Hearth and Campfire Influences on Arterial Blood Pressure: Defraying theCosts of the Social Brain through Fireside Relaxation

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Original Article

Hearth and Campfire Influences on Arterial Blood Pressure: Defraying the Costs of the Social Brain through Fireside Relaxation

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Abstract: The importance of fire in human evolutionary history is widely acknowledged but the extent not fully explored. Fires involve flickering light, crackling sounds, warmth, and a distinctive smell. For early humans, fire likely extended the day, provided heat, helped with hunting, warded off predators and insects, illuminated dark places, and facilitated cooking. Campfires also may have provided social nexus and relaxation effects that could have enhanced prosocial behavior. According to this hypothesis, calmer, more tolerant people would have benefited in the social milieu via fireside interactions relative to individuals less susceptible to relaxation response. Using a randomized crossover design that disaggregated fire's sensory properties, pre-posttest blood pressure measures were compared among 226 adults across three studies with respect to viewing simulated muted-fire, fire-with-sound, and control conditions, in addition to tests for interactions with hypnotizability, absorption, and prosociality. Results indicated consistent blood pressure decreases in the fire-with-sound condition, particularly with a longer duration of stimulus, and enhancing effects of absorption and prosociality. Findings confirm that hearth and campfires induce relaxation as part of a multisensory, absorptive, and social experience. Enhancements to relaxation capacities in the human social brain likely took place via feedback involving these and other variables.

Keywords: absorption, blood pressure, fire, hypnotizability, prosociality, relaxation response

Introduction

Controlled fire has played a key role in human evolutionary history. For ancient hominins, it would have provided the following: light to extend the day and illuminate otherwise uninhabitable dark places; heat for cooking previously inedible food, warming bodies at night, and enabling migration into colder climates; a weapon to facilitate mass hunting and stave off predators; and, according to several scholars, social nexus. Wilson (2012) argues that the habit of building campsites around fires reflects one of the hallmarks of eusocial species—the need to build and defend nests. Accessing, maintaining, and benefitting from fire may have influenced cognition related to future-planning, response inhibition, and group-level cooperation (Twomey, 2013); and such intensive use of fire, especially for cooking, may have selected for hominins that were more tolerant of one another (Wrangham, 2009). Likewise, McClenon (1997, 2002, 2006) speculates that *Homo erectus* experiencing altered states of consciousness through the hypnotic influence of watching campfires would have been more relaxed and prosocial than those that didn't. This basis of his "ritual healing hypothesis" supposes that fire has the capacity to induce a relaxation response, a position taken as given because of the common sentiment that hearth and campfires are relaxing. Fires are multisensory experiences that have numerous unexplored dimensions when considering human evolution. Through the current studies, I investigate the basis of the ritual healing hypothesis by parsing the elements of fire and examining their relationships to relaxation response, hypnotizability, absorption, and prosociality.

Humans possess the ability to moderate relaxation response via conscious cognitive processes, a capacity that has been attributed in part to fire manipulation, ritual behavior, and the hypnotic influence of hearth and campfires during human evolution (McClenon, 1997, 2002, 2006; Rossano, 2007, 2010). Relaxation response, a wakeful hypometabolic physiological state (Benson and Klipper, 2000) that deactivates or opposes stress response (Stefano et al., 2003), is an evolutionarily old and highly conserved function that is part of the negative feedback that deactivates stress response and has been directly linked to the alleviation of stress-related disease (Esch, Fricchione, and Stefano, 2003; Esch, Stefano, and Fricchione, 2002). Stress-related disorders are among the leading causes of disability in the modern era and pose significant economic impacts worldwide (Kalia, 2002), so there is great incentive to understand the evolved mechanisms and environmental triggers of stress-reduction that are specific to humans.

As is true in contemporary populations, stress was doubtless both complexly beneficial and maladaptive for hominin ancestors. Stress is a psychophysiological response to uncontrollable or unpredictable changes in one's environment (Koolhaas et al., 2011), facilitating behavior to pursue rewards—such as would have been required for coordinated hunting—and producing fight, flight, and freeze responses that help organisms avoid or escape danger. As social group sizes increased, psychosocial factors also contributed appreciable negative stress (Dunbar, 1993), given the calculus involved in mentally simulating the potential number of social situations any individual could encounter (Alexander, 1989; Flinn, Nepomnaschy, Muehlenbein, and Ponzi, 2011). Although Sapolsky (1998) has shed much light on the stress dynamics of extremely social species, human self- and other-awareness likely exacerbated this pressure in ways not well understood (Flinn et al., 2011). Self- and other-awareness entail numerous benefits—e.g., self-control, self-improvement, self-grooming, positive misperception, theory of mind, and scenario-building—but they also accrue significant costs, such as self-isolation, analysis paralysis, forecast inaccuracy, self-aggrandizement, resentment, egotism, envy, and guilt or shame (Keenan, Gallup, and Falk, 2003). The rarity of such awareness within the animal kingdom suggests these costs are significant. For self- and other-awareness to develop in humans, these costs were likely mitigated, possibly by mechanisms associated with partitioning awareness or psychological dissociation (Lynn, 2005).

