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Country roads, take me home. . . to my friends: How intelligence, population density, and friendship affect modern happiness

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We propose the savanna theory of happiness, which suggests that it is not only the current consequences of a given situation but also its ancestral consequences that affect individuals' life satisfaction and explains why such influences of ancestral consequences might interact with intelligence. We choose two varied factors that characterize basic differences between ancestral and modern life – population density and frequency of socialization with friends – as empirical test cases. As predicted by the theory, population density is negatively, and frequency of socialization with friends is positively, associated with life satisfaction. More importantly, the main associations of life satisfaction with population density and socialization with friends significantly interact with intelligence, and, in the latter case, the main association is reversed among the extremely intelligent. More intelligent individuals experience lower life satisfaction with more frequent socialization with friends. This study highlights the utility of incorporating evolutionary perspectives in the study of subjective well-being.

Positive psychology and evolutionary psychology are two subfields of psychology that have made significant advances in the last few decades (Cosmides & Tooby, 2013; Diener, 2012). While several evolutionary psychologists have written on happiness (Buss, 2000; Hill & Major, 2013; Lewis, Al-Shawaf, Russell, & Buss, 2015; Nesse, 2004), with only a couple of exceptions (Diener, Kanazawa, Suh, & Oishi, 2015; Heintzelman & King, 2014), positive psychologists have not drawn on insights from evolutionary psychology. At the same time, while positive psychologists have accumulated an impressive amount of empirical knowledge in the last few decades about who is happier than whom, when, and how, there are few systematic general theories of happiness – evolutionary or otherwise – that can explain *why* some individuals are happier than others. In this study, we propose an evolutionary psychological theory of subjective well-being that we call *the savanna theory of happiness,* and provide empirical support for the theory.

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The savanna theory of happiness

One of the fundamental observations in evolutionary psychology is that, just like any other organ of any other species, the human brain is designed for and adapted to the conditions of the ancestral environment, not necessarily the current environment, and is therefore predisposed to perceive and respond to the current environment as if it were the ancestral environment (Tooby & Cosmides, 1990). Known variously as the *Savanna Principle* (Kanazawa, 2004b), the *evolutionary legacy hypothesis* (Burnham & Johnson, 2005), or the *mismatch hypothesis* (Hagen & Hammerstein, 2006), this observation suggests that the human brain may have difficulty comprehending and dealing with entities and situations that did not exist in the ancestral environment, roughly the African savanna during the Pleistocene Epoch.

The Savanna Principle can explain why some otherwise elegant scientific theories of human behaviour, such as game theory, often fail empirically, because they posit entities and situations that did not exist in the ancestral environment. For example, nearly half the players of one-shot Prisoner's Dilemma games make the theoretically irrational choice to cooperate with their partner (Sally, 1995). The Savanna Principle suggests that this may possibly be because the human brain has difficulty comprehending completely anonymous social exchange and absolutely no possibility of knowing future interactions (which together make the game truly one-shot and defection the only rational choice; Hagen & Hammerstein, 2006; Kanazawa, 2001). Neither of these situations existed in the ancestral environment, where all social exchanges were in person and potentially repeated; however, they are crucial for the game-theoretical prediction of universal defection.

Further, recent developments in evolutionary psychology indicate that general intelligence may have evolved to solve evolutionarily novel problems (Kanazawa, 2004a, 2010). Psychological mechanisms evolved to solve adaptive problems that recurrently presented themselves in different domains of life throughout human evolutionary history, such as social exchange, infant care, and incest avoidance (Tooby & Cosmides, 1990). They are domain-specific and operate only within narrow domains of life, taking as input very specific types of information.

Recent theoretical developments suggest that general intelligence, far from being domain-general, may also have evolved as such a domain-specific evolved psychological mechanism. It may have evolved to allow individuals to solve a wide variety of *non-recurrent* adaptive challenges that also directly or indirectly affected survival or reproduction. All such non-recurrent adaptive problems were *evolutionarily novel.* General intelligence may thus have evolved to solve evolutionarily novel problems, as a psychological adaptation for the domain of evolutionary novelty.

This suggests that the evolutionary constraints on the human brain proposed by the Savanna Principle may be stronger among less intelligent individuals than among more intelligent individuals. More intelligent individuals, who possess higher levels of general intelligence and thus greater ability to solve evolutionarily novel problems, may face less difficulty in comprehending and dealing with evolutionarily novel entities and situations. In contrast, less intelligent individuals may face greater difficulty in dealing with evolutionarily novel entities and situations than more intelligent individuals.

Consistent with this reasoning, more intelligent individuals are more likely to make the theoretically rational choice to defect in one-shot Prisoner's Dilemma games (Kanazawa & Fontaine, 2013). This may be because more intelligent individuals are better able to comprehend the evolutionarily novel situations of complete anonymity and absolutely no possibility of knowing future interactions and make the rational decision to defect. In contrast, less intelligent individuals may have greater difficulty comprehending such evolutionarily novel situations and, as a result, make the theoretically irrational (*albeit evolutionarily rational*) decision to cooperate.

The Savanna Principle in evolutionary psychology, applied to life satisfaction, may suggest that it may not be only the consequences of a given situation in the current environment that influence individuals' life satisfaction but also what its consequences *would have been* in the ancestral environment. Having implicit difficulty comprehending and dealing with evolutionarily novel situations, the human brain may respond to the ancestral consequences of the current situation and individuals' life satisfaction may fluctuate accordingly. The evolutionary constraints on the human brain may incline individuals to experience a given situation as if it were taking place in the ancestral environment, not in the current environment, and be subject to its ancestral consequences for life satisfaction. Further, the effect of such ancestral consequences of current situations on life satisfaction may be greater among less intelligent individuals, for whom the evolutionary constraints specified by the Savanna Principle are stronger, than among more intelligent individuals, for whom they are weaker.

The savanna theory of happiness therefore suggests that, having implicit difficulty comprehending and dealing with evolutionarily novel situations, the human brain may respond to the ancestral consequences of the current situation and individuals' subjective well-being may fluctuate accordingly (Kanazawa & Li, 2015). Situations and circumstances that would have increased our ancestors' life satisfaction in the ancestral environment may still increase our life satisfaction today, and those that would have decreased their life satisfaction then may still decrease our life satisfaction today. The savanna theory further suggests that such effects of ancestral consequences on current life satisfaction may be stronger among less intelligent individuals than among more intelligent individuals.

