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Disentangling attentional and affective contribution to contagious yawning

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In a commentary on Palagi et al. (2020), Gallup (2021) raises concerns on "*the link between contagious yawning and emotional contagion*", proposing that "*variation in contagious yawning is driven by attentional biases and yawn detection*" We acknowledge that evidence is not always univocal and discuss here some theoretical and empirical issues relevant to advance our understanding of contagious yawning (CY).

1) Gallup's first criticism involves the influence of emotional factors on yawning: "*if a strong matching was present between contagious yawning and emotional contagion, there should be a clear and positive correlation between these measures*" (Gallup, 2021, p. 18). This argument assumes that the two phenomena are unidimensional, linearly correlated, and there is no intervening factor, which is not the case even when considering facets of the same emotional domain, such as facial mimicry and empathy. For example, a meta-analysis published after Gallup's commentary shows that "*stronger facial mimicry responses are positively related to higher dispositions for empathy, but the weakness and variability of this effect suggest that this relationship is conditional on not-fully understood factors*." (Holland et al., 2021, p. 150).
2) We agree that stimulus detection is a prerequisite for generating any response (including CY), but we also consider this a truism to some extent. From our perspective, the critical question to address experimentally is: what guides or bias attention? Affective and social signals are likely candidates. Features conveying emotional value or saliency, including familiarity, are encoded during states of inattention or unawareness through evolutionary ancient brain structures, such as the amygdala or the pulvinar, and induce facial mimicry or emotional contagion (Tamietto and de Gelder, 2010). Based on this initial pre-attentive weight of sensory information, external events are prioritized for *subsequent* attentional selection at later processing stages through bottom-up mechanisms. Direct testing on whether yawning can be induced without attention and awareness has not been carried out yet, and it would be central evidence to disentangle affective and attentional factors. Likewise, the demonstration that prior expectations or internal goals orient top-down attention, and therefore modulate frequency and likelihood of CY, is not in contrast with emotional accounts.
3) Familiarity is not only a proxy of emotional bonds but may also influence the allocation of exogenous attention. It is a matter of debate whether the evolutionary benefits lay more on focusing attention towards unexpected events and signals from outgroup members rather than those coming from familiar individuals. In this context, Campbell and de Waal (2011) study is interesting because the authors dissociated the impact of familiarity on both attention and yawning. Chimpanzees spent more time watching unfamiliar (than familiar) conspecifics' yawns, a measure that likely reflects the amount of attention, but responded contagiously more to familiar yawns. If this dissociation were confirmed in other species and contexts, also ruling out potential confounds such as differences in arousal levels when looking at ingroup vs

outgroup conspecifics, it would be paramount to clarify the role of social closeness in attention orienting and yawn contagion.

4) Social closeness is a multifaced concept that has been variably operationalized as ingroup/outgroup membership or as familiarity according to different degrees. The broad majority, but not all, studies investigating social closeness found that *personal* familiarity increases CY, which is interpreted as supporting affective processes' impact on yawning. Gallup (2021) discard this hypothesis because "*Massen and Gallup (2017) describe the findings from 14 publications at the time, with six (43 %) showing no effect or the opposite result (i.e., unfamiliar > familiar).*" Nevertheless, the papers reported in Table 1 were 15, not 14. Second, five papers found no effect of familiarity in either direction. Null findings must be reported and evaluated, but we should also remind ourselves that it is difficult to draw firm conclusions from negative findings, and the absence of (statistically significant) evidence does not equate to evidence of absence. Out of the ten remaining studies, nine showed that familiarity increases CY, whereas 1 study found an opposite trend: a convergence of results rarely attained in other fields of social and behavioural sciences.
5) Cognitive and emotional aspects of empathy-based contagion are often mistakenly conflated. Recent literature shows that these aspects do not always converge. For example, subjects with higher levels of psychopathic traits (impaired emotional empathy) can be less likely to respond to others' yawns regardless of their attention to the eyes of the triggers. On the other side, in subjects with autistic traits, CY can be negatively correlated with eye gaze levels (Helt et al., 2021), but not in subjects showing a high concentration of blood oxytocin, who yawned more regardless of their eye gaze levels. Data on the role of oxytocin should be treated with caution, also considering that contextual and individual factors can mitigate or even reverse the effects of oxytocin administration.
6) Quantification of yawning often varies between objective measurements of actual yawning, self-reports, or questionnaires about the feel and urge to yawn. This variety in the measures dampens a cross-species comprehensive approach to the phenomenon. In addition, the perceptual encoding (often measured by self-scoring questionnaires) and the actual yawning activity do not necessarily go in tandem.

The consensus on mechanisms modulating CY is still elusive and both, attentional and affective processes likely contribute to the expression of CY. The challenge for future research is to develop a comprehensive and cross-species perspective able to empirically dissociate their relative influence in different ethological contexts and define more clearly their interplay at different processing stages.

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