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Cognition in harsh and unpredictable environments

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In environments that are harsh and unpredictable, people are typically more vigilant, act more impulsively, and discount the future more. In this paper, we argue that these behaviors reflect a present-orientation produced by biological adaptations, despite potential harm to health and wellbeing. We review recent studies showing that people in stressful environments have a stronger preference for immediate over delayed rewards, have children at a younger age, and develop enhanced cognition for dealing with threat and rapidly changing conditions, compared with people from supportive environments. Moreover, people from supportive environments, when exposed to harsh-unpredictable environmental cues, shift toward a present-orientation. These findings underscore the benefits of integrating evolutionary and developmental psychology.

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'The future's uncertain, and the end is always near'

(The Doors, 1970, Roadhouse Blues)

Introduction

Although evolutionary theory is becoming increasingly integrated into the psychological sciences, challenges remain. One is the persistent but false belief that evolved traits are present at birth and not learned, unchanging during ontogeny, and universal in the species [1]. If this belief were true, it would imply that psychological variation shaped by experience — within and between individuals

— falls outside of the scope of evolutionary psychology. In fact, all traits result from development, and development always results from physiological mechanisms (e.g. gene regulatory systems) that are products of evolution [2*].

Two questions are essential to integrating evolution and development into psychological research: How does natural selection shape development, and how does development construct adaptive phenotypes? The answers to these questions depend on the trait and require a case-by-case analysis [3]. Natural selection, however, typically results in developmental mechanisms that use individual experience to tailor phenotypes to local conditions and the individual's current state [4–8]. Developmental inputs play multiple roles in shaping such phenotypes. They provide the raw materials required for tissues to grow; they may expose individuals to toxins and other causes of molecular damage; and, they provide information about an individual's situation [2*].

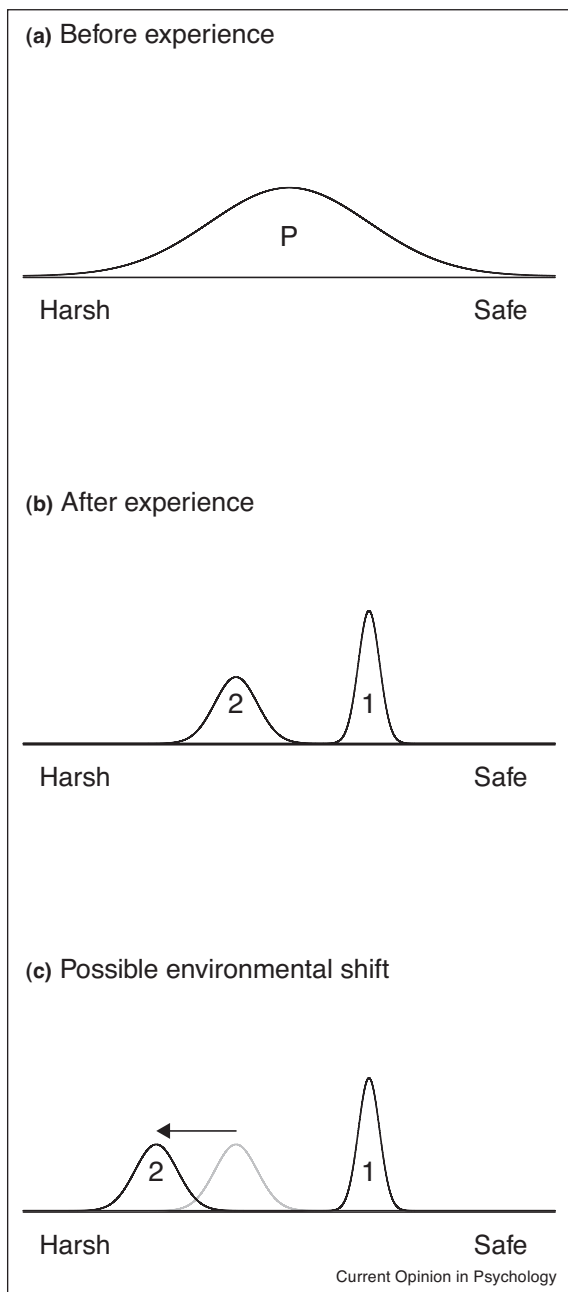
Experience conveys information

Developing organisms learn about the world and adapt accordingly, allocating resources (e.g. energy) among growth, maintenance, and reproduction [4–6]. Experience provides information — a reduction in unpredictability — about the current environmental state (Figure 1a,b). For example, frequently witnessing violence indicates a dangerous world. And, if environmental states are auto-correlated across time, experience can teach us about future conditions as well [9,10]: A dangerous world today implies a dangerous world tomorrow.

