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Original Article

Towards the development of an evolutionarily valid domain-specific risk-taking scale

Daniel J. Kruger, School of Public Health, University of Michigan, Ann Arbor, USA. Email: djk2012@gmail.com (Corresponding author)

X.T. Wang, Department of Psychology, University of South Dakota, USA. Email: xt.wang@usd.edu

Andreas Wilke, Center for Behavior, Evolution and Culture, UCLA Department of Anthropology, USA. Email: wilke@ucla.edu

Abstract: From an evolutionary perspective, human risk-taking behaviors should be viewed in relation to evolutionarily recurrent survival and reproductive problems. In response to recent calls for domain-specific measures of risk-taking, we emphasize the need of evolutionarily valid domains. We report on two studies designed to validate a scale of risky behaviors in domains selected from research and theory in evolutionary psychology and biology, corresponding to reoccurring challenges in the ancestral environment. Behaviors were framed in situations which people would have some chance of encountering in modern times. We identify five domains of risk-taking: between-group competition, within-group competition, mating and resource allocation for mate attraction, environmental risks, and fertility risks.

Keywords: risk taking, individual differences, evolutionary domains, adaptation; domain-specificity.

Introduction

Recent evidence in personality psychology and behavioral decision-making has shifted the standard psychological assessment of risk taking, in which people were seen as generally risk seeking or risk averse, towards a notion that risk taking is actually domain-specific (e.g., Horvath and Zuckerman, 1993; Zuckerman and Kuhlman, 2000; Blais and Weber, 2001). This new perspective better accounts for inter- and intra-individual differences in risk propensity and allows the systematic exploration of differences between content domains (Hanoch, Johnson, and Wilke, 2006). Although researchers intended to bring content-specificity to behavioral decision-theory and create a psychometric measurement that accounts for such individual differences (see Weber, Blais, and Betz, 2002), they had no a priori theoretical reasons for the choice of their domains.

Evolutionary psychology stresses that the human mind is not a general-purpose computer but consists of a rich array of adaptations for solving evolutionarily recurrent

problems. These problems (or specific selection pressures) are what define a domain. Like physiological adaptations, psychological adaptations evolved to solve (only) problems in particular domains and are therefore not necessarily suited for solving problems in other domains—evolutionary psychology's tenet of domain-specificity (Cosmides and Tooby, 1994; Hagen, 2001). From this perspective, analogous risks in modern times would be perceived categorically and trigger specific mental algorithms designed to solve recurrent problems in the corresponding category or domain. In the following we provide the evolutionary basis for specific risk domains and for sex-differences in risk taking.

Developing evolutionarily valid domains

Risk-taking domains and tendencies should reflect the different types of challenges that humans faced during our evolutionary history. Therefore, we assume that risks can be viewed as variations in payoff distributions in specific domains of adaptation. We used this evolutionary viewpoint to select appropriate domains for the construction of a domain-specific risk-taking scale. Such a new risk scale could then be applied in contexts where a functional perspective to human risk-taking is of key importance (e.g. investigating the signaling functions of risk-taking in mate choice). We created a pool of questionnaire items corresponding to our hypothesized domains so we could verify our predictions with factor analysis. We hypothesized five domains based on the literature of evolutionary psychology and biology: Between-group competition, within-group competition, resource allocation for costly signaling and mate attraction, mating, and environmental risks. We consider the situational contexts and behavioral responses for these domains to be qualitatively different.

Between-group competition

At some point during hominid evolution, our ancestors achieved ecological dominance over other species and thus other humans became the principal and greatest hostile force (Alexander, 1979). Territorial boundary patrols and inter-group raids have been observed in common chimpanzees, one of the two chimpanzee species that comprise our closest living non-human relatives (e.g., Goodall, 1990). Some believe that inter-group (as well as intra-group) competition was the greatest selection pressure in recent human evolution (e.g., Alexander, 1979). Examples of inter-group competition and conflict are easy to identify in our modern world, from warfare to gang violence to professional sports (for a review of evolutionary accounts of inter-group conflict, see van der Dennen, 2002). Within-group cooperation serves to facilitate inter-group competition (Bowles, 2006). Indeed, in-group-out-group bias has been extensively documented and analyzed by the social sciences (Ruffle and Sosis, 2006). For example, among New Guinea natives in egalitarian tribes, individuals playing economic games would take a higher cost to punish defectors from other tribes than defectors from their own tribe (Bernhard, Fischbacher, and Fehr, 2006). Modern Israeli kibbutz members were more cooperative toward anonymous kibbutz members than they were toward anonymous city residents (Ruffle and Sosis, 2006). Out-group members may be seen to pose a physical threat not only to oneself, but also to

one's kin and allies.

