temperature on the same date a year hence – increase with distance from the equator? That seems to be what is being proposed, but as with "harshness," the authors provide no quantified comparisons of "predictability." Instead, they simply assert that the strong seasonal *variation* in temperature at extreme latitudes is itself a sort of predictability that equatorial climates lack!

Van Lange et al.'s model also suffers from insufficient specificity. Temperature is portrayed as affecting life history, time orientation, and self-control, but how? By their own argument, the latter two are consequences of life history, not parallel constructs at the same level of analysis. The authors allude to various ways in which a relationship between climate and life history might be mediated, but do not clearly articulate the need to test among them. The theoretical chasm that presently separates the climatic inputs from the psychological outputs cries out for more explicit hypotheses about causal links, which could then be tested by structural equation modeling or path analysis. Even the premise that violence may be functional is treated obliquely: Section 3.1 hints that violent aggression is an adaptive component of a fast life history, but in ensuing sections it sounds more like a maladaptive by-product of poor self-control, leaving readers wondering whether the authors accept that aggression and violence are adaptations that are facultatively deployed (Daly 2016; Krupp et al. 2013).

Even the foundational claim that heat and violence go hand in hand is questionable. The target article's opening paragraph provides a cherry-picked contrast of "Albania, Montenegro, and Turkey" versus "Scandinavia" to illustrate how "differences in violent crime rates occur along the North-South Axis in Europe." The trouble with this is not simply that Russia has Europe's highest homicide rate and coldest average temperature, nor even that excluding the former Soviet republics and Warsaw Pact countries moves Finland into first place. The bigger problem is that, using the same Global Study on Homicide cited by the authors (United Nations Office on Drugs and Crime 2013) and mean temperatures from 1961 to 1990 (Wikipedia 2016a), the correlation between homicide and temperature is *negative* across the 37 European countries with populations greater than one million ($r = -0.43$, 95% confidence interval: -0.66, -0.12).

The only systematic, persuasive evidence of a heat/violence association that the authors cite is in Burke et al. (2015). Unfortunately, that study finds a much larger effect of climate on intergroup than on interpersonal aggression (see also Bell & Keys, in press), a result that Van Lange et al. struggle to force into their model. Are individuals with poor self-control, short time horizons, and a quarrelsome bent really better able than those with the opposite temperament to form effective coalitions in warfare (Wright et al. 1999)? This example is symptomatic of a tendency to cite results that are problematic for the authors' model as somehow supportive. They note, for example, that temperature apparently affects violent, but not nonviolent, crime; but why should poor self-control and short time horizons elevate murder rates and *not* elevate impulsive property crime or illicit drug use? And then there is the claim (sect. 3.1.2) that people with "present" time-orientations – people who are *short on time* – are the very ones who act as if they have all of the time in the world, while those with "slower" life histories move faster!

The authors maintain that their model's value is "primarily theoretical" (sect. 6, para. 3). But until their theory is grounded in explicit definitions of environmental harshness and predictability, and specifies crucial explanatory links between the climatic inputs on the one hand and the psychological outputs on the other, we do not believe that it can be helpful. Also, even with a more explicit causal model, we would still need experimental studies (*contra* the authors' claim in sect. 3.1.3), as well as correlational ones, to make causal sense of a complex and confusing set of cross-national patterns and associations.

CLASH's life history foundations

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Abstract: We recommend extending CLASH by incorporating two evolutionary accounts of the shift toward fast life histories under harsh, unpredictable conditions. These accounts, if integrated with CLASH, make different predictions about the distributions of aggression and violence within and between societies. We discuss these predictions and propose ways of testing them.

CLASH proposes that warm and less variable climates are harsh and unpredictable, and that these conditions shift individuals toward faster life histories involving a here-and-now orientation, which sparks aggression and violence. These relationships can result from a variety of adaptive processes, including development, contextual plasticity, and social learning. Here, we focus on development. Specifically, we expand CLASH by considering two distinct, but mutually compatible, evolutionary accounts of the shift toward fast life histories: external and internal predictive adaptive responses (PARs) (Nettle et al. 2013; Rickard et al. 2014).