Positive psychologists have long debated the precise definition of happiness and related concepts, such as life satisfaction and subjective well-being (Miao, Koo, & Oishi, 2013; Oishi, Graham, Kesebir, & Galinha, 2013; Pavot & Diener, 2013). Even though our empirical analyses below used a measure of global life satisfaction, the savanna theory of happiness is not committed to any particular definition and is compatible with any reasonable conception of happiness, subjective well-being, and life satisfaction (cognitive vs. affective; hedonic vs. eudaimonic, etc.). The theory does, however, treat happiness as a state, rather than a trait; it cannot explain the (partly genetically determined) 'happiness set point' (Headey & Wearing, 1989), to which individuals tend to return after momentary and situational perturbations to their baseline levels of happiness. The theory instead explains such temporary and situational fluctuations from the happiness baseline as a function of the potential evolutionary consequences of the current situations and circumstances.

In this study, we provide empirical tests of the two hypotheses derived from the savanna theory of happiness. As empirical test cases, we focus on two factors that characterize basic differences in the social landscape of ancestral versus modern environments and thus might affect life satisfaction: population density and friendships.

Population density

> The beauty of the country besides, the pleasures of a country life, the tranquility of mind which it promises, and wherever the injustice of human laws does not disturb it, the independency which it really affords, have charms that more or less attract everybody.
>
> Adam Smith, *Wealth of Nations* (1776, III.1.3)

Ruralites in economically developed nations tend to be happier than their urbanite counterparts (Berry & Okulicz-Kozaryn, 2009; Easterlin, Angelescu, & Zweig, 2011). Even in the still developing China, rural residents report higher levels of subjective well-being than urban residents, despite the fact that city dwellers are vastly wealthier (Knight & Gunatilaka, 2010). In the United States, there is an 'urban–rural happiness gradient', whereby residents of rural areas and small towns are happier than those in suburbs, who in turn are happier than those in small central cities, who in turn are happier than those in large central cities (Berry & Okulicz-Kozaryn, 2011). What accounts for the differences in happiness across these residential settings? Why are ruralites happier than urbanites?

A current leading explanation for the lower level of life satisfaction in cities is that urban life is accompanied by numerous 'social ills', such as anomie, alienation, social disorganization, and depression (Berry & Okulicz-Kozaryn, 2011; Evans, 2009; Wirth, 1938). An fMRI study shows that the brains of current city dwellers and those who grew up in cities respond to stress with greater activities than those of current country dwellers and those who grew up in the country (Lederbogen *et al.*, 2011). These studies, however, simply raise another question: *Why* does the human brain perceive urban life, but not rural life, as stressful, alienating and depressing? *Why* does urban life, but not rural life, induce alienation and depression?

The savanna theory of happiness offers one potential answer. There is converging evidence to suggest that our ancestors may have lived in groups of about 150 individuals. Comparative data on relative neocortex size in the brain and the group size among 38 genera of primates suggest that the natural size for human groups given its neocortex ratio is about 150 (Dunbar, 1992). Indeed, the mean band or village size of nine modern hunter–gatherer societies is 148.4 (Dunbar, 1993). Computer simulations of the evolution of risk aversion suggest that it can only evolve in small groups of about 150 individuals (Hintze, Olson, Adami, & Hertwig, 2013). The mean size of personal networks suggested by the number of annual Christmas cards sent is 153.5 (Hill & Dunbar, 2003). The mean size of social networks suggested by two 'small world' experiments is 134 (Killworth, Bernard, & McCarty, 1984). The typical size of Neolithic villages in Mesopotamia was 150–200 (Oates, 1977); the mean size of Hutterite farming communities in Canada is 107 (Mange & Mange, 1980); and the mean size of Amish parishes in central Pennsylvania is 112.8 (Hurd, 1985). The typical size of military unit in the classical Roman army was 120–130, and the mean company size of armies in World War II was 180 (MacDonald, 1955). Gautney and Holliday (2015) estimate the population density in Africa and Eurasia during the Pleistocene Epoch to be between 0.03 and 0.12 individuals/km^2, about one-tenth of the population density of the least dense state in the United States (Alaska = 0.46 individuals/km^2) in 2010 but denser than the least dense counties in the United States (Yukon-Koyukuk Census Area, Alaska = 0.015; and Lake and Peninsula County, Alaska = 0.027).

When the number of individuals in a group exceeds 150–200, the group typically fissions into and forms two separate groups, because in larger groups social organization based on cooperation and reciprocity becomes exceedingly difficult (Chagnon, 1979). Because the major constraint on human group size is cognitive (Dunbar, 1992, 1993), it is possible that, as the population density becomes too high, the human brain feels uneasy and uncomfortable, and such unease and discomfort may translate into reduced subjective well-being. For example, job satisfaction is significantly negatively associated with organizational size (Indik, 1965; Porter & Lawler, 1965). The savanna theory of happiness may therefore suggest that group sizes and population densities much higher than were typical in the ancestral environment may decrease subjective well-being. It further suggests that such a negative effect of population density on happiness may interact with general intelligence, such that the negative effect is greater among less intelligent individuals than among more intelligent individuals. We tested these hypotheses in Study 1A.

Friendships

> 'Friends show their love in times of trouble, not in happiness'.
>
> Euripides (480BC–406BC)

> 'Lots of people want to ride with you in the limo, but what you want is someone who will take the bus with you when the limo breaks down'.
>
> Oprah Winfrey (1954–)

One of the most important determinants of life satisfaction is the quality of social relationships, in particular friendships (Diener & Seligman, 2004, pp. 18–20; Dolan, Peasgood, & White, 2008, pp. 106–108). The more friends one has, and the more time one spends with them, the happier one tends to be on average, although recent studies suggest that the *quality* of friendships is more important for happiness than their *quantity* (Demir, Orthel, & Andelin, 2013; Demir, Orthel-Clark, Özdemir, & Özdemir, 2015). The association between satisfaction with friendships and life satisfaction is particularly stronger in more individualistic cultures (Diener & Diener, 1995; Li & Cheng, 2015). While the strong impact of friendships on subjective well-being may make intuitive sense, why are friends important for life satisfaction *theoretically*?

Perhaps the strong effect of friendships on life satisfaction is too obvious to explain; to our knowledge, only one scholar has offered a systematic explanation for why friendships increase happiness. Melikşah Demir and colleagues (Demir, 2015; Demir & Davidson, 2013; Demir & Özdemir, 2010; Demir, Özen, & Doğan, 2012; Demir, Özen, Doğan, Bilyk, & Tyrell, 2011) argue that friendships increase happiness because they satisfy some basic psychological needs, such as relatedness, the knowledge that one matters to others, and the desire to share and amplify good news and events (captured in the Swedish proverb 'Shared joy is a double joy, shared sorrow is half a sorrow'). Demir's explanation, however, raises even more fundamental questions. *Why* do humans have these basic psychological needs in the first place? And why can they be satisfied only (or primarily) by friends?