The term dissociation is used for a family of experiences characterized by combinations of depersonalization, derealization, and absorption. These range from the common and normal, such as “zoning out” while reading a book or playing a game, to the rare and aberrant, as with dissociative disorders. Theoretical approaches tend toward either a “psychiatric-adaptive” or an “anthropological-discursive” model (Seligman and Kirmayer, 2008). The evolutionary approach underlying ritual healing theory holds that dissociation is basically adaptive and functions to reduce or filter stress (Ludwig, 1983; McClenon, 2006), but in cultural manifestations dissociation also has social and rhetorical meanings (Seligman and Kirmayer, 2008). Although analogs appear in other species (Schauer and Elbert, 2010), it is important to acknowledge that dissociation is not a unified neural structure with a single essence—the varieties of dissociative phenomena simply share the trait of featuring cognitive mechanisms that relinquish or direct information processing away from the social self (Kirmayer, 1994). Dissociation is a feature of ritual and non-ritual social behavior cross-culturally (Kirmayer, 1994; Seligman and Kirmayer, 2008), but it is difficult to discover when in evolutionary history this animal capacity was enhanced. One possibility is that it developed in concert with language.

Several scholars suggest language, cooperation, and group size arose synergistically and may have been pushed by the increased necessity of maintaining fires as humans moved into geographic regions that suffered global cooling following the Mount Toba eruption ~71,000 years ago (Ambrose, 1998; Burton, 2009; Gamble, Gowlett, and Dunbar, 2011; Gowlett, 2006, 2010; Rossano, 2007, 2010; Twomey, 2013; Wrangham, 2009). Fires have been manipulated since roughly 1 million years ago (Berna et al., 2012), but there is as yet no evidence of hominin knowledge of ignition or kindling until the Upper Paleolithic, approximately the same period when evidence appears for elaboration of symbolic communication (Gowlett, 2006, 2010; Twomey, 2013). This suggests that ancestral groups migrated, were successful and grew in size, and then were pressured by environmental change to better control fire as temperatures dropped. The inability to start fires would have required groups to coordinate activities to access and maintain them. This continual cooperation would have put pressure on cognitive capacities for social tolerance, conceiving of others as collaborators in future cooperation, episodic memory to understand past ecological problems, extended working memory of operations associated with fire maintenance, and protolanguage to coordinate collective activities and intentions (Gowlett, 2006, 2010; Rossano, 2007, 2010; Twomey, 2013; Wrangham, 2009).

Campfires are still used as social pivots in modern societies, even when other forms of light, warmth, cooking, and predator avoidance are available (see Figure 1). Fireplaces are often kept in houses purely for decorative purposes, despite actually reducing heating efficiency; TV channels and video recordings feature Yule fires that people watch; candle flames are frequently used as visual foci for meditation; and virtual fires are marketed under the auspices of promoting relaxation and used in therapeutic biofeedback (e.g., Riva et al., 2010). Indeed, most other species avoid fire, save a few that use charcoal as medicine or harvest other creatures serendipitously roasted in wildfires (Burton, 2009), a distinction that seems to have had profound influences beginning approximately 400–800 thousand years ago (Twomey, 2013).

As hominin ancestors sat around hearth and campfires, they may have experienced secondary relaxation benefits, particularly in the dark when other stimuli were limited and firelight was the only thing to see well or focus on (McClenon, 1997). At night, circadian rhythms and the properties of fire converge for hallucinatory effects, which may have influenced the emergence of religio-ritual behaviors (McClenon, 1997, 2002, 2006). Konner (1985) reports that among the !Kung San foragers of the Kalahari Desert, there was likely a synergy between the music, dancing, hyperventilation, smoke inhalation, and staring into flames that produced an effect unlike any other. A parlor trick at the heart of the children's game Bloody Mary affirms the visual distortions firelight can create in the dark (Caputo, 2010). Additionally, close proximity fire could have benefited social behavior through the influences of blue spectrum light on mood and other cognitive processes (Burton, 2009).

Figure 1. Humans build nests around fires and enjoy the mesmeric effects when camping, even though more efficient resources are available

Photo courtesy of Heath Kinzer

The model I have outlined for a cognitive evolutionary influence of fire via its relaxation effects is based in part on the common sentiment that firelight is relaxing and that relaxed people are more amiable, but neither this supposed absorptive-hypnotic influence nor a link to prosociality have been empirically verified. Therefore, through the project outlined in this article, I tested the hypothesis that the properties of hearth and campfires influence relaxation by reducing blood pressure and that this reduction is enhanced by hypnotizability, absorption, and prosociality. Because fire is a multisensory and often social experience and it would otherwise be difficult to assess what was influencing blood pressure, I used experimental conditions to parse sensory and social elements and test the following predictions:

1. Watching a fire should result in lower blood pressure than a control condition.
2. An audiovisual fire experience should result in lower blood pressure than a control condition.
3. An audiovisual fire experience should result in lower blood pressure than merely watching a fire with no sound component.
4. Hypnotizability, absorption, and prosociality should interact with the fire stimulus to increase relaxation response.

This project changed over time because of feedback from participants and preliminary analyses, and I therefore present it as three studies conducted in conjunction with a number of undergraduate research assistants. Protocols for all three studies as outlined below were approved by the University of Alabama Institutional Review Board.