Within-group competition

In contrast to between-group competition, where the goal is to reduce or eliminate the threat of possibly fatal violence from those outside one's social group, the goal of within-group competition is to better one's position or rank within one's social group. Although within-group challenges could involve the threat of physical violence, a clear distinction would be understood. For example, in pre-industrial nomadic Asian peoples, wooden clubs were used for intra-group fighting, whereas metal weapons were reserved for inter-group warfare (American Museum of Natural History, 2007). The former were less likely to result in fatalities, which could be disadvantageous when conflicts arose with other groups. Within-group competition is more complex than between group competition. Although within-group competition includes physical fighting, it would also involve other forms of social competition. In fact, dominant individuals may be motivated to keep peace within the group, as a strong alliance would buttress against external threats.

Competition for social status occurs in both men and women, but may be especially relevant to men because social status is more closely related to male mate value across-cultures (e.g., Buss, 1994; Kenrick and Simpson, 1997; Wiederman and Allgeier, 1992). Men with more social power may have greater mating success both because they can coerce other men and because women may seek men with sufficient power to defend them and their offspring (Betzig, 1986; Hill and Hurtado 1996). In ancestral times, men who controlled more resources married younger women, married more women, and produced offspring earlier (Low, 1998). Even in relatively egalitarian foraging societies there is some differentiation of status, and men with higher status have increased access to mates (Chagnon 1992; Hill and Hurtado 1996). Social status has also affected reproductive success in recent centuries (Betzig, 1986) and various measures of male status show a positive relationship to reproductive success across a wide variety of societies (for a summary, see Hopcroft, 2006). Position in the social hierarchy is also related to biased outcome in conflict resolution, with the disproportionately more valuable compensation generally awarded according to status (Betzig, 1986). Of course, the competition for higher social status itself is sometimes fatal (Betzig, 1986; Kaplan and Hill, 1985).

Resource allocation for costly signaling and mate attraction

Darwin (1871) noted that costly traits such as peacock tails could not be accounted for by survival advantage, but rather by reproductive advantage. In humans, displays of wealth may literally be a costly signal analogue to the peacock's tail. Reproductive effort includes both mating effort and parental effort, which are considered to be inversely related. Mating effort is a broad category of physiological investment and behavior that includes direct competition with conspecifics as well as indirect competition for assets and attributes that make one attractive as a mating partner. One can also distinguish between competition for assets and competition through the display of assets. The former is more closely related to within-group competition, whereas the latter involves trade-offs in

investment allocation. Acquiring and displaying costly assets necessarily involves trade-offs with other possible forms of investment.

Although the most valuable asset owned by many in modern nations is one's home, this is not conducive to portable displays of status facilitating mate attraction. Home ownership may be more accurately considered a form of parental investment, as it provides a stable environment for offspring. Luxury cars, designer clothing, and expensive jewelry are more likely to be used to advertise economic power in one's broader community. Popular culture recently generated the term "bling" to refer to financially costly displays, as well as a lifestyle of excess spending and ostentation. We expect to see individual variation in tendencies to save/invest economic resources versus purchasing luxury goods to confer social status and mating advantage. We also expect to see sex differences, as economic power is also more strongly related to male mate value than female mate value across cultures (e.g., Buss, 1994; Kenrick and Simpson, 1997; Wiederman and Allgeier, 1992).