The savanna theory of happiness can provide one potential answer to such fundamental questions. As noted before, our ancestors lived as hunter–gatherers in small bands of about 150 individuals (Dunbar, 1992, 1993). In such settings, having frequent contact with lifelong friends and allies was likely necessary for survival and reproduction for both sexes, as evidenced by studies of both contemporary hunter–gatherers (Apicella, Marlowe, Fowler, & Christakis, 2012; Hruschka, 2010; Lewis *et al.*, 2015) and our primate cousins (Smuts, 1985; de Waal, 1982). For instance, cooperative alliances may have allowed men to overcome critical challenges posed by hunting and warfare (Bowles, 2009; Geary, Byrd-Craven, Haord, Vigil, & Numtee, 2003), and close relationships among unrelated women may have facilitated joint childcare and allomothering (Hrdy, 2009). Likewise, reciprocal food-sharing among group members occurs commonly in modern-day hunter–gatherers and may have allowed our ancestors to survive despite success or failure in hunting and gathering on any given day (Hill & Hurtado, 1996).

The evolutionary significance of friendships and alliances is suggested by numerous studies indicating that ostracism is invariably painful and distressful across various contexts and sources (Williams, Forgas, & von Hippel, 2005). In one experiment, participants earned money to be excluded in a game and lost money to be included. Despite earning more money than others, those who were ostracized still experienced pain (van Beest & Williams, 2006). Indeed, fMRI studies show that being ostracized activates the same region of the brain that lights up when individuals experience physical pain (Eisenberger, Lieberman, & Williams, 2003). Given the available evidence, it is reasonable to assume that humans evolved to detect ostracism (Gruter & Masters, 1986) largely because friendship ties and alliances were very important for the survival and reproductive success of our ancestors (Lewis *et al.*, 2015).

In contrast, survival and reproduction today depend increasingly more on one's ability to navigate myriad evolutionarily novel entities such as the internet, governments, banks, corporations, trusts, and the legal system. Instead of relying on reciprocal cooperation with friends and allies for basic needs, modern-day individuals deal with strangers or faceless entities and have no way of identifying those involved in the procurement and processing of necessities such as food (Pollan, 2006). It is entirely possible for individuals in modern society to survive and reproduce successfully without having any friends; friendships are not as critically necessary today for day-to-day living as they were in the ancestral environment. Hruschka (2010, p.2) notes, in a book entirely devoted to the importance of friendship, that 'while friends make us happy and help us in small ways, it is not entirely clear that they are important in the high-stakes game of survival and reproduction'. In 1998, 9% of respondents in the General Social Survey in a representative sample of non-institutionalized American adults responded that they did not have any good friends to whom they felt close (Smith, Marsden, & Hout, 2015, p. 639).

The savanna theory of happiness therefore suggests that the human brain may have implicit difficulty comprehending and dealing with life without frequent contact with close friends and allies, and such difficulty may decrease individuals' subjective well-being. Further, such an effect of friendships on life satisfaction may be particularly stronger among less intelligent individuals, who are likely less able to adapt to evolutionarily novel circumstances such as a dearth of close friends. Thus, we expect friendships to have a positive effect on subjective well-being and further (and more importantly) that such an effect will be stronger among less intelligent individuals. We tested these hypotheses in Study 1B.

STUDY 1A

Methods

Data and participants

We used Wave III data from the National Longitudinal Study of Adolescent Health (Add Health), which consisted of personal interviews held in 2001–2002 with 15,197 individuals aged 18–28 (M = 21.96, SD = 1.77). The participants were part of a large sample of students originally selected in 1994–1995 (Wave I) from middle and high schools that were representative of US schools with respect to region of country, urbanicity, school size, school type, and ethnicity. For further details of the sampling and study design, see http://www.cpc.unc.edu/projects/addhealth/design.

Dependent variable: Global life satisfaction

Add Health asked its respondents 'How satisfied are you with your life as a whole?': 1 = *very dissatisfied*, 2 = *dissatisfied*, 3 = *neither satisfied nor dissatisfied*, 4 = *satisfied*, and 5 = *very satisfied* (reverse coded). We used this measure of life satisfaction as the dependent variable in our ordinal regression analysis.[1]

Independent variable: Population density

Add Health measured the population density at the level of census block group (a subdivision of a census tract and the smallest geographic unit for which the Census Bureau tabulates aggregate data), census tract, county, and state. It was measured as the number of persons in thousands/km^2.

The distributions of population density at all levels were extremely positively skewed (skewness: block group = 6.780; census tract = 7.449; county = 8.702; state = 17.460). We therefore took the natural log of the measures of population density, which nearly eliminated the skewness (skewness after log normalization: block group = −.809; census tract = −.684; county = .023; state = −.121). We used the natural logs of measures of population density in our regression analyses below.

Independent variable: Intelligence

Add Health measured respondents' intelligence by an abbreviated version of the Peabody Picture Vocabulary Test. Their raw scores were transformed into the standard IQ metric, with a mean of 100 and a standard deviation of 15. The Peabody Picture Vocabulary Test is properly a measure of verbal intelligence. However, verbal intelligence is known to be highly correlated with and thus heavily load on general intelligence (Huang & Hauser, 1998; Miner, 1957; Wolfle, 1980).

Control variables

In addition, we controlled for the following characteristics of the respondent: sex (0 = *female*, 1 = *male*); age (in years); ethnicity (with three dummies for African American, Asian American, and Native American, with White American as the reference category); education (in years of formal schooling); and current marital status (1 = *currently married*, 0 = *otherwise*). All of these variables are known correlates of happiness (Dolan *et al.*, 2008). Preliminary analysis showed that the respondent's earnings had no association with life satisfaction among Add Health respondents (r = .013, p = .116, n = 14,414), perhaps because of their relative youth and little variance in earnings (M = 11,744, median = 8,000 SD = 17,289, IQR = 16,500, n = 14,425). This was consistent with earlier studies, which showed that variance in earnings generally increased with age (Beach, Finnie, & Gray, 2010; Caswell & Kluge, 2015; Lam & Levison, 1992).