Study 1

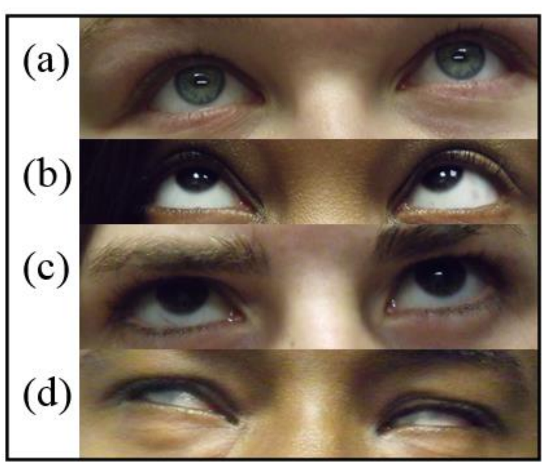
Materials and Methods

Data were collected by undergraduate assistants, who recruited 64 adults (51 women), ages 19–36 ($M \pm SD$ = 21.8 ± 3.84), via University of Alabama courses and community postings from September 2010—May 2011 to complete study questionnaires and measurements. After obtaining contact information from potential participants, an email was sent explaining the study and what it entailed. Participants were scheduled to come to our lab and complete study protocols. I excluded one person who reported taking medication known to control blood pressure, leaving a total of 63 participants for analysis.

Upon arrival, participants provided informed consent, completed a questionnaire, and were assessed for hypnotizability, which took approximately 10 minutes, allowing their heart rates to return to steady-state before the first blood pressure measure. The survey queried sex; age; ethnicity; occupation; education level; major, grade point average, and credit hours (if student); social status (Singh-Manoux, Adler, and Marmot, 2003); relationship status; medication; social support (Blake and McKay, 1986); perceived stress (Cohen and Williamson, 1988); and religiosity (Rohrbaugh and Jessor, 1975).

Hypnotizability was assessed using the eye-roll test (Spiegel, 1972), which entails rotating one's eyes toward the top of the head while keeping the head still, then slowly rolling one's eyelids down while continuing to look up (see Figure 2). The amount of sclera visible during the upgaze and roll (or squint if they cannot roll) is assessed on a 5-point scale (or 4-point scale for squints if they cannot roll their eyes down; 0 = least sclera visible/least hypnotizable). A team of trained raters conducted scoring to achieve agreement. Despite a 75% success rate in predicting hypnotizability in clinical cases, the validity of the eye-roll test relative to other hypnotizability measures is only 0.22 (Hilgard, 1981, 1982), but it has the benefit of providing a spot assessment not possible via other methods.

Figure 2. Upgaze (a and b) and eye roll (c and d) variations associated with hypnotic capacity



Blood pressures were assessed with regard to a 5-minute fire simulation on a computer screen as the experimental condition and a 5-minute blank computer screen as the control condition. Blood pressure was measured in millimeters of mercury (mmHG) before and after each condition using an Omron HEM-711 automatic blood pressure monitor (Omron Healthcare, Inc., Bannockburn, IL), which has reliability equivalent to mercury sphygmomanometers (Rotch, Dean, Kendrach, Wright, and Woolley, 2001). The fire condition involved watching a randomly assigned digital recording of either a hearth or campfire (*Ambient Fire*, Jumby Bay Studies, 2006) with the sound muted (see Figure 3). In the control condition, participants merely watched a blank computer screen (i.e., powered off). Conditions were administered on a 19” computer monitor while wearing noise-cancelling headphones in a darkened office with the doors closed and noise kept to a minimum, though an experimenter remained in or just outside the room to monitor the session. The headphones limited exposure to distractions outside the room so participants could focus more easily in both conditions. The darkened room was meant to simulate nighttime fireplace or campfire environments, when outside lights would be dimmed or absent. Participants sat with their faces approximately 30–40” from the screen in a cushioned desk chair with armrests, rollers, and a straight back. They were asked to turn off their cell phones and other devices and not do anything else while watching the screen, though they could move slightly or make adjustments if need be. Participants were randomly assigned to either the control or muted-fire first and completed both conditions. Room temperature was monitored continually throughout both conditions ($M \pm SD$ = 74.8°F ± 3.70, min/max = 67.5/83.6) and controlled for in preliminary analyses, but made no statistical difference.

Figure 3. Screenshots of hearth and campfire videos used in fire conditions

I analyzed the data using SPSS version 20 for Windows (IBM Corp., Armonk, NY). I calculated descriptive statistics for demographic and dependent variables and, following the recommendation of Simmons, Nelson, and Simonsohn (2011), have provided statistics of only those measures used for analyses. To test the hypothesis that the muted-fire condition would influence blood pressure reduction relative to the control condition, I compared mean systolic and diastolic blood pressure (pre- and posttest) using paired samples *t*-tests and considered results significant at $p < .05$.

