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Abstract

Diversification of resources is a strategy found everywhere from the level of microorganisms to that of giant Wall Street investment firms. We examine the functional nature of diversification using life-history theory—a framework for understanding how organisms navigate resource-allocation trade-offs. This framework suggests that diversification may be adaptive or maladaptive depending on one's life-history strategy and that these differences should be observed under conditions of threat. In three studies, we found that cues of mortality threat interact with one index of life-history strategy, childhood socioeconomic status (SES), to affect diversification. Among those from low-SES backgrounds, mortality threat increased preferences for diversification. However, among those from high-SES backgrounds, mortality threat had the opposite effect, inclining people to put all their eggs in one basket. The same interaction pattern emerged with a potential biomarker of life-history strategy, oxidative stress. These findings highlight when, and for whom, different diversification strategies can be advantageous.

Keywords

evolutionary psychology, socioeconomic status

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A typical Walmart store is 42,000 square feet, almost as large as a football field. Within that space one can find a large diversity of products ranging from Apple iPads to Ziploc freezer bags (including, but not limited to, blueberries, blue jeans, bibs, cribs, treadmills, washing machines, and Starbucks coffee). By contrast, a typical Apple store is many times smaller and contains only a tiny fraction of the products found in Walmart, ranging from Apple iPads to Apple iPods (and a few accessories). The Walmart and Apple approaches represent different business models, but the question of how much to diversify goes beyond retailing to touch on many aspects of life. From planting crops and buying stocks to dating and raising children, individuals often face a choice between diversifying their resources across many options or funneling those resources into a more limited set of options.

In the research reported here, we examined the functional nature of diversification through the lens of

life-history theory, a framework developed to understand how organisms allocate resources across the life span (Kaplan & Gangestad, 2005; Roff, 2002; Stearns, 1992). This framework has garnered empirical support in the study of animal behavior (Ellis, Figueredo, Brumbach, & Schlomer, 2009) and has made important contributions to research on human behavioral ecology and child development (e.g., Belsky, Steinberg, & Draper, 1991; Del Giudice, 2009). Importantly for the current investigation, life-history theory suggests that diversification may be adaptive or maladaptive depending on environmental circumstances and individual differences in life-history strategy. In four studies, we used the life-history framework to

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derive and test novel predictions about who chooses to diversify or put their eggs in one basket, and when.

Life-History Theory: Fast and Slow Strategies

According to life-history theory, all organisms—including humans—face fundamental trade-offs in the allocation of limited resources to growth, maintenance, and reproduction across the life span. Because the “best” allocation strategy can vary as a function of the local ecology (Crawford & Anderson, 1989), individuals vary in how they navigate these trade-offs—referred to as variability in their life-history strategy. Researchers commonly describe life-history strategies as varying along a single “fast” to “slow” continuum (Bielby et al., 2007; Ellis et al., 2009; Figueredo et al., 2005; Griskevicius et al., 2013). In general, faster strategies are associated with more rapid physiological and sexual development, resulting in more offspring, and reduced parental investment in each offspring. Conversely, slower strategies are associated with slower physiological and sexual development, resulting in fewer offspring, and greater parental investment in each offspring.

Individuals’ life-history strategies are calibrated in part on the basis of early-life experiences (Belsky et al., 1991; Kuzawa, McDade, Adair, & Lee, 2010). Early-life environments characterized by high levels of unpredictability and harshness lead people to enact faster strategies by speeding up the timing of physiological development and sexual maturation (Belsky, Houts, & Fearon, 2010; Ellis, 2004; Wilson & Daly, 1997). Fast strategies make sense in harsh and unpredictable ecologies because the future is uncertain and individuals may not live long enough to reproduce if they delay. Conversely, when external causes of mortality can be managed, slower strategies associated with delaying reproduction and investing in future outcomes become advantageous (Ellis et al., 2009).

Although early-life experience can shunt individuals down different life-history trajectories, research suggests that early-life experience may also sensitize contingent expression of different life-history strategies. Sensitization models propose that early-life experiences may program individuals to respond in different ways to adversity encountered later in life (Griskevicius, Delton, et al., 2011; Griskevicius et al., 2013). Studies have found that people’s responses to perceived mortality dangers diverge as a function of their childhood socioeconomic status (SES), a modern marker of early-life environmental harshness (Belsky, Schlomer, & Ellis, 2011; Simpson, Griskevicius, Kuo, Sung, & Collins, 2012). Whereas low-SES early-life environments are associated with a higher

degree of harshness and sensitize faster life-history strategies, high-SES early-life environments are associated with a lower degree of harshness and sensitize slower strategies.