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[1] *More sophisticated statistical procedures like structural equation modelling (SEM) or multilevel modelling (MLM) are not feasible with our data. SEM is not feasible because we have only one indicator each for all of the variables in our analysis, and MLM is not feasible because, while we know the population density of the county or the state of residence, for example, we do not know in which county or state the Add Health respondents reside. (Add Health is extremely concerned about privacy issues and does not make much individually identifiable information available in the data.) So we cannot perform MLM by nesting individual respondents in the county or state of their residence.*

Results

The results of the ordinal regression analysis appear in Table 1. Whether measured at the level of block group, census tract, county, or state, population density was significantly negatively associated with Add Health respondents' life satisfaction (Columns 1–4; block group: $b = -.058$; census tract: $b = -.055$; county: $b = -.076$; state: $b = -.100$; $p < .001$ for all). This did not change at all when we controlled for sex, age, ethnicity, education, and current marital status (Columns 5–8). Consistent with the prediction derived from the savanna theory of happiness, the higher the population density of the immediate environment, the less happy Add Health respondents were.

Further analyses (Columns 9–12) showed that, consistent with the prediction, the negative association between population density and life satisfaction was significantly stronger among less intelligent individuals than among more intelligent individuals. The interaction terms between population density and intelligence were statistically significantly positive for block group ($b = .002$, $p < .001$), census tract ($b = .002$, $p < .001$), county ($b = .002$, $p < .001$), and state ($b = .003$, $p = .010$).

Figure 1 presents the statistical interaction graphically. While county population density had a significantly negative association with life satisfaction among both less intelligent (with IQ of 81.39, one standard deviation below the mean) and more intelligent (with IQ of 115.57, one standard deviation above the mean) individuals, the negative association was greater among less intelligent individuals ($M = 4.2617$ vs. 4.1090) than among more intelligent individuals ($M = 4.2161$ vs. 4.1495). Put another way, in a county with low population density (41 persons/km^2, one standard deviation below the mean), less intelligent individuals had higher mean life satisfaction than more intelligent individuals did. In contrast, in a county with high population density (937 persons/km^2, one standard deviation above the mean), more intelligent individuals had higher mean life satisfaction than less intelligent individuals did.[2]

There is currently no accepted method of computing effect sizes or standardized regression coefficients in ordinal regression and other generalized linear models, partly because the effects of independent variables on the dependent variable in ordinal regression are proportional, not constant. However, the mean differences in life satisfaction in low and high densities in Figure 1 allowed us to compute Cohen's d as an estimate for the effect of population density on life satisfaction. Given that the standard deviation of life satisfaction was 0.815, the mean difference in life satisfaction for low-IQ individuals (−0.1527) translated to $d = -.19$, and that for high-IQ individuals (−0.0666) to $d = -.08$. The effect of population density on life satisfaction was therefore more than twice as large for low-IQ individuals than for high-IQ individuals.

Given that our data are correlational and population density and life satisfaction were measured at the same time, we cannot rule out an opposite causal order to what we hypothesize in the savanna theory of happiness, where people who experience higher life satisfaction are more likely to move to rural areas. This does not appear to be the case. While life satisfaction at Wave III was significantly positively associated with the distance

[2] *In generalized linear models (such as ordinal regression that we employed here), the independent variables have proportional effects on the dependent variable and constant effects* on the logit *(natural log of odds of a respondent being in one category of the dependent variable versus another). As a result, simple slope analysis, of the kind described in Aiken and West (1991) for OLS regression, cannot be performed on raw dependent variable and must instead be performed on the logit. Because the logit has no intuitive or readily interpretable meaning, we have chosen not to perform a simple slope analysis.*

Table 1. Population density and life satisfaction

	(1) Block group	(2) Census tract	(3) County	(4) State
Population density	−.058***	−.055***	−.076***	−.100***
	(.008)	(.008)	(.010)	(.019)
Age				
Sex				
Ethnicity				
African American				
Asian American				
Native American				
Education				
Currently married				
Intelligence				
Intelligence*population density				
Threshold				
Y = 1	−5.106	−5.095	−4.996	−4.837
	(.106)	(.106)	(.107)	(.118)
Y = 2	−3.135	−3.124	−3.025	−2.866
	(.041)	(.041)	(.044)	(.066)
Y = 3	−1.594	−1.584	−1.484	−1.326
	(.022)	(.022)	(.027)	(.056)
Y = 4	.570	.581	.682	.836
	(.017)	(.017)	(.024)	(.055)
−2Log Likelihood	23549.434***	19396.470***	5169.710***	993.527***
Cox & Snell pseudo-R^2	.003	.003	.004	.002
Number of cases	14,877	14,877	14,877	14,877

	(5) Block group	(6) Census tract	(7) County	(8) State
Population density	−.049***	−.047***	−.068***	−.079***
	(.008)	(.008)	(.010)	(.019)
Age	−.052***	−.053***	−.051***	−.056***
	(.009)	(.009)	(.009)	(.009)
Sex	.118***	.118***	.118***	.120***
	(.032)	(.032)	(.032)	(.032)
Ethnicity				
African American	−.178***	−.181***	−.173***	−.193***
	(.038)	(.038)	(.038)	(.038)
Asian American	−.253***	−.258***	−.248***	−.289***
	(.058)	(.057)	(.058)	(.057)
Native American	−.203**	−.204**	−.209**	−.226***
	(.069)	(.069)	(.068)	(.068)
Education	.151***	.152***	.152***	.148***
	(.008)	(.008)	(.008)	(.008)
Currently married	.715***	.715***	.713***	.724***
	(.044)	(.044)	(.044)	(.044)
Intelligence				
Intelligence*population density				
Threshold				
Y = 1	−4.237	−4.233	−4.084	−4.152
	(.236)	(.236)	(.239)	(.243)

Continued

Table 1. (*Continued*)

	(5) Block group	(6) Census tract	(7) County	(8) State
$Y = 2$	−2.258	−2.254	−2.105	−2.173
	(.215)	(.215)	(.218)	(.222)
$Y = 3$	−.690	−.686	−.536	−.606
	(.212)	(.212)	(.216)	(.220)
$Y = 4$	1.539	1.543	1.694	1.621
	(.212)	(.212)	(.216)	(.220)
−2Log Likelihood	32503.061***	31976.678***	27210.467***	21051.828***
Cox & Snell pseudo-R^2	.042	.042	.043	.041
Number of cases	14,811	14,811	14,811	14,811