Mating risks

Sociosexuality is defined as an individual's perception of the requirements in terms of time, attachment, and commitment for having a sexual relationship (Gangestad and Simpson, 2000). There is individual variation in sociosexuality; those with unrestrictive sociosexuality allocate relatively more resources to mating effort at the expense of paternal effort. It is easy to see why male reproductive success would benefit from an increased number of sexual partners (in the absence of contraception). There are individual differences in male mating effort (Rowe, Vazsonyi, and Figueredo, 1997) and evidence that some males specialize in a short term mating strategy, seeking to mate with a large number of partners (e.g., Belsky, Steinberg, and Draper, 1991). Although women have serial pregnancies and thus do not benefit proportionally to the number of partners as would men, women do occasionally undertake short-term relationships with men (see Mealey, 2000). A small but substantial proportion of children have genetic fathers different from their putative fathers, according to DNA analyses (Anderson, 2006; Baker and Bellis, 1995). Evolutionary explanations for why women would have promiscuous or extra-pair sexual relationships include obtaining genes for offspring from males with high quality phenotypes in the present environment (Fisher, 1930) and confusing paternity to prevent harm to or elicit support for offspring (Hrdy, 1981).

Extra-pair sexual relationships carry the risk of partner desertion and sexually transmitted infection. Moreover, the consequences could also be much more drastic. Jealous partners may become violent, with sometimes fatal consequences for the cheating partner or third party (Buss, 2005; Wilson and Daly, 1998). Violent consequences in mating competition are also not limited to incidences of cheating, they also occur prior to the establishment of relationships (Daly and Wilson, 1988; Chagnon, 1996). We distinguish mating risks, which involve interpersonal behavior, from costly signaling for mate attraction, which involves the allocation of material resources.

Environmental risks

The risk domains described above generally involve social risks and resource allocation. In contrast to these there were also considerable ancestral adaptive challenges from the natural environment. Environmental risks, possibly the most ancient domain included in our set, stems from our ancestral history of foraging, hunting, and avoiding/escaping predators. Modern foraging peoples face substantial mortality risks from predators, accidents, and parasites (e.g., Hill and Hurtado, 1996). Exploring or migrating into unknown areas in search of food, shelter, or better climate was likely a common theme given the primate and later hominid expansions across continents (Hoffecker, 2002; Templeton, 2002). Previous studies have shown that foraging strategies are sensitive and contingent on both survival requirement (e.g., somatic energy budget) and environmental variations in expected foraging outcomes (e.g., Kacelnik and Bateson, 1996; Stephens and Krebs, 1986). It is conceivable that a forager who is too risk-seeking may die in completion whereas a forager who is too risk-averse may die of starvation. Thus, we predict individual variations in foraging risk strategies.

Fertility risks as a comparison domain

The ultimate goal of evolution is not survival but reproduction. We developed a domain that involves tradeoffs between resources and reproduction. We included behaviors which entailed a direct risk to fertility and should thus create a contrast to the behaviors in the other domains. These behaviors are an evolutionarily novel and modern knowledge-based form of risk to reproductive success. Items were often framed as tradeoffs of financial reward with a risk of producing infertility. We expect these behaviors to be rated the least likely to occur and, as a group, to have the least amount of correspondence to likelihood of risky behaviors in other domains.

Sex differences in risk propensity

Darwin stated that competition for women was the primary cause of both between- and within-group mortality in non-industrial societies (1871). Gardner (1993, p. 67) noted that young adult males form the front ranks of every nation's military, and "lacking the opportunity for warfare, some [young adult men] will find other ways to place their lives at risk." Because females in most species invest more in offspring than males, males vie for reproductive access to females through intra-sexual competition and inter-sexual attraction (Bateman, 1948; Darwin, 1871; Trivers 1972). Higher levels of mating effort and lower levels of parental investment should correspond with riskier behavioral strategies (see Low, 2000). The risky behavioral strategies of young males were selected for because they tended to promote social status and resource control as well as mating competition, ultimately enhancing reproductive success (Wilson and Daly, 1992; Wilke, Hutchinson, Todd, and Kruger, 2006).

Humans are far less polygynous than most other primates, but the variation in male reproductive success is still substantially higher than that for females. Young males who do

not have substantial resources or status may be unable to establish enduring partnerships and a few males gain a disproportionately high number of matings, creating a positively skewed distribution of male reproductive success that makes mating competition a potent selection force (Betzig 1986). In humans, the power of sexual selection is demonstrated by mortality rates that are higher for males than females across the lifespan, with a peak difference around sexual maturity (Kruger and Nesse, 2004).