Two environmental dimensions, *harshness* and *unpredictability*, are fundamental to individual development [11]. Harshness refers to the rates of mortality and morbidity caused by factors an individual cannot control (e.g. high rates of infectious disease). The shorter one's expected reproductive life span is, the greater the benefits of accelerating maturation and reproducing early, even if it compromises bodily maintenance [12,13]. There are different notions of unpredictability [11,14], which are compatible: first, for a given mean level of harshness, the range of possible outcomes (Figure 1b); second, variation in the mean level of harshness across time and space (Figure 1c). Both harshness and unpredictability can affect adaptive developmental trajectories.

Some people experience environments that are both harsh and unpredictable, such that mortality and morbidity are high, threats appear without warning, and opportunities are fleeting. In such conditions, present-orientation may be adaptive [13,15–20,21**,22,23]. This orientation can

Figure 1



Experience and unpredictability. The horizontal axis depicts the outcome dimension. The height of the curve at any point corresponds to the likelihood of that outcome occurring. The curve in (a) represents the range of possible outcomes before experience. All naive individuals share this range of expectations; 'P' denotes the 'population'. In (b), we see the expectations of two individuals diverge after experience (see [52]). Individual 1 expects safer and more predictable (narrower curve with a higher mean) outcomes than individual 2. In (c), we revisit these individuals at a later time. Individual 1 has not changed her expectations. Individual 2, however, has experienced an environmental shift (e.g. a change in family composition); he now lives in a harsher environment.

psychologically manifest in: first, vigilance used to detect threats and opportunities; second, impulsive reactions (little deliberation) in order to respond quickly; and third, steep future discounting to motivate the capture of immediate benefits, as future rewards are less likely to be cashed in. When we argue that present-orientation may be 'adaptive' in certain contexts, we are referring to biological fitness, not health or wellbeing [7], as we explain below.

Empirical research

'I say fuck tomorrow. It's all about today. Might not be a tomorrow. Might get shot. Might get hit by a bus. So get it now. Now, now, now. Next week might as well be next century. Fuck next week. Fuck tomorrow' (offender named Blue Eyes, age 23 [quoted in 23, p. 1116])

A common view in psychology is that 'there may be no such thing as 'too much' self-control' [(24, p. 2639)], as by definition, self-control helps us to achieve 'valued, longer term goals in the face of conflicting impulses to seek immediate gratification' [(25, p. 32)]. High self-control predicts numerous 'desirable' outcomes, including better health, higher education, and more wealth [24–26]. Accordingly, psychologists often describe a here-and-now preference as shortsightedness, or failure to delay gratification, implying dysfunction [27]. Such descriptions may be valid from a (mental) health perspective, which focuses on wellbeing. However, natural selection maximizes fitness, not (mental) health and wellbeing.

We and others [13,15–20,21[•],22,23] argue that a present-orientation reflects a biological *adaptation* to harsh-unpredictable environments. By 'adaptation', we mean that the orientation would have increased reproductive success in ancestral environments; there is no necessary commitment to the idea that the orientation does so under current conditions. However, it is still of interest to know whether the fitness costs of a here-and-now preference (e.g. worse health) are counteracted by fitness benefits (e.g. more sexual partners). Some evidence points in this direction. For example, violent offenders typically act more impulsively, increasing their risk for sexually transmitted diseases, physical injury, and early death [(23,27–29; but see 30)]. On the benefit side, however, delinquents may have more sexual partners [31,32[•]] and also more children [32[•]].

Exposure to harsh and unpredictable conditions predicts current time preference in diverse populations. For instance, American university women who recollect more early life stress are more present-oriented and have their first sexual intercourse at a younger age [13]. In a mixed-sex sample, North Americans' past experiences of close bereavement — the number of people a person knew who

had died and to whom they felt close — predict steeper future financial discounting (e.g. \$5 now versus \$10 next month) and earlier reproduction [33]. In a UK community sample, adults who had lived in more deprived neighborhoods at age 16 show greater behavioral disinhibition [34]. In Brazil, favela youth discount the future more than university students from more affluent neighborhoods [35] and less well off students choose careers that offer quicker returns and require smaller investments than wealthier students [36].