	(9) Block group	(10) Census tract	(11) County	(12) State
Population density	−.248***	−.222***	−.284***	−.435**
	(.054)	(.054)	(.059)	(.141)
Age	−.050***	−.051***	−.049***	−.054***
	(.010)	(.010)	(.010)	(.009)
Sex	.118***	.118***	.119***	.120***
	(.032)	(.032)	(.032)	(.032)
Ethnicity				
African American	−.192***	−.191***	−.188***	−.197***
	(.041)	(.041)	(.041)	(.040)
Asian American	−.256***	−.263***	−.255***	−.288***
	(.059)	(.059)	(.059)	(.059)
Native American	−.194**	−.198**	−.203**	−.220**
	(.069)	(.069)	(.069)	(.069)
Education	.153***	.153***	.154***	.149***
	(.009)	(.009)	(.009)	(.009)
Currently married	.710***	.710***	.708***	.716***
	(.045)	(.045)	(.045)	(.045)
Intelligence	−.001	.000	.003*	.010*
	(.001)	(.001)	(.001)	(.004)
Intelligence*population density	.002***	.002***	.002***	.003*
	(.001)	(.001)	(.001)	(.001)
Threshold				
$Y = 1$	−4.227	−4.167	−3.765	−3.098
	(.253)	(.253)	(.266)	(.469)
$Y = 2$	−2.258	−2.197	−1.795	−1.129
	(.233)	(.233)	(.247)	(.458)
$Y = 3$	−.691	−.630	−.227	.436
	(.230)	(.230)	(.244)	(.457)
$Y = 4$	1.537	1.596	2.001	2.661
	(.231)	(.231)	(.245)	(.458)
−2Log Likelihood	31731.139***	31710.645***	31321.322***	30674.162***
Cox & Snell pseudo-R^2	.043	.042	.043	.041
Number of cases	14,278	14,278	14,278	14,278

Note. Main entries are unstandardized regression coefficients.
Numbers in parentheses are standard errors.
*$p < .05$; **$p < .01$; ***$p < .001$.

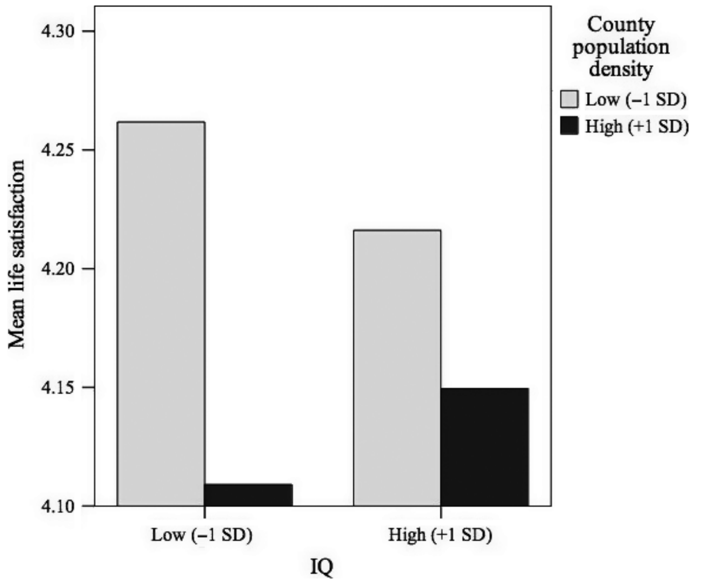

Figure 1. Interaction effect between county population density and intelligence on life satisfaction.

Add Health respondents moved between Waves I and III ($r = .022, p = .008, n = 14{,}801$), the distance moved was more strongly positively associated with Wave III population density (block group: $r = .072$; census tract: $r = .076$; county: $r = .060$; state: $r = .046$; $p < .001, n = 14{,}813$ for all). In other words, longer-distance movers were more likely to move to urban areas, not rural areas, and they became more satisfied with their life *despite* their long-distance move (to urban areas), not because of it. As a result, controlling for the distance moved *strengthens* the negative association between population density and life satisfaction, not weakens or eliminates it, at all levels except for state, where the association remains unchanged.

Discussion

Consistent with our prediction derived from the savanna theory of happiness, population density measured at the block group, census tract, county, and state levels had a significantly negative association with Add Health respondents' life satisfaction. The lower the population density of the immediate environment and the closer it was to what it was in the ancestral environment, the higher life satisfaction Add Health respondents experienced.

Further, as predicted, the association between population density and life satisfaction was significantly stronger among less intelligent individuals than among more intelligent individuals. Less intelligent individuals might have had greater difficulty comprehending and dealing with the evolutionary novelty of living in a high population density area and become less satisfied with life as a result. In contrast, more intelligent individuals might have had less difficulty with living in a high population density area and their life satisfaction might not have been affected as much. In low population density, less intelligent individuals on average had higher life satisfaction than more intelligent individuals did, but in high population density, more intelligent individuals on average had higher life satisfaction than less intelligent individuals did.

Interestingly, Add Health respondents' intelligence was significantly *negatively* associated with the natural log of population density (block group: $r = -.041$, $p < .001$; census tract: $r = -.027$, $p = .001$; county: $r = -.038$, $p < .001$; state: $r = -.028$, $p < .001$; $n = 14{,}351$ for all). It means that more intelligent individuals did *not* selectively migrate to urban areas, and less intelligent individuals did *not* selectively migrate to rural areas, in order to take advantage of their respective levels of intelligence to become more satisfied with life. We believe there are two potential (and non-mutually exclusive) reasons for this. First, individuals in general may not be (either consciously or unconsciously) aware of the negative effect of population density on happiness and its divergent effects by intelligence. Second, individuals may not have complete freedom to move where they want in order to pursue life satisfaction, especially at such a young age. They may be constrained by the requirements of their education, employment, and family.

STUDY 1B

Methods

Data and participants, dependent variable (global life satisfaction), one of the independent variables (intelligence), and all control variables for Study 1B were identical to those in Study 1A.

Independent variable: Frequency of socialization with friends

Add Health asked its respondents 'In the past 7 days, how many times did you just "hang out" with friends, or talk on the telephone for more than five minutes?': 0 = *not at all* to 7 = *7 or more times*. Add Health did not clearly define or explain to its respondents exactly who counted as friends. This is unlikely to be a problem in the current study, however, because Demir (2015, p. vii) concludes, based on the review of a large number of studies in the literature, that 'friendship is related to happiness regardless of the ways the constructs were assessed'.