The external PAR account proposes that fast life histories evolved in response to factors in the external environment (e.g., warm, variable climates) that *forecasted future environmental conditions* that reduce life expectancy (e.g., famine) (Belsky et al. 1991). The internal PAR account, in contrast, proposes that fast life histories evolved in response to factors that directly reduced life expectancy (e.g., nutritional deprivation) by *accelerating somatic aging* (e.g., impairing cell repair), irrespective of future environmental conditions (Nettle et al. 2013; Rickard et al. 2014).

Mathematical modeling indicates that external and internal PARs evolve under different conditions (Nettle et al. 2013; Rickard et al. 2014). External PARs require that environmental conditions are stable over individuals' lifetimes (e.g., if there is drought today, there will likely be drought next year). Internal PARs do not require such stability, but rather require individuals' somatic conditions to be stable over their lifetimes (e.g., if my body is in a poor state today, it will be likely in a poor state next year). In an environment that is completely unpredictable, external PARs cannot evolve; however, internal PARs can, if earlier somatic states are correlated with later somatic states. Such somatic autocorrelation is well known to exist in humans (Blackburn et al. 2015).

The internal and external PAR accounts often make the same predictions about the effects of environment on life history and hence, if integrated with CLASH, about the distributions of aggression and violence. For example, if warm and variable climates are harsh and unpredictable (as CLASH proposes), both accounts predict that such climates produce fast life histories, albeit for different reasons. The external PAR account posits this because it supposes that earlier environmental adversity predicts later environmental adversity. The internal account posits it because it supposes that earlier adversity accelerates somatic aging, irrespective of future environmental conditions.

Despite partial overlap in predictions, the internal and external PAR accounts make different predictions about individuals or populations of the same chronological age in two cases: (1) when they have the same somatic age, but have been exposed to different environmental conditions, and (2) when they have

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been exposed to the same environmental conditions, but vary in their somatic age. Here, we focus on the second case.

Individuals or populations that have been exposed to the same environmental conditions (e.g., drought) may vary in their somatic quality (e.g., tissue damage) for many different reasons, including genetic mutations, developmental noise, and chance events (e.g., idiosyncratic exposure to disease). The internal PAR account predicts that individuals or populations that have incurred higher levels of somatic damage (e.g., telomere attrition) will develop faster life histories than those within the same environment that have incurred lower levels of damage. This prediction does not follow from the external PAR account, as all people in this environment will be equally likely to suffer from death and disability caused by future external conditions.

Consistent with the internal PAR account, British data indicate that girls who experienced chronic disease in childhood develop faster life histories, as indicated by earlier timing of first reproduction, even though chronic disease was not correlated with other measures of environmental stress (e.g., father absence, parental socioeconomic status) (Waynforth 2012). Similarly, Danish data indicate that low birth weight (a marker for somatic quality) predicts lower levels of trust in adulthood, even after controlling for multiple indicators of childhood family environment (e.g., mother's education and income). A possible explanation is that low birth weight predicts small size and physical vulnerability later in life, increasing the risk of being socially exploited (Petersen & Aarøe 2015).

The internal PAR account predicts that individuals who have incurred higher levels of somatic damage are more here-and-now oriented. Interestingly, in European starlings, individuals with greater developmental telomere attrition show higher impulsivity in their foraging decisions (Bateson et al. 2015). According to CLASH, a stronger here-and-now orientation increases aggression and violence. A caveat here is that adults who are physically small (e.g., because of low birth weight or disease in childhood) are less likely to be successful when engaging in aggression and violence (Sell et al. 2009). Therefore, tests of the internal PAR account should control for current somatic factors (e.g., body size) that affect the likelihood of winning fights.