People raised in lower-SES environments respond to mortality threats by becoming more impulsive, engaging in more risk-seeking behavior, and wanting to start a family sooner—a pattern consistent with a faster life-history strategy (Griskevicius, Delton, Robertson, & Tybur, 2011; Griskevicius, Tybur, Delton, & Robertson, 2011). In contrast, people raised in higher-SES environments respond to mortality threats by becoming less impulsive and more risk averse and wanting to delay starting a family—a pattern consistent with a slower life-history strategy. These patterns were found to be contingent on childhood SES rather than current SES, which suggests that early-life environments sensitize life-history strategies. Notably, developmental experiences had relatively little effect on adult behavior in benign situations. Only when facing current harsh and unpredictable conditions did individuals express divergent responses based on childhood SES.

Managing Risk Through Conservative and Diversified Bet Hedging

Organisms facing adverse conditions often adopt bet-hedging strategies to shield against total reproductive failure. Bet hedging involves trading off arithmetic mean fitness for diminished variance in fitness, which reduces an organism’s fitness under average conditions but makes the organism better suited to a wider range of conditions (e.g., Philippi & Seger, 1989). Bet hedging is useful in managing risk and uncertainty because it prepares organisms to better cope with a range of adverse conditions.

There are two fundamentally different forms of bet hedging—diversified and conservative. Life-history researchers have argued that each form of bet hedging corresponds to a specific life-history strategy (e.g., Ellis et al., 2009). Fast strategists are believed to rely on diversified bet hedging, which involves managing risk by increasing variation and spreading the risk. For example, producing more offspring increases phenotypic variation among the offspring (Simons, 2007), thereby increasing the probability that at least one offspring will survive and succeed in adverse conditions. Like fast life-history strategies, this type of bet-hedging strategy is adaptive in harsh and unpredictable ecologies, such as those characterized by high extrinsic mortality, in which it is not possible to prepare for or control environmental dangers.

By contrast, “conservative bet-hedging corresponds to pursuing a relatively slow life history strategy” (Ellis et al., 2009, pp. 229–230). This type of bet hedging entails

managing risk by investing more in a smaller number of options. For example, producing fewer offspring but investing more in each one increases the probability that each offspring will be well-equipped to handle a range of conditions and be in position to outcompete rivals (Ellis et al., 2009). Like slow life-history strategies, this type of bet-hedging strategy is adaptive in harsh ecologies, such as those characterized by scarce resources and high levels of competition, in which it is important to be appropriately prepared to manage difficulties and successfully compete for scarce resources.

The proposed relationship between fast and slow life-history strategies and diversified and conservative bet hedging has garnered some empirical support. Modeling studies have suggested that under conditions of unpredictability, individuals with shorter life spans, indicative of a faster life history, produce more variable offspring than those with longer life spans do (Olofsson, Ripa, & Jonzen, 2009). Furthermore, a comparative analysis of 25 species of marine invertebrates found that species with reduced parental investment, characteristic of organisms with faster life-history strategies, had more variability among offspring than did species with greater parental investment (Marshall, Bonduriansky, & Bussiere, 2008).

Bet-hedging strategies can be applied to many types of resource-allocation decisions (Goland, 1993; Mace, 1990). For example, herders in East Africa facing the uncertainty of drought must decide whether to invest in a smaller quantity of large-stock animals (camels) or a larger quantity of small-stock animals (goats and sheep). Investing in small-stock animals reflects a diversified bet-hedging strategy: Although goats and sheep are more susceptible to drought, they require less investment and have higher reproductive rates. By contrast, investing in large-stock animals reflects a conservative bet-hedging strategy: Although camels require high investment, they are resistant to drought. Mirroring the results of research on life-history strategies, whether pastoralists adopt a high-diversification strategy or a low-diversification strategy depends on their wealth (Mace, 1990). Poorer households adopt a high-diversification strategy by investing in many small animals, whereas wealthier households adopt a low-diversification strategy by investing in a few large animals.