Results

The results of the ordinal regression analyses appear in Table 2. As Column (1) shows, when entered alone, frequency of socialization with friends had no significant association with life satisfaction ($b = .008$, $p = .201$; $r = .010$, $p = .208$). This was because current marital status masked their association. Currently married Add Health respondents *simultaneously* were happier (4.11 vs. 4.35), $t(15{,}155) = -13.840$, $p < .001$, *and* socialized with their friends less frequently (4.56 vs. 3.24), $t(15{,}117) = 26.201$, $p < .001$. This is consistent with the dyadic withdrawal hypothesis (Johnson & Leslie, 1982).[3] As Column (2) shows, once current marital status was controlled, frequency of socialization with friends had a significantly positive association with life satisfaction ($b = .031$, $p < .001$), and, as Column (3) shows, this did not change even when we further controlled for age, sex, ethnicity, and education.

Column (4) shows that, consistent with the prediction, the positive association between frequency of socialization with friends and life satisfaction was significantly

[3] *We thank an anonymous reviewer for alerting us to the dyadic withdrawal hypothesis.*

Table 2. Frequency of socialization with friends and life satisfaction

	(1)	(2)	(3)	(4)
Frequency of socialization with friends	.008	.031***	.017*	.103**
	(.006)	(.007)	(.007)	(.035)
Currently married		.663***	.773***	.765***
		(.043)	(.045)	(.045)
Age			−.060***	−.059***
			(.009)	(.009)
Sex			.126***	.125***
			(.031)	(.032)
Ethnicity				
African American			−.194***	−.203***
			(.038)	(.040)
Asian American			−.301***	−.301***
			(.057)	(.058)
Native American			−.215**	−.210**
			(.068)	(.069)
Education			.145***	.147***
			(.008)	(.009)
Intelligence				.003
				(.002)
Intelligence*frequency of socialization with friends				−.001*
				(.000)
Threshold				
$Y = 1$	−5.060	−4.876	−4.389	−4.028
	(.108)	(.109)	(.236)	(.282)
$Y = 2$	−3.113	−2.928	−2.434	−2.084
	(.049)	(.051)	(.215)	(.264)
$Y = 3$	−1.573	−1.382	−.866	−.518
	(.035)	(.037)	(.213)	(.262)
$Y = 4$	.590	.806	1.364	1.710
	(.033)	(.036)	(.213)	(.262)
−2Log Likelihood	255.142	408.003***	15615.357***	29472.587***
Cox & Snell pseudo-R^2	.000	.016	.041	.041
Number of cases	15,111	15,111	15,047	14,513

Note. Main entries are unstandardized regression coefficients.
Numbers in parentheses are standard errors.
*$p < .05$; **$p < .01$; ***$p < .001$.

stronger among less intelligent individuals than among more intelligent individuals. The interaction term between intelligence and frequency of socialization with friends was significantly negative ($b = -.001, p = .014$).

Figure 2 presents the statistical interaction graphically. Among less intelligent individuals (with a mean IQ of 81.39), frequency of socialization with friends had a significantly positive effect on life satisfaction. Those who socialized with friends more frequently (6.71, nearly every day) had a significantly higher life satisfaction ($M = 4.1586$) than those who socialized with friends less frequently (1.95, less than twice a week) ($M = 4.1163$). In contrast, among more intelligent individuals (with a mean IQ of 115.57), those who socialized with friends more frequently were actually *less satisfied with life*

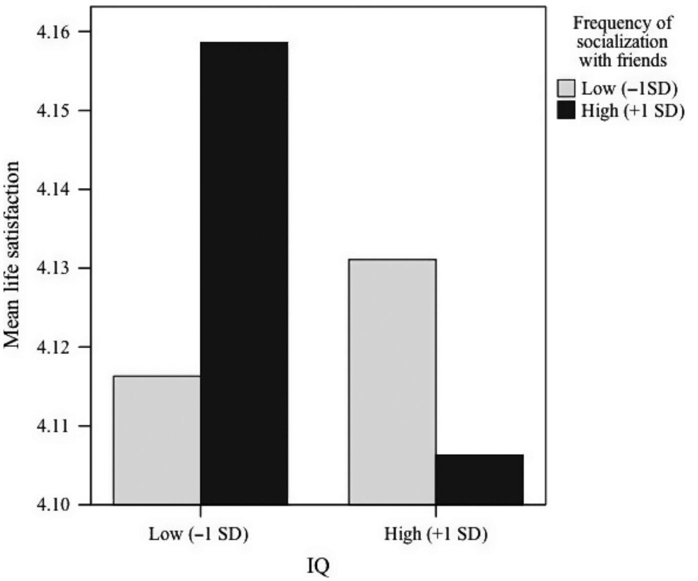

Figure 2. Interaction effect between frequency of socialization with friends and intelligence on life satisfaction.

(M = 4.1063) than those who socialized with friends less frequently (M = 4.1311). The statistical interaction was such that more intelligent individuals were actually *less* satisfied with life if they socialized with their friends more frequently. Among low-IQ individuals, the mean difference in life satisfaction between those who socialize with friends more and less frequently (0.423) translated to $d = .05$, and that among high-IQ individuals (−0.0248) to $d = -.03$.

Given that our data are correlational and frequency of socialization with friends and life satisfaction were measured at the same time, we cannot rule out an opposite causal order to what we hypothesize, where happier people choose to socialize with their friends more frequently. This may potentially be a problem because our measure of frequency of socialization with friends referred to recent past ('In the past 7 days'), while the measure of life satisfaction was global ('as a whole'). We are sure there are some mutual influences between life satisfaction and frequency of socialization with friends, but there are a few considerations, suggesting that the results largely reflect our hypothesized causality. For instance, Baker, Cahalin, Gerst, and Burr (2005) showed that the positive effect of seeing family and friends on subjective well-being remained even after controlling for the earlier level of life satisfaction in a previous wave of a longitudinal survey. Similarly, in our data, frequency of socialization with friends was still significantly associated with life satisfaction even after happiness at Waves I and II (measured by the question 'How often was each of the following things true during the past seven days? You were happy'. 0 = *never or rarely*, 1 = *sometimes*, 2 = *a lot of the time*, 3 = *most of the time or all of the time*), in addition to current marital status, was controlled ($b = .018$, $p = .016$).

Discussion

Consistent with our prediction derived from the savanna theory of happiness, and with past empirical studies, frequency of socialization with friends had a significantly positive association with life satisfaction among Add Health respondents, once current marital status, which acted as a suppressor, was controlled. The more frequently individuals socialized with their friends, the more satisfied they were with their lives.