Generally, the internal PAR account predicts that somatic age mediates the link between exposures to harsh, unpredictable environments and faster life histories. Testing this mediation would require measures of somatic aging (e.g., telomere attrition, oxidative stress), environmental stress (e.g., socioeconomic status), and aggression and violence of the same individuals. The external PAR account predicts that higher environmental stress predicts greater aggression and violence. The internal PAR account predicts this relationship as well (as environmental stress causes somatic damage), and additionally predicts that (1) higher somatic age (for a given chronological age) is associated with greater aggression and violence, and (2) the relationship between environmental stress and aggression and violence is reduced when somatic age is included as a mediating variable.

Of course, the internal and external PAR accounts are not mutually exclusive. It is possible that individuals predict both their future environment and their future somatic states and tailor their life histories accordingly. However, as these two accounts are distinct and make different predictions about life history in certain circumstances, CLASH could benefit from incorporating both.

The CLASH model lacks evolutionary and archeological support

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Abstract: Data from archaeology and paleoanthropology directly challenge the validity of the basic assumptions of the CLASH model. By not incorporating a "deep time" perspective, the hypothesis lacks the evolutionary baseline the authors seek to infer in validating the model.

There are a number of significant methodological and theoretical errors in the article by Van Lange and colleagues. We take one specific element as the focus of our response here: they fail to include historical, archaeological, and paleoanthropological data in their model. By not incorporating a "deep time" perspective, the hypothesis lacks the evolutionary baseline the authors seek to infer in validating the model. Data from human history directly challenge the validity of the basic assumption of the CLASH model that higher average temperature with smaller seasonal variation creates an evolutionary process biasing populations toward increased aggression.

If Van Lange et al. are correct about the relationships among aggression/violence, climate, and life history, we should find the majority of conflicts occurring in equatorial regions during prehistoric and historic times. This is not the case, as historical (e.g., Vikings, Mongols), recent (e.g., World War 1, World War 2), and archeological data attest (e.g., Ferguson 2013). Such data illuminate a significant problem for the model. The authors fail to consider historical and cultural legacies and deep-time data relevant to the exhibition of aggression. Moreover, we wonder how the CLASH model, and its focus on countries as units of analysis, accounts for migration in recent and historical contexts, as genetic evidence points to substantial migration across latitudes throughout human history (Cavalli-Sforza et al. 1996; Coop et al. 2009; Templeton 1999). How many generations, under CLASH, would a group need to live in a lower latitude to evolve this new disposition? Likewise, would a person who grew up in the southern latitudes and then migrated to the north be more aggressive than a native-born northerner?

Indeed, we are surprised that for a paper making such grandiose claims, so few data are offered in support their assertions. They rely on citing compilation works or making assumptions such as "societies closer to the equator are also relatively harsh and unpredictable" (sect. 3.1, para. 7), without defining which societies these are or how parameters like unpredictability are measured. For a model that seeks to explain major behavioral components through causal links, we would hope to see more empirical support. For example, while they note that they only look at the Northern Hemisphere, they suggest that the model will hold for the Southern Hemisphere as well. But is this true? Figure 1 illustrates the homicide rate by country per year (between 2012 and 2014) per 100,000 inhabitants (data from the World Bank) by the latitude of the country (taken as the midpoint of the country). As can be seen, the data support the model in the northern hemisphere, with $r^2 = 0.108$. However, in the Southern Hemisphere the relationship does not hold ($r^2 = 0.007$). This suggests to us that other factors are in play.

Variation in temperature may provide a perspective on environmental impact, but it does not take into account more accurate reflections of local ecologies such as rainy seasons, droughts, and other climatic events that could increase variability and its interplay with historical, political, and economic contexts. For example, the authors rely extensively on the meta-analyses of Burke et al. (2015), whose data sets strongly indicate that economic impacts of climatic variation are critical in leading to conflicts and that such conflicts are tied to the relative importance of local agricultural production. Temperature out of context is meaningless.

For the CLASH model to reflect an actual outcome of natural selection processes, there must be a demonstrated connection between the ecological variables of interest (in their case temperature) and specific effects on fitness values of the populations of interest. Their limited attempt to connect with Life History

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