Similar types of bet-hedging strategies are also witnessed among entrepreneurs, who use different strategies to manage the possibility of total business failure. One strategy involves investing all of one's time and resources into one business and making it the best that it can be. This strategy reflects conservative bet hedging because it reduces the probability of failure by increasing the likelihood that the business will survive regardless of future environmental circumstances (e.g., a recession). A different strategy involves spreading one's time and

resources among multiple businesses. This strategy reflects diversified bet hedging because it reduces the probability of total failure by increasing the likelihood that at least one business will survive regardless of environmental conditions.

Overview

In our investigation, we explored how adversity cues, in conjunction with individual life-history strategies, influence diversification across a range of domains, from consumer products and financial investments to agricultural resource allocation. Integrating research on the contingent expression of life-history strategies with theories of bet hedging, we predicted that mortality cues would lead people from low- and high-SES backgrounds to adopt different bet-hedging strategies. Those from low-SES backgrounds should respond by increasing diversification—in accordance with a faster life-history strategy and diversified bet hedging. Conversely, those from high-SES childhoods should respond by decreasing diversification—in accordance with a slower strategy and conservative bet hedging.

Study 1

Study 1 was a correlational study that tested the natural relationships among perceived mortality threat, SES, and preferences for diversification.

Method

Participants. One hundred ninety-four participants (118 females, 76 males; mean age = 36.1 years) completed a survey on attitudes and perceptions. Participants were recruited from Amazon's Mechanical Turk Web site and received monetary compensation in return for their participation.

Procedure. Participants first responded to questions about preferences for variety and diversification and then to items measuring SES and perceptions of mortality threat. To assess preferences for diversification, we used four questions from the Exploratory Acquisition of Products scale (Baumgartner & Steenkamp, 1996), which measures people's attitudes toward variety and diversity (example item: "I enjoy taking chances in buying unfamiliar brands to get some variety in my purchases"). Participants rated their agreement with each statement using 7-point scales from *strongly disagree* (1) to *strongly agree* (7). Responses were averaged into a diversification composite, $\alpha = .72$.

Following Griskevicius, Delton, et al. (2011; Griskevicius, Tybur, et al., 2011), we then had participant

rate their agreement with four statements concerning subjective childhood SES (e.g., “I felt relatively wealthy compared to the other kids in my school”) and two statements concerning subjective current SES (e.g., “I have enough money to buy things I want”) using 7-point scales from *strongly disagree* (1) to *strongly agree* (7). Past research has found that these questions reflect two distinct but correlated factors. Responses were averaged to create a childhood-SES composite ($\alpha = .85$) and a current-SES composite ($\alpha = .80$), which were moderately correlated, $r(194) = .28$.

To measure perceived mortality threat, we asked participants three questions about their current perceptions of the unpredictability of crime: (a) “How predictable is crime in the U.S. these days?”; (b) “How predictable is crime in your state these days?”; and (c) “How predictable is crime in your local community these days?” Participants responded using 7-point scales from *extremely predictable* (1) to *extremely unpredictable* (7). Responses were averaged to create a mortality-threat composite, $\alpha = .91$.

Results and discussion

A regression predicting diversification-composite scores from perceptions of mortality threat, childhood SES, and their interaction showed a significant Mortality Threat \times Childhood SES interaction, $t(194) = 3.48$, $p < .001$, $\beta = -0.13$. Following Aiken and West (1991), we probed the interaction by examining the relationship between perceptions of mortality threat and preferences for diversification at 1 standard deviation above and below the mean of childhood SES. For people from low-SES backgrounds ($-1 SD$), as perceptions of mortality threat increased, preferences for diversification increased, $t(194) = 2.11$, $p = .037$, $\beta = 0.15$. However, for people from high-SES backgrounds ($+1 SD$), as perceptions of mortality threat increased, preferences for diversification decreased, $t(194) = 2.67$, $p = .008$, $\beta = -0.23$. Thus, whereas lower-SES individuals who felt threatened preferred more diversification, in accordance with a faster life-history strategy and diversified bet hedging, high-SES individuals who felt threatened preferred less diversification, in accordance with a slower strategy and conservative bet hedging.