Further, as predicted by the savanna theory of happiness, the association between socialization with friends and life satisfaction was significantly stronger among less intelligent individuals than among more intelligent individuals. Less intelligent individuals might have had greater difficulty comprehending and dealing with the evolutionary novelty of not associating with friends and allies regularly and become less satisfied with life as a result. In contrast, more intelligent individuals might have had less difficulty with not associating with friends and allies regularly and their life satisfaction might not have been affected as much. In fact, extremely (+1 SD) intelligent individuals even appeared to become *more* satisfied with life when their frequency of socialization with friends was *lower*.

Interestingly, Add Health respondents' intelligence was significantly *positively* associated with the frequency of socialization with friends ($r = .121$, $p < .001$, $n = 14{,}581$); more intelligent individuals socialized with their friends more frequently. The association between intelligence and frequency of socialization with friends was stronger among currently unmarried individuals ($r = .131$, $p < .001$, $n = 12{,}091$) than among currently married individuals ($r = .083$, $p < .001$, $n = 2{,}490$). It means that more intelligent individuals did *not* voluntarily decrease their frequency of socialization with friends, and less intelligent individuals did *not* voluntarily increase it, in order to take advantage of their respective levels of intelligence to increase their life satisfaction. As in Study 1A, we believe there are two potential (and non-mutually exclusive) reasons for this. First, individuals in general may not be (either consciously or unconsciously) aware of the divergent effect of socialization with friends on happiness by intelligence. Second, individuals may not have complete control over how frequently to socialize with their friends (or how many friends to have). Friendship is a two-way street, and friends must mutually seek each other to establish friendship and socialize together – something that may be increasingly difficult to do in transient modern environments. More intelligent individuals may simply have more friends to begin with.

Combined models

To investigate the independence of the effects observed above, we examined a model in which the two major predictors of life satisfaction in our study (population density and friendship) were simultaneously considered. The two variables very weakly correlated with each other in the Add Health data (correlation with frequency of socialization with friends: census block $r = .046, p < .001$; census tract $r = .050, p < .001$; county $r = .034$, $p < .001$; state $r = .021, p = .012$; $n = 14{,}839$ for all). As a result, the associations of these predictors with life satisfaction were statistically independent. Net of each other (and current marital status), population density at all levels, and frequency of socialization with friends were still statistically significantly associated with life satisfaction, and this did not change at all when we further controlled for age, sex, ethnicity, and education. When entered together in the same ordinal regression equations, the predicted interaction terms between each predictor and intelligence still remained statistically significant. It therefore appeared that population density and socialization with friends (and their interactions with intelligence) were statistically independent predictors of life satisfaction. There was no significant three-way interaction effect among intelligence, population density (measured at any level), and friendship.

GENERAL DISCUSSION

While positive psychologists in the last few decades have accumulated an impressive amount of empirical knowledge about who under what circumstances or in what conditions are happier than whom, there have been few general theories in positive psychology that explain *why* some individuals are happier than others (other than to point to genetic predisposition and the heritability of happiness). In this paper, we proposed *the savanna theory of happiness*, which suggests that it is not only the current consequences of a given situation but also its ancestral consequences that affect subjective well-being (Kanazawa & Li, 2015). That is, individuals' life satisfaction may fluctuate with what the situation *would have meant* in the ancestral environment. The savanna theory of happiness further suggests that such an effect of the ancestral consequences on life satisfaction may be greater among less intelligent individuals than among more intelligent individuals.

We chose two varied factors representing basic differences in the social landscape between modern and ancestral environments – population density and socialization with friends – as empirical test cases for the theory in this paper. Despite their widely varied nature, population density and socialization with friends had remarkably similar associations with life satisfaction among the Add Health respondents. Both factors had the anticipated main association: Population density, whether measured at the level of census block group, census tract, county or state, was significantly negatively associated with life satisfaction, and socialization with friends, once current marital status was controlled, was significantly positively associated with life satisfaction. More importantly, we observed the predicted statistical interaction with intelligence for both factors; in fact, in the case of socialization with friends, we observed the reversal of the main association among the extremely intelligent. More intelligent individuals actually experienced *higher* life satisfaction with *lower* frequency of contact with friends.

Our studies uniquely highlight three important determinants of individual differences in life satisfaction: population density, friendship, and intelligence. The importance of population density can potentially explain the 'urban–rural happiness gradient' (Berry & Okulicz-Kozaryn, 2011) observed in the United States and other nations, where ruralites are significantly happier than suburbanites, who are in turn significantly happier than urbanites. In our study, we treated population density as a continuous variable and showed that it was negatively associated with life satisfaction.

The importance of friendship in our analysis is consistent with a large number of previous studies on life satisfaction (Diener & Seligman, 2004, pp. 18–20; Dolan *et al.*, 2008, pp. 106–108). However, to the best of our knowledge, no one else has demonstrated the statistical interaction between socialization with friends and intelligence. Nor has anyone demonstrated that extremely intelligent individuals may be *less* satisfied with life if they socialized with their friends *more* frequently.

The current research adds to a growing body of literature indicating that the human brain may have difficulty with conditions that are mismatched to the natural environments of the ancestral past, when psychological mechanisms are hypothesized to have evolved (Tooby & Cosmides, 1990). Building on previous work on the evolutionary constraints on the human brain (Burnham & Johnson, 2005; Hagen & Hammerstein, 2006; Kanazawa, 2004b), our research extends the consequences of such cognitive limitations and mismatch from areas as diverse as relationship satisfaction (Russell, McNulty, Baker, & Meltzer, 2014), eating disorders (Li, Smith, Griskevicius, Cason, & Bryan, 2010), and leadership (van Vugt & Ronay, 2014) to affective states like happiness. Our results also show important interaction between such evolutionary limitations and general intelligence and suggest that more intelligent individuals might suffer from affective consequences of evolutionary limitations on the brain to a significantly lesser degree than less intelligent individuals might.

Further, our study is consistent with a large body of literature on life history theory (Charnov, 1993; Ellis, Figueredo, Brumbach, & Schlomer, 2009; Figueredo *et al.*, 2006), a framework rooted in the biological sciences that deals with how all organisms, including humans, assess the environment in order to allocate their time, energy, and resources optimally on survival and reproductive activities across the entire lifespan. In an ancestral environment, higher population densities and less interaction with friends may be indicative of high competition for scarce resources (Ellis *et al.*, 2009) and a dearth of coalitional support, respectively. As such, overall mood may be calibrated downward and life history strategy adjustments may be made accordingly. If individuals who are less generally intelligent are less capable of weathering disadvantageous conditions, they may experience greater shifts in life history strategy in conjunction with decrements in life satisfaction. Further research may benefit from an investigation of the role that life satisfaction plays in relation to life history strategies.