Territorial patrols in chimpanzees are a male activity (Goodall, 1990), and we also expect to see higher likelihoods of between-group competition for male than female participants. Within-group competition, resource allocation for costly signaling and mate attraction, and promiscuity also carry greater potential benefits for males than for females. We expect to see greater likelihoods for male risk taking across domains (see Byrnes, Miller, and Schafer, 1999), although we do not make this prediction for fertility risks because taking these risks would not benefit reproductive success for either sex. We still expect to see variation in the risk taking likelihood ratings of male participants, as women also evaluate potential mates on tendencies to share resources and to be good fathers (see Wilke et al. 2006). Trade-offs among traits and risk taking tendencies will limit selection for ever more risky behavioral strategies.

We developed five items for each hypothesized domain. We aspired to create behavioral items that fulfill 4 important criteria: 1.) Behaviors are related to domains in the ancestral environment that impact on reproductive success; 2.) Behaviors are qualitatively similar to likely actions in the ancestral environment; 3.) Behaviors are potentially beneficial but also potentially (or actually) costly to reproductive success, and thus risky; 4.) Behaviors would reasonably occur with substantial frequency in the modern environment, so that at least some portion of participants would encounter a similar situation during their lifetime. The behavioral items for the comparison condition of fertility risks do not fulfill criteria 1 and 2, and only barely fulfill the criteria for 3 and 4.

Study 1

Methods

A total of 693 participants from the University of South Dakota (USD; 316 females, 132 males, *M* age = 21, *SD* age = 4) and the University of Michigan (UM; 131 females, 114 males, *M* age = 19, *SD* age = 2) responded to an online questionnaire. Participants received course credit for their participation in the study. Participants rated each of 30 risky behaviors for the likelihood with which they would engage in each behavior or activity. Responses were given on a 5-point bipolar scale from 1 (very unlikely) to 5 (very likely) with the scale midpoint 3 being neutral. We used the HC-Holm procedure (Toothaker, 1993) to hold the family-wise error rate (ERFW) at .05 for evaluating sex differences in scores across domains.

Results

Before we conducted our main analyses, we tested whether the sample

demographics and the questionnaire responses significantly differed between the USD and the UM samples. Separately for males and females, we ran *t*-tests on all five domains with sample as a grouping variable. Neither the compared means nor Levene's test for the equality of variances indicated any significant differences. Thus, participants from the two samples were combined and analyzed together.

Exploratory principal component analysis with promax rotation examined whether our a priori classification of five evolutionary domains was supported. With the goal of creating a reliable and valid risk scale, we aimed at selecting only those items within each domain that provided the best factorial structure for our empirical data. The best interpretation was reached with a five-factor model containing 3 items in each domain and explained 55% of the variance. Other factorial solutions that focused only on one common factor (as domain-general approaches to risk taking would imply) did not go beyond 20% of explained variance. In the case of two or three factors, the item loadings were not conceptually interpretable. Items generally loaded on the expected domains, however items for resource allocation and mating loaded on a single factor, which we named "mating and resource allocation for mate attraction."

Table 1 shows our selection of 15 questionnaire items and their corresponding factor loadings. Our results show that the fertility and between-group competition domains accounted for the most variance (20.07 and 13.92%) and the environmental domain for the least (6.37%). As predicted, the two competition domains indeed loaded on two separate factors, that is, between-group and within-group competition.

Table 2 shows means and standard deviations of risk behavior separately for male and female respondents and for each of the five domains. In all domains, men were significantly more risk taking than women. On average, both males and females were most likely to take risks in the within-group competition domain (*M* = 3.68 and *M* = 3.51, respectively) and in the environmental domain (*M* = 3.29 and *M* = 2.96, respectively). In contrast, both males and females were least likely to take risks in the fertility domain (*M* = 1.90 and *M* = 1.57, respectively). Encouraged by these results, we attempted to replicate the factor structure with a new sample of participants.