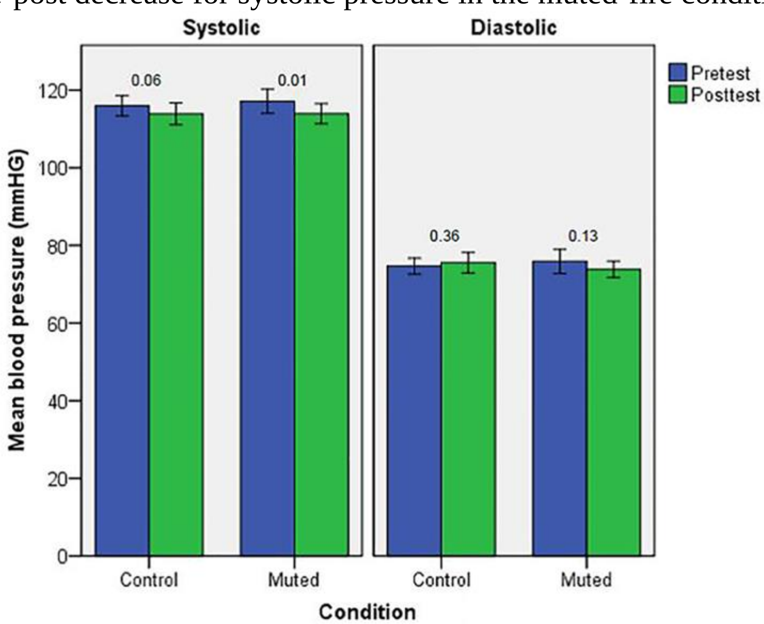
Results

There were significantly more women than men in the sample, and the mean age was relatively low, reflecting a preponderance of college-age participants. These subjects were ethnically representative of the community, with 89% self-reporting as white, 9% as African-American, 2% as Hispanic, and 2% not answering. Seventy-eight percent were college students and 44% were single, with the remainder in some type of relationship. Subjects were predominantly upper-middle status ($M \pm SD = 6.7 \pm 1.34$), according to self-report on a 10-point scale (1 = least money/education, worst job, and fewest friends) and average in hypnotizability ($M \pm SD = 2.6 \pm 1.03$).

Fifty-seven percent of participants received the fire condition first. Mean systolic blood pressure across all three measures was 115.7 mmHG, and mean diastolic pressure was 75.0. Comparison of the blood pressure of women (systolic: $M \pm SD = 117.2 \pm 9.75$; diastolic: $M \pm SD = 75.6 \pm 9.65$) and men (systolic: $M \pm SD = 127.0 \pm 12.25$; diastolic: $M \pm SD = 75.6 \pm 12.92$) at the first measure indicated a significant difference in systolic pressure, $t(62) = -3.0$, $p = .004$, but not diastolic pressure, $t(62) = 0.01$, $p = .99$.

In testing the hypothesis, as Figure 4 illustrates, there was a significant decrease in systolic blood pressure in the muted-fire condition ($M \pm SD = 3.21 \pm 9.35$), $t(62) = 2.72$, $p = .01$, and a non-significant decrease in diastolic pressure ($M \pm SD = 2.05 \pm 10.51$), $t(62) = 1.55$, $p = .13$. In the control condition, a systolic decrease was borderline significant ($M \pm SD = 2.10 \pm 8.50$), $t(62) = 1.96$, $p = .06$, and diastolic pressure increased slightly from pre- to posttest ($M \pm SD = -0.89 \pm 7.69$), $t(62) = -0.92$, $p = .36$. Randomization of hearth or campfire had no effect.

Figure 4. Study 1 comparisons of mean blood pressure with paired samples *t*-tests indicate a significant pre-post decrease for systolic pressure in the muted-fire condition



Note. *p*-values shown above bars; Error bars represent 95% CI

Discussion

The prediction that fire is captivating because of its visual flickering, influencing a relaxation response, was partially supported by reductions in blood pressure in the muted-fire condition, especially compared to the increase in diastolic pressure in the control. However, the short durations and anecdotal reports by participants that both conditions were unrealistic though somewhat relaxing indicated the need for modifications.

Study 2

Materials and Methods

Study 2 was conducted from September 2011—May 2012. One hundred nine additional participants were recruited in the same manner as Study 1 and tested with regard to 5-minute muted-fire, fire-with-sound, and blank computer screen conditions. Of these additional subjects, six were excluded because blood pressure measures were incomplete. The combined total sample of data from Study 1 and Study 2 participants retained for analysis came from 121 women and 46 men, ages 19–53 ($M \pm SD = 21.5 \pm 4.3$).

The hearth- and campfire-with-sound condition included naturalistic crackling noises and, for the campfire, faint nature ambience delivered through the headphones, which provided a more natural simulation. Because populations and protocols for Study 1 and Study 2 were the same except for the addition of a new condition, samples were combined for hypothesis testing. I assessed blood pressure changes and the influence of hypnotizability using repeated measures analyses of variance (ANOVA), controlling for the sex disparity in the sample, established age-related variation in blood pressure (Franklin et al., 1997), and trial sequence. To assess differences between group combinations, I used post-hoc pairwise comparisons with Bonferroni adjustments (by multiplying the *p*-value by the number of comparisons). All other protocols and analyses were the same as those in Study 1.