Limitations, implications, and future directions

Despite using a large, nationally representative sample with over 15,000 participants, a limitation of the current studies is that the data are correlational. Although we have considered and potentially ruled out some alternative explanations, we cannot be sure of any causal relationships until experiments are conducted. Accordingly, future research should attempt to manipulate the key factors and observe and measure the appropriate outcomes. Of course, it may not be feasible to manipulate where people live or the number of friends with whom they regularly socialize. Nevertheless, studies using modern media such as printed photographs, television, and computers briefly to present social and environmental stimuli have effectively induced people into believing that they are exposed to real-life individuals or certain environments (Gutierres, Kenrick, & Partch, 1999; Li *et al.*, 2010). Such methods may be adopted in order to manipulate exposure to rural versus urban environments (van der Wal, Schade, Krabbendam, & van Vugt, 2013), and larger versus smaller number of friends.

Aside from the alternative explanations that we tested within the studies, there may be other explanations for our findings. For instance, general intelligence might equip individuals to better handle all situations including high population densities and a lack of interactions with friends. Although plausible, other studies seem to suggest that this is not likely the case. General intelligence appears not to matter for solving evolutionarily familiar problems in domains spanning mating, parenting, interpersonal relationships, and wayfinding (Kanazawa, 2004a, 2010). Moreover, such an explanation does not simultaneously address why higher population density poses a problem requiring greater intelligence to rectify and why associating with friends is assumed to be desirable. Indeed, we know of no alternative explanation that can parsimoniously explain all our findings and address the ultimate causes of each issue. Nevertheless, the literature will benefit from a greater consideration and integration of proximate and ultimate explanations. We encourage researchers from different perspectives to construct and test alternative models.

Another potential limitation concerns the very small mean differences that are reported here. While the mean differences we report are small by the standards of experimental psychology, which relies on direct manipulations of independent variables in controlled experiments, their magnitudes are reasonable by the standards of survey research (see De Neve, Christakis, Fowler, and Frey (2012) for an example of a non-experimental study which uses the same dependent variable from the same survey data that we use here). Nevertheless, further studies are necessary to corroborate the pattern of findings reported here.

Far from being conclusive, our findings raise numerous questions for future research. For example, we do not know exactly what it is about denser populations that reduces happiness. Is it the density itself, or other evolutionarily novel factors closely associated with it, such as less access to greenery and nature (Kim *et al.*, 2010), greater interactions with strangers versus kin, friends, and acquaintances? Nor do we know exactly how more intelligent individuals are better able to handle the evolutionary novelty of urban life. Future research can explore specific factors to gain a better understanding of the mechanisms underlying the relationships between population density, intelligence, and happiness.

Likewise, (how) does modern technology change the nature and magnitude of the effect of friendships and socialization with friends? The only way our ancestors could interact and socialize with their friends and allies was face-to-face. Add Health only asks about 'hanging out' with friends in person or talking to them on the phone. Is talking to them via Skype or FaceTime the same as or better than talking to them on the phone? Do Facebook friends (and online interactions with them) count as socializing with them? Consistent with the Savanna Principle, there is some suggestion that humans have implicit difficulty distinguishing between real friends and characters they repeatedly see on TV because realistic electronic images of other humans did not exist in the ancestral environment (Derrick, Gabriel, & Hugenberg, 2009; Gardner & Knowles, 2008; Kanazawa, 2002). This seems to suggest that staying in touch on Skype and FaceTime is just as good as doing so in person and better than talking on the phone, but socializing on Facebook or with text messages has little effect. Indeed, Facebook use has been linked to depression (for a review and evolutionary explanations, see Blease, 2015; Pinker, 2014), which suggests that it is not an effective substitute for live encounters with friends. Investigating such distinctions in light of the present findings may have implications for public policy and policy-related research by suggesting how interventions can be designed to increase people's actual or perceived level of interaction with friends and thus life satisfaction.

Similarly, our research here can be tied together with work on environmental psychology to shed light on how spaces can be designed to reduce real or perceived population density. For instance, urban centres can be designed to diffuse large populations across wider areas. At the same time, given that many people spend a significant amount of time commuting to and from work on crowded trains, busses, or highways, it is possible that their perceptions of population density may be skewed upwards – and their life satisfaction downwards – by the high population density encountered during the commute. As such, increasing the number of trains and busses as well as shifting work schedules by an hour or two may be cost-effective methods of increasing life satisfaction.

Another potentially fruitful avenue to explore involves investigating people who are satisfied with life despite living in crowded cities or associating with friends infrequently. Aside from intelligence, there may be other traits, conditions, or behaviours that are effectively boosting their life satisfaction. One such candidate is the strength of one's family ties, which tends to be positively associated with life satisfaction (Schilling & Wahl, 2002) and negatively associated with depression (Hammen & Brennan, 2002). It may be the case that strong relations with family members can insulate individuals from the potential harms of evolutionary novelty regardless of intelligence.

Finally, ancestral environments differ from modern ones in many ways. For example, our ancestors tended to interact largely with kin and familiar others. In modern environments, people vary more widely on such interactions, with some individuals rarely interacting with kin and dealing largely with strangers. Investigating this and other key differences may yield interesting discoveries on what can impact life satisfaction. In addition to helping inform the larger body of research on subjective well-being, such work, and the avenues described above, may have implications for interventions aimed at improving well-being in the modern society.

Conclusion

The empirical evidence from the two studies presented above provide tentative support for the savanna theory of happiness, which explains why rural Americans tend to be happier than their urban counterparts, and why Americans who socialize with friends more frequently are happier. More importantly, the studies illustrate the value of incorporating evolutionary perspectives to the study of subjective well-being. The current paper adds to the growing body of knowledge on evolutionary mismatch theory indicating that many of the ills of modern society might owe themselves to the disparity between modern environments and the ancestral environments in which our brain evolved and to which it is adapted (Buss, 2000; Hill & Major, 2013). Such work cuts across all areas of psychology, including mating and relationships (Russell *et al.*, 2014), cooperation (Hagen & Hammerstein, 2006), clinical health (Li *et al.*, 2010), behavioural economics (van der Wal *et al.*, 2013), and industrial–organizational psychology (van Vugt & Ronay, 2014). In this rapidly growing area with far-reaching implications, the savanna theory of happiness provides a novel answer to the question of what makes individuals happier and why.

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