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The Evolutionary Mismatch Hypothesis: Implications for Psychological Science

Norman P. Li[1], **Mark van Vugt**[2,3], **and Stephen M. Colarelli**[4]
[1]School of Social Sciences, Singapore Management University; [2]Department of Experimental and Applied Psychology, Vrije Universiteit Amsterdam; [3]Institute for Cognitive and Evolutionary Anthropology, University of Oxford; and [4]Department of Psychology, Central Michigan University

Abstract
Human psychological mechanisms are adaptations that evolved to process environmental inputs, turning them into behavioral outputs that, on average, increase survival or reproductive prospects. Modern contexts, however, differ vastly from the environments that existed as human psychological mechanisms evolved. Many inputs now differ in quantity and intensity or no longer have the same fitness associations, thereby leading many mechanisms to produce maladaptive output. We present the precepts of this *evolutionary mismatch* process, highlight areas of mismatch, and consider implications for psychological science and policy.

Keywords
mismatch, adaptive lag, supernormal stimuli, evolutionary psychology

Evolutionary psychology considers human cognition, emotion, and behavior to be products of psychological mechanisms that evolved to solve recurrent survival and reproduction challenges in ancestral environments (Buss, 1995; Tooby & Cosmides, 1992). Humans, however, have begun living in environments diverging vastly from those in which they evolved. In evolutionarily novel contexts, key aspects of psychological mechanisms may no longer be linked to the environment in the same way. This phenomenon, known as *evolutionary mismatch*, has profound implications for not only the functioning of mechanisms, but also human psychology, conduct, and public policy.

Although mismatch concepts have been raised in biology (e.g., Schlaepfer, Runge, & Sherman, 2002), economics (Burnham, 2016; Kanazawa, 2004), health (Buss, 2000), medicine (Nesse & Williams, 1994), and social (Maner & Kenrick, 2010), cognitive (Tooby & Cosmides, 1990), and organizational (Spranger, Colarelli, Dimotakis, Jacob, & Arvey, 2012; van Vugt & Ronay, 2014) psychology, there has been little or no systematic organization of core principles, evidence, and implications for psychology. The purpose of this article is to fill that gap.

Precepts of Mismatch Theory

The mismatch concept takes evolution by natural selection as a starting point. This process produces physiological and psychological adaptations: inherited, species-typical traits that develop reliably and have been retained by selection because they solved a problem of survival or reproduction better than alternative designs during their period of evolution (Buss, 1995; Williams, 1966). Psychological adaptations are mechanisms that take specific environmental cues as input, process these inputs according to evolved decision rules, and produce adaptive cognitions, attitudes, and behaviors as output. Evolutionary mismatch refers to the *adaptive lag* that occurs if the environment that existed when a mechanism evolved changes more rapidly than the time needed for the mechanism to adapt to the change (Crawford, 1995; Tooby & Cosmides, 1990).

The human suite of psychological mechanisms evolved mainly during the period—99% of human history—when people likely lived as hunter-gatherers in small kin-based groups in African savannas and later in Asia and Europe. The seeds for present-day evolutionary mismatch were sown roughly 10,000 years ago when agriculture arose and humans began living in contexts diverging from their hunter-gatherer past. The

Corresponding Author:
Norman P. Li, Singapore Management University, School of Social Sciences, 90 Stamford Rd., Singapore 178903
E-mail: normanli@smu.edu.sg

Table 1. Examples of Mismatch Sources and Types

	Source	
Type	Natural	Human-induced change
Forced	Environmental changes inducing mass extinctions in the late Permian period	Eye mechanisms receiving fewer stimuli required for proper development
Hijacked	Louder begging calls of cuckoo chicks lure mother birds to feed cuckoo chicks over their own chicks	Candy being preferred over fruit by food-selection mechanisms

Table 2. Examples of Mismatch Causes and Their Impacts

Cause	Impact
Changes in input	
Change in input intensity	Increased number of opposite-sex individuals, affecting mechanisms that calibrate relationship commitment
Missing input	Lack of a supportive family network that serves as input to mechanisms that calibrate resource availability and reproductive timing
Input replaced by novel or fake cues with similar attributes	Internet pornography replacing actual partners as input to mechanisms that trigger sexual excitement and induce reproductive activity
Change in consequences of output	Selection of leaders who are tall and masculine despite such traits not being necessary for the tasks at hand