Table 1. Factor loading of 15 items of the evolutionary domain risk behavior scale

Domain and questionnaire items	Factor				
	1	2	3	4	5
Fertility					
Getting sterilized so you cannot have children but have more leisure time and more financial flexibility	**0.83**	− 0.02	0.06	− 0.02	0.07
Exposing yourself to chemicals that might lead to birth defects for a high-paying job	**0.73**	0.03	− 0.02	0.07	0.05
Participating in medical research that pays $10,000 but has some chance of making you sterile	**0.80**	− 0.10	0.04	0.04	0.01
Between-group competition					
Adamantly defending the honor of your local team against a fan from a different sporting team even if it might cause a fight	− 0.08	**0.66**	0.15	0.15	0.04
Sitting in the section for fans of the opposing team with a group of friends while wearing your team's colors	− 0.05	**0.74**	0.05	− 0.07	0.05
Driving to a rival university at night and stealing the school's flag from the flagpole at the center of campus	0.04	**0.75**	−0.12	0.10	0.03
Within-group competition					
Standing up to your boss in front of coworkers when your boss is being unfair	0.14	0.01	**0.68**	0.06	0.06
Trying to take a leadership role in any peer group you join	− 0.03	0.00	**0.80**	0.10	− 0.12
Physically intervening between two friends who are aggressively pushing each other, to prevent a fight	− 0.04	0.30	**0.39**	− 0.16	0.10
Mating and resource allocation for mate attraction					
Spending a large portion of your salary to buy a sporty new convertible	0.04	0.15	0.28	**0.53**	0.09
Engaging in unprotected sex during a one-night stand	0.12	0.08	− 0.08	**0.73**	0.13
Maintaining long-term romantic relationships with more than one partner	0.06	0.12	− 0.15	**0.71**	− 0.03
Environmental risks					
Chasing a bear out of your wilderness campsite area while banging pots and pans	0.34	0.19	0.03	− 0.17	**0.48**
Swimming far out from shore to reach a diving platform	0.07	0.13	− 0.17	0.01	**0.79**
Exploring an unknown city or section of town	− 0.15	− 0.23	0.31	0.14	**0.66**

Note. Bold font indicates highest loading matches intended domain.

Table 2. Means (*M*) and standard deviations (*SD*) of the evolutionary risk behavior scale by sex

	Study 1 *N*=693		Study 2 *N*=479	
	Males (*n*=246)	Females (*n*=447)	Males (*n*=238)	Females (*n*=241)
Domain	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Fertility	1.90 (0.84)	1.57 (0.71)	1.57 (0.77)	1.51 (0.74)
Between-group competition	2.80 (0.94)	2.49 (0.91)	3.13 (0.93)	2.92 (0.98)
Within-group competition	3.68 (0.70)	3.51 (0.72)	3.74 (0.64)	3.67 (0.66)
Mating and resource allocation for mate attraction	2.22 (0.83)	1.89 (0.69)	2.24 (0.84)	2.08 (0.78)
Environmental risks	3.29 (0.79)	2.96 (0.77)	3.25 (0.82)	3.15 (0.86)

Note. Male and female means are significantly different except for Environmental risks in Study 2, *ERFW* < .05 within studies.

Study 2

Methods

Ethnically diverse (60% indicated some non-Western European ancestry) students (*N* = 497; female = 238, *M* age = 18.92, *SD* age = 1.42) at the University of Michigan participated to fulfill a course requirement. Participants completed the same online survey instrument. We used the HC-Holm procedure (Toothaker, 1993) to hold the family-wise error rate (ERFW) at .05 for evaluating sex differences in scores across domains and comparing scores on fertility risks to other domains.

Results

The five factor model had a good fit to the data according to the goodness of fit indicators: $\chi^2(80)$ = 174.24, GFI = .95, RSMEA = 0.050, SRMR = 0.054, CN = 327. The five factor model had a much better fit than a one factor model of general risk-taking, $\Delta\chi^2(10)$ = 723.17, *p* < .001. Modification indices suggested that 11 items may load on multiple factors; but each had the highest loading on the factor consistent with our prediction, except one item. "Exploring an unknown city or section of town" was estimated to have an item-factor correlation of .51 with within-group competition and .47 with environmental risks. The five factor model had a better fit than four factor models that combined between-group competition and within-group status $\Delta\chi^2(4)$ = 31.5, *p* < .001, within-group status and survival, $\Delta\chi^2(4)$ = 100.89, *p* < .001, between-group competition and environmental, $\Delta\chi^2(4)$ = 36.96, *p* < .001, and fertility risks and mating and resource allocation for mate attraction $\Delta\chi^2(4)$ = 52.26, *p* < .001. These pairs of factors had the largest intercorrelations, ranging from .46 to .73 (see Table 3). As expected, men scored higher on within-group status, between-group competition, and mating and resource allocation for mate attraction. There were no significant differences by sex for environmental risks. Men

also scored higher on fertility risks. As predicted, the estimated likelihood of behaviors inducing fertility risks was lower than those in all other domains.

