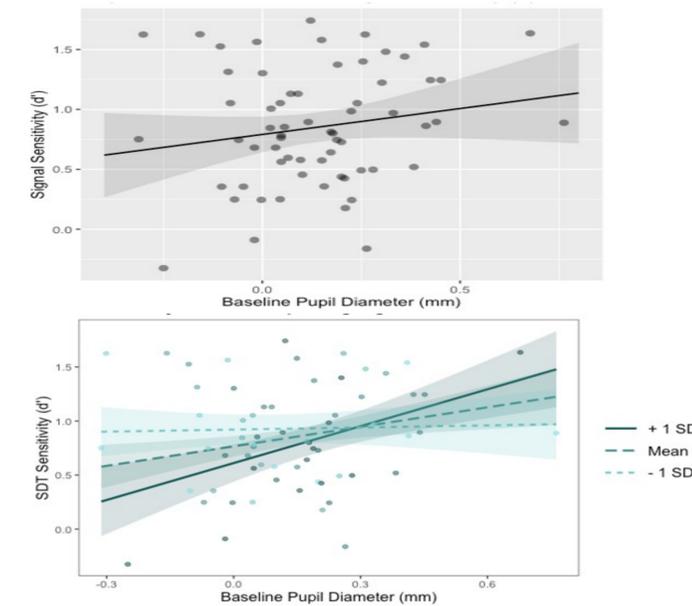


Figure 4. Greater magnitudes of PD change associated with enhanced d' sensitivity (top panel), which was moderated by MAAS (bottom panel)



Discussion

We found that greater pre-trial pupil diameter (PD) – a proxy for tonic LC-NA activity – was reliably accompanied by exploratory disengagement during periods of waning task utility / cost:reward inconsistency, thus providing further support for AGT-predicted LC-NA function and the utility of PD in assessing tonic transitions (Aston-Jones & Cohen, 2005; Gilzenrat et al., 2010).

We also demonstrated that the magnitude of inconsistency-induced, PD-inferred tonic LC-NA activity was reliably associated with subsequent compensatory abstraction in response to this arousal. These findings support extant models of inconsistency-compensation processes (Proulx et al., 2012; Proulx & Heine, 2009), and augment existing research into relationships between inconsistency-arousal and compensatory affirmation (Randles et al., 2013; Slegers et al., 2020) by showing that compensatory abstraction may be an additional palliative response to inconsistency-arousal.

Finally, we offer novel evidence that dispositional personality variables play a salient role in responses to environmental inconsistency and subsequent compensatory processes, specifically that mindfulness may be conceptualized as a distinct tonic capacity (Amihai, 2015) that moderates arousal and compensatory outcomes.

Conclusions

Our findings offer the first empirical demonstration of the link between inconsistency-arousal and subsequent compensatory abstraction, supporting extant inconsistency-compensation frameworks. Moreover, we demonstrate that specific dispositional characteristics may moderate this process.

Future Directions

Implementing a between-subjects version of the current study with ‘high’ and ‘low’ inconsistency manipulations would further qualify present findings.

Future studies could also explore the impact of mindfulness-based interventions on inconsistency arousal and compensatory abstraction.

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