Past research has demonstrated that mortality threat interacts with childhood SES, but not with current SES, to influence behaviors related to life-history strategy. To test this possibility using our own data, we performed a regression predicting diversification-composite scores from perceptions of mortality threat, current SES, and their interaction. This analysis revealed no Mortality Threat \times Current SES interaction, $p > .6$. In addition, the Mortality Threat \times Childhood SES interaction reported

earlier remained significant even when controlling for current SES, $p < .001$.

Study 2

In subsequent studies, we experimentally manipulated mortality threat. In Study 2, we also sought to replicate and extend the findings of Study 1 by using a different measure of diversity: preferences for more or less diversified product bundles. In addition, to ensure the robustness of the SES findings, we used a different measure of SES in Study 2: family income. Past research has documented that subjective and objective measures of SES similarly influence a range of psychological outcomes (e.g., Kraus, Piff, & Keltner, 2009).

Method

Participants. One hundred sixty-one participants (90 females, 71 males; mean age = 33.3 years) were recruited from Amazon’s Mechanical Turk Web Site.

Procedure. Participants were told that they would read a short news article and later be given a memory test. To allow for memory decay after the reading task, we had participants answer questions on diversification for what was ostensibly a separate study. At the end of the session, participants responded to SES items.

Participants were randomly assigned to read one of two news articles that they were told had recently appeared in the *New York Times*. The articles were formatted to look authentic, featuring the newspaper’s logo, font, and style. In the mortality-threat condition, participants read about increasingly rising violence in the United States. The control condition described a person searching the house for lost keys. Past research has shown that these articles elicit the same level of negative arousal but that the mortality threat article leads people to see the world as more dangerous and unpredictable (Griskevicius, Delton, et al., 2011).

After reading one of the articles, participants made a series of choices between product bundles that were either diversified or not. For example, participants chose among (a) three milk chocolate Hershey’s bars or (b) one milk chocolate Hershey’s bar, one milk chocolate Hershey’s bar with almonds, and one Cookies ‘n’ Creme Hershey’s bar. Participants made seven choices among different kinds of products (e.g., cereal, coupons, shirts). The dependent measure was the number of times people selected the diversified option. Participants then indicated their childhood and current household incomes, using an 8-point scale from *\$15,000 or less* (1) to *\$150,000 or more* (8).

Results and discussion

A regression with condition, childhood SES, and their interaction showed a significant Condition \times Childhood SES interaction, $t(161) = 3.08$, $p = .002$, $\beta = -0.28$ (see Fig. 1). For those from low-SES backgrounds (-1 SD), the mortality prime increased diversification, $t(161) = 2.34$, $p = .021$, $\beta = 0.63$. For those from high-SES backgrounds ($+1$ SD), the mortality prime decreased diversification, $t(161) = 2.04$, $p = .043$, $\beta = -0.56$.

Conceptually replicating the correlational findings in Study 1, the results showed that experimentally manipulating mortality threat led individuals from lower-SES backgrounds to seek more diversification but led those from higher-SES backgrounds to seek less diversification. As in Study 1, these effects were unique to childhood SES (for details about analyses concerning current SES, see Study 2: Additional Analyses in the Supplemental Material available online).

Study 3

In Study 3, we sought to extend our findings to a different form of diversification: stock preferences.

Method

Participants. One hundred fifteen participants (69 females, 46 males; mean age = 34.4) were recruited from Amazon's Mechanical Turk Web site.

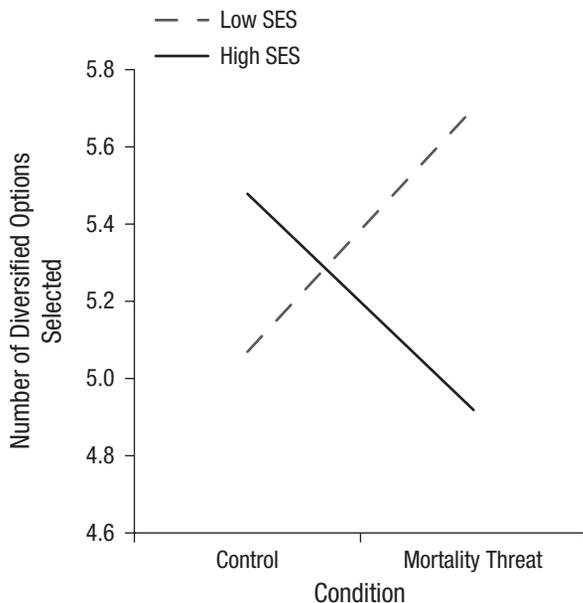


Fig. 1. Results from Study 2: selection of diversified options in choices among different product bundles as a function of condition and childhood socioeconomic status (SES; low = 1 SD below the mean; high = 1 SD above the mean).