Results

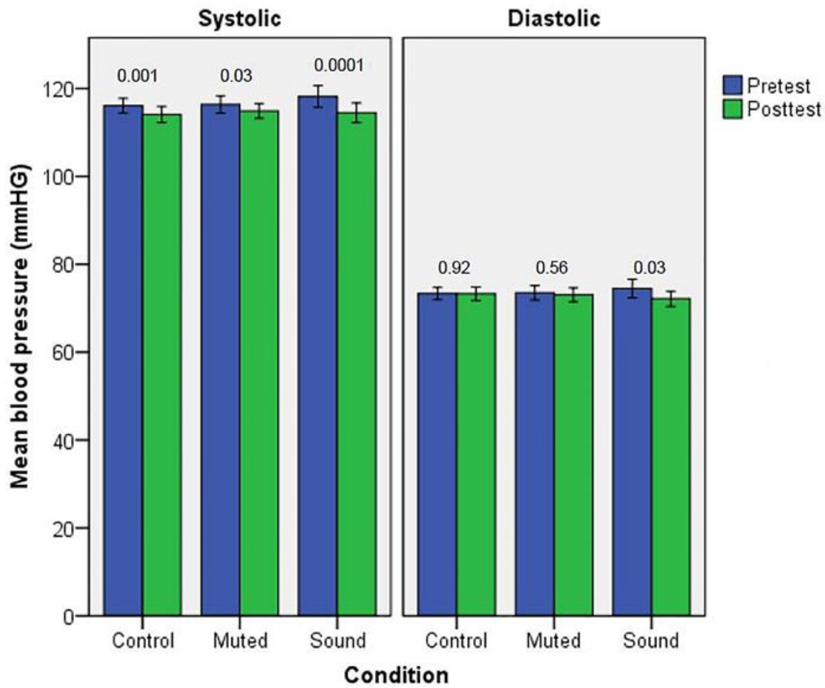
As with Study 1, the majority of participants were white (80%), upper-middle status ($M \pm SD = 6.4 \pm 1.22$) college students (97%), with minorities of African-American (4%), Hispanic (5%), and Asian (1%), with the remainder (11%) not answering; and they were average in hypnotizability ($M \pm SD = 2.94 \pm 0.87$).

Among Study 2 participants, 33% received the fire-with-sound condition first, 37% received it as their second trial, and 30% received it last. Mean systolic blood pressure was 116.1 ± 10.63 (women: $M \pm SD = 112.7 \pm 8.64$; men: $M \pm SD = 125.2 \pm 10.06$; $t[101] = -8.0$, $p < .01$), and diastolic was 73.7 ± 8.29 (women: $M \pm SD = 73.2 \pm 8.03$; men: $M \pm SD = 75.1 \pm 8.88$; $t[101] = -1.3$, $p = 0.19$).

Differences among conditions in the combined sample of Study 1 and Study 2 participants are depicted in Figure 5 and indicate a significantly greater difference in systolic blood pressure ($M \pm SD = 3.52 \pm 7.67$; $t[101] = 4.63$, $p = .001$) and diastolic blood pressure ($M \pm SD = 2.31 \pm 10.69$; $t[101] = 2.19$, $p = .03$) in the fire-with-sound condition relative to muted-fire (systolic: $M \pm SD = 1.48 \pm 8.79$; $t[165] = 2.17$, $p = .03$; diastolic: $M \pm$

SD = 0.45 ± 9.74; *t*[165] = 0.59, *p* = .56) or control (systolic: *M* ± *SD* = 2.02 ± 8.03; *t*[165] = 3.25, *p* = 001; diastolic: *M* ± *SD* = 0.05 ± 7.06; *t*[165] = 0.10, *p* = .92). However, Figure 5 also shows that the pretest blood pressure in the fire-with-sound condition was significantly elevated relative to the control (systolic: *t*[102] = 2.42, *p* = 0.02; diastolic: *t*[102] = 2.12, *p* = .04) and muted-fire (systolic: *t*[102] = 2.49, *p* = .01; diastolic: *t*[102] = 2.56, *p* = .01), despite trial randomization.

Figure 5. Comparisons of mean blood pressure with paired samples *t*-tests of combined Study 1 and Study 2 participants indicated significant pre-post decreases in all conditions for systolic pressure and only in the sound condition for diastolic pressure



Note. *p*-values shown above bars; Error bars represent 95% CI

One-way repeated measures ANOVAs were used to test for differences among groups and indicated a borderline significant influence of the condition, with a moderate effect size for systolic blood pressure, $F(2, 100) = 2.90$, $p = .06$, partial eta^2 = 0.055. Post-hoc pairwise comparisons with Bonferroni adjustments indicated a borderline significant difference between muted and sound conditions (p = .06). However, two-way repeated measures ANOVA models including hypnotizability as a between-subject factor, condition-by-hypnotizability as a within-subjects factor, and controlling for sex, age, and trial sequence (see Table 1) were not significant and indicated the between-subjects effect for systolic blood pressure was largely due to age, $F(1, 54) = 3.20$, $p = .08$, partial eta^2 = 0.054. There were no significant differences in diastolic measures and no significant interactions with hypnotizability or pairwise differences for systolic or diastolic pressure.