Table 3. Examples of Mismatch Consequences for Individuals and Reproductive Fitness

Effect on reproductive fitness	Effect on individuals	
	Undesirable	Desirable
Decrease	Consumption of processed sugars in large quantity	Birth control methods preventing sexual intercourse from leading to reproduction for people not wanting children
Increase	Nepotistic favoring of relatives over more qualified individuals in a business	Internet dating providing high mate-value individuals with greater (worldwide) access to high-value mates

recent industrial and digital revolutions have introduced further divergences (Giphart & van Vugt, 2016).

To elucidate this process, we classify mismatch along four dimensions: source, type, cause, and consequences (Tables 1–3). Mismatch can arise through natural sources or, commonly in modern societies, human-induced changes. Two types of mismatch are "forced"—when a new environment is imposed on an organism—and "hijacked"—when novel stimuli are favored by a mechanism over stimuli that the mechanism evolved to process. Mismatch occurs because of significant changes in either (a) input cues, which have changed in intensity or quantity, are altogether missing, or have been replaced by novel cues mimicking the original cues, or (b) the consequences of the mechanism's output.

Mismatch can positively or negatively affect both a mechanism's impact on reproductive fitness and the degree to which the mechanism's outputs align with individuals' well-being or values. Importantly, these two aspects are separate considerations. Also, while we focus on evolutionary mismatches, novel environments may also create developmental mismatches (e.g., prenatal undernutrition; Frankenhuis & Del Giudice, 2012) or cultural mismatches (e.g., living in a totalitarian state).

Although the tables indicate discrete categories, distinctions are often blurred between dimensions, which may also vary on a continuum. Also, consequences are likely multifaceted for many mismatches. Indeed, we believe that the mismatch cases that are most interesting—for both research and policy—involve novel stimuli that yield not only attractive benefits (which is why they exist and are favored) but also substantial fitness or individual (health, psychological) costs.

Examining the Mismatch Hypothesis in Psychology

Physiological and psychological maladies and other undesirable phenomena that are unique to or exacerbated in the modern world may be due to mismatches (Buss, 2000). However, not all undesirable phenomena stem from mismatch—for example, affective distress

(e.g., anxiety) may be produced by properly functioning mechanisms. To substantiate a mismatch case, one must specify the function of a proposed evolved mechanism, its underlying decision rule (or rules), and the inputs and outputs it evolved to process and produce, respectively. As discussed above, the mechanism needs to meet the criteria for an adaptation (Williams, 1966). A discrepancy between the current and ancestral environment should also be shown in the (a) quantity, intensity, or constitution of input cues being processed by the mechanism or (b) consequences of a mechanism's output. Evidence that the reproductive fitness or well-being of individuals is negatively impacted by this difference may be of interest but is not necessary to substantiate input-driven mismatch. Likewise, changes in inputs are not necessary for demonstrating output-based mismatch.

Compared with the ancestral world, the modern world is marked by higher population densities, greater dispersal of families, and a proliferation of attractive individuals encountered electronically. Modern people are also exposed to less nature, are more sedentary, and ingest processed foods and substances. Accordingly, psychological and physiological mechanisms that process these types of inputs are particularly likely to be affected by mismatch. Such mechanisms include ones that assess mate value and mating opportunities, reproductive timing, relationship commitment, life satisfaction, competition, resource and social support availability, and nutrition (e.g., Kanazawa & Li, 2015; Yong, Li, Valentine, & Smith, 2017).

The Role of Mismatch in Psychology

An understanding of a mechanism's functional features along with relevant mismatched conditions can lead to predictions about mismatch consequences and a greater understanding of modern ailments. Below, we review mismatch evidence in three domains: (a) physical and mental health, (b) mating, and (c) work and organizations.