Procedure. Study 3 used the same experimental manipulations and cover story as Study 2. After reading one of the two articles, participants made a series of five choices among financial-investment options varying in their level of diversification. For example, participants were asked to choose among four stock packages that had the same current value but varied in the number of companies in the portfolio (Package A: 100 shares in each of eight electronics companies; Package B: 200 shares in each of four electronics companies; Package C: 400 shares in each of two electronics companies; Package D: 800 shares in a single electronics company). Participants received a score for each choice; scores ranged from 1 (for the least-diversified option) to 4 (for the most-diversified option). Responses were averaged into a diversification composite, $\alpha = .87$. Childhood and current SES were assessed using the same measures used in Study 1.

Results and discussion

A regression predicting diversification from condition, childhood SES, and their interaction showed a significant Condition \times Childhood SES interaction, $t(115) = 3.23$, $p = .002$, $\beta = 0.33$. For people from low-SES backgrounds (-1 SD), the mortality prime increased preferences for diversification, $t(115) = 2.04$, $p = .044$, $\beta = 0.40$. For those from high-SES backgrounds ($+1$ SD), the mortality prime decreased preferences for diversification, $t(115) = 2.54$, $p = .012$, $\beta = -0.47$. As in our previous studies, these effects were unique to childhood SES (for details about analyses concerning current SES, see Study 3: Additional Analyses in the Supplemental Material).

Study 4

In Studies 1 through 3, we used childhood SES as an indicator of life-history strategy. In Study 4, we sought to test whether oxidative stress, a suggested biomarker of life-history strategy (Gangestad, Merriman, & Emery Thompson, 2010; Griskevicius et al., 2013), would show similar results. Oxidative stress reflects damage resulting from the activity of reactive oxygen produced during cellular metabolic processes. It has been proposed that higher levels of oxidative stress may be related to faster life-history strategies. There are several reasons to believe that such a relationship exists. Increased oxidative stress is associated with faster aging and decreased longevity (see Parsons, 2005). Increases in reproductive effort, characteristic of fast life-history strategies, increase susceptibility to oxidative stress (Alonso-Alvarez et al., 2004; Dowling & Simmons, 2009). Further, oxidative stress is associated with several indicators of environmental harshness and unpredictability: increased levels of chronic stress, subjective perceptions of stress, and lower levels

of parental education (Epel et al., 2004; Wong et al., 2005). In this study, we assessed one indicator of oxidative stress, 8-hydroxy-2'-deoxyguanosine (8-OHdG; Griffiths et al., 2002) and predicted that it would moderate the effects of mortality threat on diversification.

Study 4 also used a better measure to assess diversified and conservative bet hedging. The first two studies assessed preferences for variety and diversity. The third study examined preferences for stock packages that varied in the number of stocks offered—a dimension that helped to differentiate diversified and conservative bet hedging. However, conservative bet hedging involves investing more resources into fewer options. Thus, the measure in Study 4 was designed to provide a more explicit and direct test of conservative bet hedging—making it clear that lower levels of diversification were associated with higher investment into fewer options.

Method

Participants. One hundred and two participants (59 females, 43 males; mean age = 23.03 years) from a mixed sample of students and members of the community took part in this study in exchange for \$15.

Procedure. We used the same experimental manipulation as in Studies 2 and 3. After reading one of the two articles, participants made a series of choices about crop planting. Each choice was between a conservative bet-hedging option (planting one crop and investing more in it) and a diversified bet-hedging option (planting two crops but investing less in each). For example, “(a) You can plant one crop on 110 acres of land, or (b) you can plant two crops, but you only get 98 acres of land.” Participants responded to 10 items. In each choice, the two-crop option offered fewer total acres of land. The dependent measure was the number of times people selected the diversified option.