Table 1. Two-way repeated measures ANOVA for systolic and diastolic blood pressures with sex, age, and trial sequence as covariates

	F	*df*	*p*	Partial eta^2
Systolic Blood Pressure				
Within-subjects				
Condition	1.7	2, 168	.18	0.020
Condition-*x*-hypnotizability	0.8	8, 168	.59	0.009
Between-subjects				
Hypnotizability	1.0	4, 84	.41	0.046
Diastolic Blood Pressure				
Within-subjects				
Condition	0.6	2, 112	.57	0.010
Condition-*x*-hypnotizability	0.5	8, 112	.86	0.034
Between-subjects				
Hypnotizability	0.7	4, 56	.63	0.044

Discussion

In study 2, I tested the revised hypothesis that fire with sound would produce the greatest relaxation effect and muted fire would be secondary in its influence, controlling for baseline variation in hypnotizability. I found a reduction from pre- to posttest in the fire-with-sound condition that approached significance, but only with regard to systolic blood pressure; it is possible this effect was due to the relatively elevated blood pressure in the fire-with-sound pretest. Muted fire did not produce the effect I expected and, based again on post-experiment reports from participants, may have been an irritant because of its lack of other sensory components. Furthermore, the greater influence on systolic pressure according to the two-way ANOVA appears to have been age.

As with Study 1, participants reported that the period of time for each condition was so short the entire experiment felt like a relaxing respite from other obligations, indicating the need to extend trial durations in subsequent study.

Study 3

Materials and Methods

Ninety-five adults were recruited from September 2013—May 2014 for Study 3 via the same mechanisms as studies 1 and 2 but were sent a link to complete questionnaires online before being scheduled for the experimental conditions. Twenty-three did not arrive for the experimental portion, and another 11 did not provide enough information for inclusion, leaving 60 participants (53 women) for Study 3 analyses.

Feedback regarding Study 2 led to several modifications in Study 3. An expanded survey queried the following: experience with fireplaces and campfires, computers, television, and smartphones (to control for conditioning to fire- and screen-based relaxation); anxiety (to control for ability to relax during the experiment); absorption (as a better validated measure than the eye-roll test of ability to focus attention); and prosociality (to test fire's theorized role in influencing cooperation and social tolerance). Caffeine, tobacco, and recreational drug use were queried as possible influences on blood pressure or relaxation but exhibited no associations. Participants were also asked to complete a paper-and-pencil exit-survey upon finishing the experiment.

Absorption was measured using the Tellegen Absorption Scale (TAS—Tellegen and Atkinson, 1974) on a 5-point Likert array (Glisky, Tataryn, Tobias, Kihlstrom, and McConkey, 1991). TAS is a 34-item standardized survey and elicited a reliability coefficient of 0.92 for this study. Anxiety was measured using the State-Trait Anxiety Inventory (Spielberger and Gorsuch, 1983), which is a standardized survey including two 20-item subscales that measure anxiety with regard to one's current state and the degree to which it is part of one's general personality. Cronbach's alphas for state and trait anxiety were both 0.91, indicating excellent reliability, but state anxiety had a significantly lower response rate and was therefore excluded from analyses. Media and fire habituation were elicited with items querying the average number of leisure hours per week spent in front of a TV, computer, or smartphone (1 = "none," 2 = "1–2," 3 = "3–5," 4 = "5–9," 5 = "10+"), and no/yes questions measured if one's family home had a fireplace that was regularly used, if the participant had gone camping often and built fires, or if the TV was the center of the family home. I tested these items for collinearity and, finding none, summed them to create a single variable. Prosociality was measured using 43 items from the Myer-Briggs Personality Inventory (Myers and McCaulley, 1988) and the Altruistic Personality Scale (Rushton, Chrisjohn, and Fekken, 1981). These combined items achieved an extremely reliable Cronbach's alpha of 0.85.

Because Study 1 and Study 2 participants indicated that all 5-minute conditions were relatively relaxing, condition lengths were extended to 15 minutes. Additionally, the blank computer screen control was replaced with an upside-down screenshot of the campfire used in the other conditions (see Figure 6). Given the hypothesis that the flickering light and sudden sounds may stimulate orienting response, the upside-down static fire retains the structural properties of the experimental fires (e.g., color, brightness, shapes) while eliminating and thus isolating other sensory aspects that may be effective. All other Study 3 protocols were the same as those in studies 1 and 2.

I conducted analyses using repeated measures ANOVAs as in Study 2.

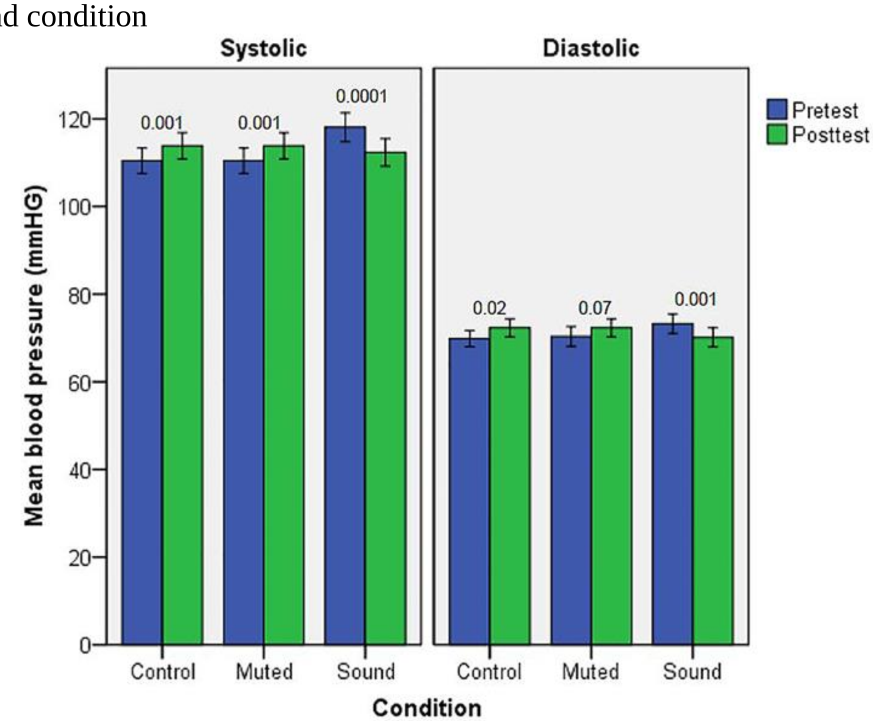
Figure 6. Upside-down static campfire image used in study 3 to control for structural features of a normal fire