Physical and mental health

Modern people are increasingly facing physical and mental health issues rarely found in current hunter-gatherer societies (which model those of our ancestral past). A common hijack mismatch occurs with food choices. Sweet tastes in ancestral environments were associated with foods such as fruit, yams, and honey that have naturally useful levels of carbohydrates and nutrients. Accordingly, a decision rule of "prefer and eat the sweetest-tasting things" led to beneficial consumption of such foods (Fig. 1a). Today, however, the sweetest tastes belong to readily available foods manufactured with copious amounts of processed sugars and stripped of nutrients (Fig. 1b). These mismatched food

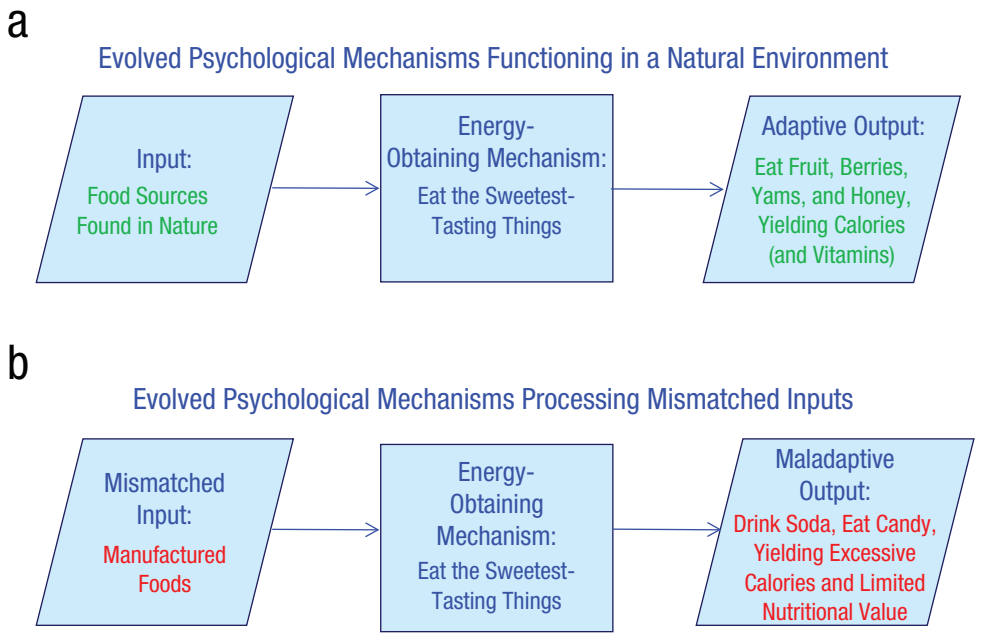

Fig. 1. Schematic showing (a) how an evolved psychological mechanism functions in a natural environment and (b) how the same psychological mechanism functions in a modern context. Although the same decision rule is followed in each case, different inputs lead the mechanism to produce different outputs. As a result, mechanisms that were evolutionarily beneficial can be maladaptive in the modern world.

sources then lead to illnesses such as diabetes because physiological mechanisms involving insulin and glucagon did not evolve to repeatedly metabolize unnaturally large amounts of sugar (Gluckman & Hanson, 2006).

Myopia (nearsightedness) may be a mismatch consequence of mechanisms involved in eye development and maintenance. According to the visual stimuli hypothesis (Lieberman, 2013), various eyeball parts are designed to view a diverse range of natural stimuli that move (e.g., animals, leaves) while individuals themselves are moving. When such stimuli are replaced by close-up ones, such as words in books and computers, eyeballs tend to develop maladaptively, and individuals lose the ability to focus on distant objects. Accordingly, we can predict that children spending more time reading or looking at computers versus playing outdoors are more likely to develop myopia. Indeed, myopia is less common in individuals who engage in physical and outdoor activity (e.g., Dolgin, 2015).