Observational studies such as these cannot establish that developmental inputs cause different time preferences, as the associations could always be brought about by differential selection of impulsive individuals into certain social environments. However, experimental animal models allow stronger inference about causation. Colorado *et al.* [37] showed that exposing rat pups to maternal separation caused them to become bolder as adolescents. Bateson *et al.* [38] found that European starlings that had experienced greater telomere attrition, a marker of developmental stress, were more impulsive. They also found an independent effect of current energy reserves: birds with lighter current body weight showed steeper discounting. These findings raise the question whether self-control is set during development and then becomes fixed and trait-like, or is dynamically adjusted in response to ongoing contextual factors.

Experimental studies suggest that delinquent involvement can be altered over short timescales in adolescence using interventions that provide vivid representations of the self in the future [39,40]. A recent study by Kidd *et al.* [41**] further throws into question the view that variation in self-control is mostly trait-like. The researchers gave the classic delay of gratification ‘marshmallow test’ to 4 and 5 year-olds in two conditions: a control, and one where the experimenter had revealed herself to be subtly unreliable. Children in the unreliable condition showed reduced delay of gratification, and the effects were large relative to the individual differences in the control condition. Nonetheless, long-term developmental experience is likely to be important in setting norms of reaction to current cues. For example, a series of priming studies has shown that people’s self-control is responsive to immediate cues of environmental adversity, but the magnitude and even direction of the response depends on the person’s long-term developmental history, usually measured using childhood socioeconomic position [17,18,20,21**].

Enhanced cognition in stressful environments

In pioneering work, Dickman [42] distinguished functional impulsivity — ‘the tendency to act with relatively little forethought when such a style is optimal’ (p. 95) — and dysfunctional impulsivity — ‘the tendency to act with less forethought (...) when this tendency is a source

of difficulty’ (p. 95). High impulsives make more errors in a pattern recognition task, but when exposure duration is extremely brief, they are slightly more accurate [43]. Moreover, if the number of comparisons is made too large to complete, the faster, less accurate strategy of high impulsives yields more correct answers than the slower, more accurate style of low impulsives [42]. Other scholars have shown that previously institutionalized US children (orphans) — who may prefer immediate gains due to the developmental stress they experienced — attained more success than a control group on a risk-taking task that rewards exploitation (‘cash in’ early for a certain smaller gain) and less success when it rewarded exploration (persist for potentially larger gains) [44*].

A novel hypothesis is that people who grow up in stressful conditions show enhanced cognition for solving problems that they have developmentally adapted to [45**]. For example, physically abused children are better at detecting and memorizing threats than non-abused children [46]. Recent innovative studies show that people — from college as well as community samples — who grow up in unpredictable conditions develop enhanced shifting abilities (efficiently switching between different tasks) and reduced inhibition (overriding dominant responses) [21**]. This ‘enhanced shifting effect’ occurs only when people are tested under conditions of uncertainty (after reading about economic recession and economic uncertainty) and only for unpredictable, rather than harsh, childhood exposures.

Implications and future directions

Time preference mediates the effects of exposure to adversity on risky behaviors statistically [47] and perhaps causally [39,40]. It is therefore important to understand how adversity shapes time preference, and how this preference influences behavior. Exposure to unpredictable conditions may result in a belief that the world is chaotic [48], orienting individuals toward immediate payoffs (e.g. fast cash) as opposed to delayed rewards (e.g. college degree). Public health research shows that perceptions about the controllability of mortality are critical: these may not only mediate the effects of socioeconomic position on health behaviors [49], but also causally influence health-related decisions, such as whether people choose a healthier food reward over an unhealthy alternative [50].

We have discussed recent studies showing that instilling a greater sense of vividness of the future self motivates people to become more future-oriented, reducing delinquent involvement [39,40]. Although promising, such interventions do raise ethical issues. For example, expanding people’s time horizons may be ethical if their actual prospects are better than they think, but not if current estimates are accurate. We hope that the prospects of people in harsh environments do actually improve. As Caldwell *et al.* [51] note: ‘Adolescents might

perceive longer, safer lives ahead if people in their neighborhood actually appeared to be living long and safe lives; if families provided an atmosphere of security and hope; and if adolescents felt empowered to realize their dreams and aspirations, rather than feeling as though they were at the mercy of hostile forces beyond their control' (p. 600).

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