Results

As in studies 1 and 2, subjects were mostly white (69%), upper-middle status ($M \pm SD$ = 6.4 ± 1.53) college students (76%) with average hypnotic capacity ($M \pm SD$ = 2.9 ± 0.66), and were also average in absorption ($M \pm SD$ = 71.0 ± 14.95).

Thirty-eight percent of the participants received the fire-with-sound condition first, 35% received it second, and 27% received it third. Mean systolic blood pressure at the first measure was 124.4 ± 7.91 (women: $M \pm SD$ = 114.8 ± 9.95; men: $M \pm SD$ = 134.0 ± 5.86; t[58] = -4.98, p < .001), and diastolic pressure was 72.6 ± 7.93 (women: $M \pm SD$ = 72.8 ± 8.11; men: $M \pm SD$ = 72.4 ± 7.74; t[58] = 0.11, p = .91). Average change in blood pressure is depicted in Figure 7 and shows that blood pressure increased in the control (systolic: $M \pm SD$ = -3.2 ± 7.06; diastolic: $M \pm SD$ = -2.4 ± 8.48) and muted-fire (systolic: $M \pm SD$ = -3.3 ± 7.06; diastolic: $M \pm SD$ = -2.0 ± 9.43) conditions but decreased in the fire-with-sound condition (systolic: $M \pm SD$ = 5.9 ± 7.36, diastolic: $M \pm SD$ = 3.0 ± 7.53). However, the pretest blood pressure was significantly elevated in the fire-with-sound condition relative to the control (systolic: t[69] = 6.97, p < .001; diastolic: t[69] = 3.69, p < .001) or muted-fire (systolic: t[69] = 6.97; p < .001; diastolic: t[69] = 3.64; p = 0.001), despite randomization of the order of the conditions. Furthermore, posttest blood pressures were lower in the fire-with-sound condition than for the control (systolic: t[66] = -1.32, p = .19; diastolic: t[66] = -1.85, p = .07) and muted conditions (systolic: t[66] = -1.32, p = .19; diastolic: t[66] = -1.85, p = .07). Though these latter differences were not statistically significant, they indicate a relatively large decrease overall in blood pressure for fire-with-sound.

Figure 7. Study 3 comparisons of mean blood pressure with paired samples t-tests indicated significant pre-post increases in systolic and diastolic in the control condition and in systolic in the muted condition but significant pre-post decreases in systolic and diastolic in the sound condition



Note. p-values shown above bars; Error bars represent 95% CI

A one-way repeated measures ANOVA indicated a significant influence of condition for systolic pressure with a large effect size, $F(1, 66) = 45.04$, $p < .001$, partial $eta^2 = 0.406$. Post-hoc pairwise comparisons indicated significant differences between fire-with-sound and control ($p < .01$) and between fire-with-sound and muted-fire ($p < .01$). I also found a significant difference with a large effect size for diastolic pressure, $F(2, 65) = 7.40$, $p = .001$, partial $eta^2 = 0.185$, with significant pairwise differences between fire-with-sound and control ($p = .001$) and between fire-with-sound and muted-fire ($p = .01$).

I tested the influence of hypnotizability, absorption, and prosociality on these differences using two-way ANOVA models while controlling for sex, age, anxiety, screen/fire habituation, and trial sequence. As outlined in Table 2, the systolic multivariate model was borderline significant with a large effect size and a borderline significant within-subjects condition-by-prosociality interaction. Pairwise differences between fire-with-sound and control and fire-with-sound and muted-fire remained significant ($p = .03$). The diastolic multivariate model for condition and pairwise comparisons were not significant, but there was a significant within-subject condition-by-absorption interaction and a large between-subject effects for absorption and prosociality (see Table 2).