A final example is postpartum depression, which has recently been hypothesized to result from a mismatch involving the presence of cues that separately trigger depressive symptoms and the absence of cues that attenuate their effects (Hahn-Holbrook & Haselton, 2014). Compared with their counterparts in traditional societies, modern-day mothers of newborns often lack kin support (which, in ancestral times, was critical for infant survival), engage in less breastfeeding, are exposed to less sunshine, consume less omega-3 fatty acids, and engage in less physical activity—conditions that each increase inflammation and may activate mechanisms evolved to downregulate activity in the presence of disease or stress (Dantzer, O'Conner, Freund, Johnson, & Kelley, 2008). Accordingly, researchers predicted that postpartum depression occurs more often under each of these conditions (Hahn-Holbrook & Haselton, 2014). Alternatively, postpartum depression has been hypothesized to reflect an adaptive defection mechanism for downregulating maternal investment under suboptimal childrearing conditions, including lack of social support, poor infant health, and infant development problems (Hagen, 1999). Correlational data have thus far supported both hypotheses.

Mating

Reflecting reproduction's centrality to evolution, mismatch affects various aspects of mating-related psychology. Brief exposure to just 10 photos of physically attractive female faces reduces men's commitment to their long-term mates and women's self-perceived desirability (e.g., Kenrick, Neuberg, Zierk, & Krones, 1994). These findings, together with numerous studies linking media consumption to devaluing body image and lowering self-esteem, suggest that evolved mechanisms assessing intrasexual competition and mate availability process images not only of individuals encountered in social media but also of actors and models. Hence, we can predict that prolonged media consumption contributes to the destabilization of long-term relationships and to various types of self-dissatisfaction (Yong et al., 2017).

Another disruptive process occurs through oral contraceptives, which suppress natural hormones that are input to ovulation mechanisms. Studies have indicated that contraceptive usage is correlated with shifts away from adaptive mate preferences (Roberts, Gosling, Carter, & Petrie, 2008) and increased jealousy toward partners (Cobey, Pollet, Roberts, & Buunk, 2011), suggesting that the suppressed hormones are—or influence inputs to—key psychological mechanisms for mate selection and maintenance.

Paradoxically, the wealthiest countries are now reproducing the least—in all East Asian and many European countries, fertility rates are well below replacement level. A consideration of evolutionary mismatch together with life history theory (e.g., Ellis, Figueredo, Brumbach, & Schlomer, 2009) may facilitate the identification of factors that underlie this widespread phenomenon. For instance, modern population densities are up to 100,000 times larger than in ancestral environments and have been linked to lower life satisfaction. Especially high densities may indicate to psychological mechanisms assessing competition and resources that the environment is intensely competitive for very limited natural resources (Li & Kanazawa, 2016) and may induce reproductive-timing mechanisms to delay marriage and reproduction. Consistent with these ideas, archival records and experimental studies have recently demonstrated links between population density and slow life history strategies (Sng, Neuberg, Varnum, & Kenrick, 2017).

Work and organizations

Modern-day organizations and work arrangements bear little resemblance to human labor practices throughout evolutionary history. Not surprisingly, mismatch challenges permeate workplaces. The design of most modern work spaces, for example, focuses on space efficiency, forcing people into input-mismatched settings. Modern work spaces tend to be barren and angular and to minimize nature exposure. From an evolutionary perspective, exposure to natural elements is beneficial because they are stimuli that were ancestrally associated with safety and resource abundance (Ulrich et al., 1991). Accordingly, researchers predicted that employees function better in workplaces with more natural elements and found that people with greater exposure to natural elements at work are indeed less depressed and more satisfied with and

committed to their jobs (An, Colarelli, O'Brien, & Boyajian, 2016).

In the evolutionary past, leadership was often a physical activity, and hunting, warfare, and group movement were led by prestigious, physically strong individuals. It was adaptive to learn from and follow these specialists. Modern organizations, however, need different types of leaders to guide them through today's novel, complex environments. Yet our evolved followership mechanisms often (though not always; e.g., Elgar, 2016) use cues reliably associated with good leadership in ancestral times: being male, tall, and physically strong. Accordingly, the selection of leaders on these bases has been predicted to result in suboptimal outcomes for modern organizations (van Vugt & Ahuja, 2011; van Vugt & Ronay, 2014).