At the end of the study, participants were given a sterile cup and asked to go to a nearby restroom to provide a urine sample. All but one subject provided samples, which were immediately pipetted into a 3-ml container and frozen at -20°C . (for a description of urinary analyses, see Study 4: Urinary Analyses in the Supplemental Material).

Results and discussion

A regression predicting diversification from condition, oxidative stress, and their interaction showed a significant Condition \times Oxidative Stress interaction, $t(101) = 3.17$, $p = .002$, $\beta = 0.44$ (see Fig. 2). For participants high in oxidative stress (+1 *SD*), the mortality prime increased preference for diversification, $t(101) = 2.78$, $p < .01$, $\beta = 0.37$. For participants low in oxidative stress (−1 *SD*), the



Fig. 2. Results from Study 4: selection of diversified options as a function of condition and oxidative stress (low = 1 *SD* below the mean; high = 1 *SD* above the mean).

mortality prime decreased preference for diversification, $t(101) = -1.72$, $p = .089$, $\beta = -0.23$.

Conceptually replicating childhood-SES findings from previous studies, results from Study 4 showed that mortality threat led individuals with higher oxidative-stress levels to seek more diversification and spread their eggs among different baskets but led individuals with low oxidative-stress levels to seek less diversification and put their eggs in one basket.

General Discussion

Four studies demonstrated the predicted relationship between contingent life-history strategies and diversification. In Study 1, perceptions of mortality threat interacted with childhood SES to influence diversification: As perceptions of mortality threat increased, individuals from low-SES backgrounds preferred more diversity, but individuals from high-SES backgrounds preferred less diversity. In Studies 2 and 3, an experimental manipulation of mortality threat led those from low-SES backgrounds to prefer more diversity (in product bundles and stocks) but those from high-SES backgrounds to prefer less diversity. Across all of these studies, mortality threat interacted with childhood SES, but not with current SES. Finally, in Study 4, mortality threat interacted with oxidative stress to affect diversification. Following a mortality threat, people higher in oxidative stress preferred to diversify and spread their risk, whereas those lower in oxidative stress preferred to not diversify and instead put all their eggs in one basket.

These findings build on previous research on the contingent expression of life-history strategies by suggesting that fast and slow strategies are associated with specific types of bet hedging. Under conditions of mortality threat, people from lower-SES backgrounds engaged in diversified bet hedging, associated with a fast life-history strategy, whereas those from higher-SES backgrounds engaged in conservative bet hedging, associated with a slow life-history strategy. Although the initial studies assessed high versus low diversification, Study 4 more directly assessed diversified versus conservative bet hedging by making the trade-offs between the two strategies explicit. All studies showed the same interactive pattern, providing support for the relationship between life-history strategies and bet hedging.

We have suggested that higher levels of oxidative stress may be indicative of a faster life-history strategy (following Griskevicius et al., 2013). However, research has not directly linked oxidative stress to other indices of life-history strategy. Moreover, little research has used oxidative stress as an individual-difference measure. Therefore, future research is needed to relate oxidative stress to other life-history variables and to better understand how oxidative stress varies both temporarily and chronically.

In our studies, we manipulated perceived mortality threat and found that people from low-SES backgrounds and high-SES backgrounds adopt different life-history strategies and, as a consequence, different bet-hedging strategies. One potential reason for this is that people with poor childhood backgrounds and wealthy childhood backgrounds have different interpretations of mortality threat encountered in adulthood (Griskevicius, Delton, et al., 2011; Griskevicius, Tybur, et al., 2011). Whereas the threat may be perceived as uncontrollable and unpredictable for those who grew up in poorer conditions, it might be perceived as controllable and predictable for those who grew up in wealthier conditions. Future research is needed to better understand the psychological mechanisms driving these diverging patterns of results.

The relationship between a person's life-history strategy and diversification underscores the deeper evolutionary rationality of diversification strategies: They are functionally attuned to respond to environmental conditions in theoretically sensible ways. Thus, the current investigation shows the functional logic behind when, and for whom, different diversification strategies can be advantageous.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information may be found at <http://pss.sagepub.com/content/by/supplemental-data>

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