Table 3. Correlations among factor scores in Study 2

	1	2	3	4
1. Fertility				
2. Between-group competition	.12*			
3. Within-group competition	-.39***	.46***		
4. Mating and resource allocation for mate attraction	.67***	.40***	.05	
5. Environmental risks	.04	.62***	.73***	.20*

Note. * indicates $p < .05$, *** indicates $p < .001$.

Discussion

Risk-taking domains and tendencies should reflect recurrent survival and reproductive challenges that humans faced during our evolutionary history. Our analyses confirmed separate domains of risk taking which generally follow our theoretical predictions. It is notable that we were able to generate behaviors and situations corresponding with these domains that are also likely to occur in our modern society. We argue that these actions are qualitatively similar to actions which if successful, would have conferred reproductive advantage in human ancestral environments. These actions would also carry risks, not only of failure to achieve the desired goal, but also threats to health and survival.

We were able to distinguish between-group competition from within-group competition. Although 21% of the variance was shared between these domains, the model predicting interrelated but separate domains fit the data better. In our ancestral environment, the former was probably more limited in scope, consisting mostly of physical fighting and intimidation. Within-group competition is more complex. Although this includes physical fighting, it also encompasses a broader range of interpersonal skills. Common chimpanzee males can maintain high social status and reproductive access past their physical prime by cultivating alliances with other males (deWaal, 2005). Interactions with in-group members were also more likely to include cooperation than with out-group members, as members of groups cooperate to facilitate competition with other groups (Alexander, 1979; Bowles, 2006). We note that items related to mating effort clustered together, regardless of whether they involved resource allocation for mate attraction or decisions in interpersonal relationships.

As predicted, the estimated likelihood of behaviors inducing fertility risks was lower than those in all other domains in both studies. Correspondence between fertility risks and other domains was lower for all combinations except for the relationship with mating and resource allocation for mate attraction. Although fertility risks were not as

likely as mating risks, there appears to be some commonality among items involving sexual and reproductive risks. Perhaps respondents considered the risk of a sexually transmitted disease in promiscuous behaviors, and this was considered along with threats to fertility as threats to reproductive health.

Consistent with the risk-taking literature (e.g. Byrnes et al., 1999), men reported greater likelihood of risky behaviors across all domains except for environmental risks in Study 2. Despite the general trend of riskier behaviors in men, there may be specific risky behaviors that are more likely to be exemplified by women. For example, women may be more likely to risk their lives to save an infant because they typically have greater investment in offspring and fewer opportunities for potential future offspring than men of a similar age.

The current risk scale contains only 3 items per domain and is therefore a first step toward the validation of an evolutionary domain-specific risk scale. Future studies will attempt to increase the number of items for each of the pre-existing domains. For instance, the environmental domain could be expanded to include risks associated with tasting novel food items or collecting edibles. It may also be possible to identify additional distinct domains.

Our understanding of tendencies for risky behaviors across domains would also benefit from studies that sample representative cross-sections of the population. Perceived likelihood of certain forms of risk taking may be higher for traditionally aged college students than for older persons. Men's testosterone levels decrease following marriage (Mazur and Michalek, 1998), concurrent with the notion of a strategy shift in the allocation of effort from mating to parenting and hence less-risky, longer-term strategies. Those experiencing more adverse conditions, especially males, may develop riskier behavioral strategies in response, as reflected in patterns of mortality rates by sex and socio-economic background (Kruger and Nesse, 2006).

Our research shows that individuals who exhibit high likelihood of risk-taking behavior in one risk domain can exhibit moderate or low likelihood of risk taking in other risk domains, suggesting that risk analysis should pay heed to heterogeneity of risk profiles of individual decision makers. Our results also offer implications for risk communication. Given the domain-specificity of risk perception and propensity, the same risk problem can presented and perceived in difference domains and thus resulted in different risk preferences. Future research would benefit from recognizing the various types of risk taking, corresponding to challenges in the human ancestral environment. This study also provided additional support for the domain specificity of cognitive architecture, that the human mind is a set of functional adaptations to specific challenges rather than a general information processor.

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