Another output-consequence mismatch occurs when our evolved kinship psychology operates in modern work contexts. Genes can propagate by increasing the reproductive success of not only host organisms but also others who have copies of those genes. Because individuals share more genes with genetic relatives than unrelated others, mechanisms can evolve that impel organisms to behave altruistically toward relatives, as long as reproductive gains accruing to those relatives (weighted by their relatedness to the host) exceed the reproductive costs to the host organism (Hamilton, 1964). Yet the presence and favoring of kin in modern organizations is problematic to achieving the modern ethos of merit and universalism (Nicholson, 2015) and may have implications for greater employee theft (O'Brien, Minjock, Colarelli, & Yang, 2017). In family-owned businesses, tensions exist between family-member and non–family-member employees, with the latter feeling greater injustice, particularly when family-member density is high (Spranger et al., 2012). Accordingly, many organizations have implemented antinepotism policies. Yet while their intent (eliminate favoritism and cronyism) is laudable, blanket antinepotism policies forgo tapping into family ties for developing trust and cooperation (Colarelli, 2015; Jones & Stout, 2015).

Informing Public Policy

Aside from advancing theoretical knowledge, a greater understanding of evolved psychological mechanisms and the role of evolutionary mismatch—in particular, mismatches inducing negative consequences or costs to individuals and society—can lead to more informed problem solving and public policy (Griskevicius, Cantu, & van Vugt, 2012). Ignoring evolved mechanisms and how they respond to mismatched inputs can yield ineffective or harmful interventions. For example, despite the benefits of modern sanitation and hygiene, evidence indicates that our immune systems were designed to be stimulated in infancy by exposure to bacteria. Accordingly, sanitary modern environments lack key bacterial inputs for mechanisms that develop immune systems and have been positively linked to childhood asthma, allergies, and ear infections (e.g., Bach, 2002). Thus, individuals and policymakers may wish to limit, not promote, the use of evolutionarily novel antibacterial products and high cleanliness standards in modern homes (though not necessarily in schools and other crowded venues, where evolutionarily novel amounts of pathogens abound).

An understanding of mismatch may also provide insights into designing more effective solutions to global concerns such as ecological conservation. Attempts to induce conservation behaviors have met with limited success, largely because conversation itself is evolutionarily novel—humans evolved to consume local resources without concern when pollutant output was relatively low, populations were small, and migration to new locations was feasible. Similar strategies enacted today, however, have greater repercussions for health and sustainability. Researchers have proposed that psychological mechanisms likely operate in service of several basic evolved human tendencies: self-interest, concerns over relative social status, social imitation, future discounting, and disregard for impalpable concerns (Griskevicius et al., 2012). Accordingly, successfully encouraging ecologically sustainable or other desired behavior requires interventions that align with, versus oppose, these evolved tendencies.

Conclusion

As societies globalize and human-induced environmental change occurs progressively faster, evolutionary mismatch is only becoming increasingly prevalent. Given that mismatch often brings negative consequences for physical and psychological health and values, understanding the mismatch process is important not only for basic psychological science research but also for achieving key insights into more effective avenues to address the numerous problems of the modern world.

Recommended Reading

An, M., Colarelli, S. M., O'Brien, K., & Boyajian, M. E. (2016). (See References). Describes a study showing how natural elements (or lack thereof) affect employee well-being and work attitudes.

Barrett, D. (2010). *Supernormal stimuli: How primal urges overran their evolutionary purpose*. New York, NY: W. W. Norton. Discusses how modern-day problems stem from our evolved instincts (psychological mechanisms) being taken over by supernormal stimuli.

Hahn-Holbrook, J., & Haselton, M. (2014). (See References). Provides a very clear explanation of a puzzling affliction in terms of mismatch.

Li, N. P., & Kanazawa, S. (2016). (See References). Reveals how life satisfaction can be affected by mismatch.

van Vugt, M., & Ahuja, A. (2011). (See References). Discusses leadership from an evolutionary perspective and explains how today's leaders may be mismatched to current needs.

ORCID ID

Norman P. Li https://orcid.org/0000-0002-4059-1613

Declaration of Conflicting Interests

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