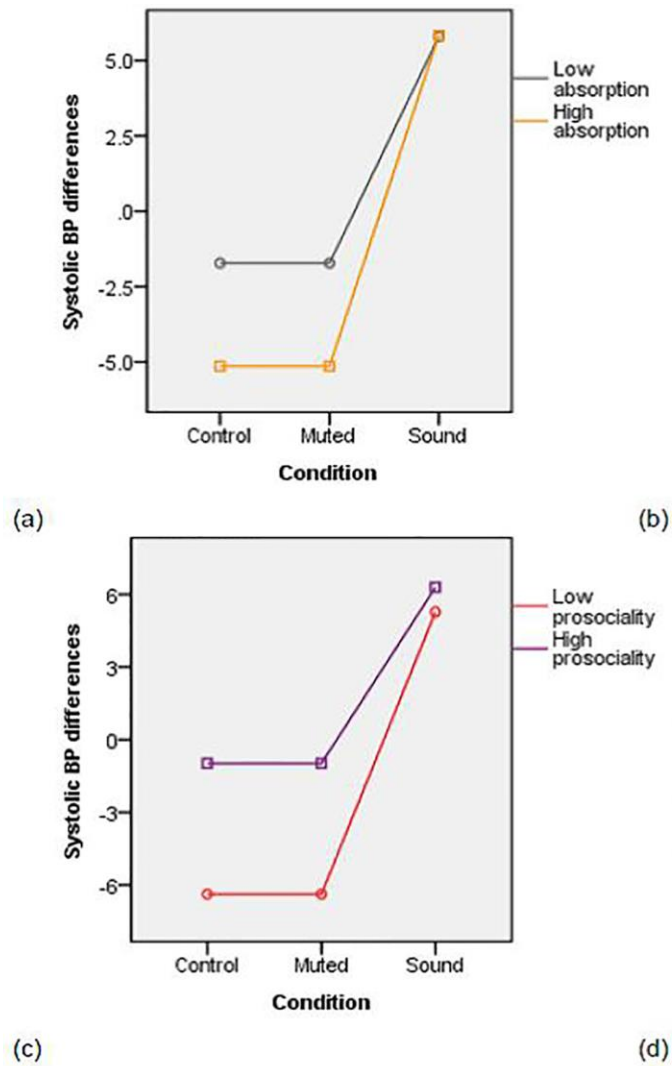
Table 2. Two-way repeated-measures ANOVAs for systolic and diastolic blood pressure with sex, age, anxiety, screen/fire habituation, and trial sequence as covariates

		F	*df*	*p*	Partial eta^2
Systolic Blood Pressure					
Within-subjects					
	Condition	3.2	2,62	.05	0.092
	Condition-*x*-hypnotizability	1.3	4,62	.28	0.077
	Condition-*x*-absorption	0.4	2,62	.71	0.011
	Condition-*x*-prosociality	3.1	2,62	.05	0.091
Between-subjects					
	Hypnotizability	0.8	3,31	.48	0.047
	Absorption	0.3	1,31	.59	0.010
	Prosociality	3.0	1,31	.10	0.087
Diastolic Blood Pressure					
Within-subjects					
	Condition	1.0	2,42	.40	0.043
	Condition-*x*-hypnotizability	0.2	4,62	.93	0.013
	Condition-*x*-absorption	4.1	2,62	.02	0.116
	Condition-*x*-prosociality	1.9	2,62	.17	0.057
Between-subjects					
	Hypnotizability	0.7	2,31	.51	0.042
	Absorption	12.4	1,31	.001	0.285
	Prosociality	8.3	1,31	.01	0.212

To understand the nature of these effects, I transformed absorption and prosociality into dichotomous variables based on their means (absorption: low = 42–71, high = 72–101;

prosociality: low = 67–101, high = 102–135) so they could be plotted against pre-posttest blood pressure differences at each condition. Figures 8a and c suggest that those relatively higher in absorption were more relaxed in the control and muted-fire trials than participants with lower absorption, but the fire-with-sound condition not only produced the greatest relaxation effect, it did so amongst those with the lower absorptive capacities. Figures 8b and 8d illustrate a similar relationship with regard to prosociality, except that the relaxation effect is diminished in the fire-with-sound condition for those more highly prosocial.

Figure 8. Between-subjects effects of absorption (a and b) and prosociality (c and d) dichotomized as high/low and plotted against estimated marginal means of pre-posttest differences in systolic (a and c) and diastolic (b and d) blood pressure across conditions, controlling for sex, age, anxiety, screen/fire habituation, and trial sequence



Finally, 51% of Study 3 participants provided study feedback via the post-experiment survey. Thirty-eight percent of those respondents found the fire-with-sound condition the most relaxing, while 11% felt it was the muted-fire condition, and 1% preferred the control.

Discussion

In Study 3, I found a significant decrease in blood pressure in the fire-with-sound condition and effects of absorption and prosociality. Although these effects were not consistent across models, they support the hypothesis that the fire-with-sound condition is the most influential in effecting relaxation response and involves focused attention and cooperative intent. The hypothesis that muted fire would be secondarily influential, however, was not supported.

By extending the duration of conditions and using a finer-grained control, Study 3 established the influential effect of fire-with-sound versus the other conditions as a multisensory experience rather than a visual effect. In fact, the upside-down image had unforeseen side effects, as several participants reported seeing faces in the image or that the inversion bothered them.

Despite validating Study 2's *t*-test and one-way ANOVA results, Study 3 also replicated a curious elevation in the pretest blood pressure for the fire-with-sound condition, which cannot be accounted for by trial sequence. Continued research should compare fire with sound to more naturalistic conditions to explore the physiological influences fireside environmental and circumstantial factors exert on relaxation response.

General Discussion

Across three studies, I tested the common belief that staring into fires is relaxing, a rather noncontroversial supposition but one that lacked empirical support or explanations as to why fires might elicit said effect. I used a randomized, controlled pre-posttest paradigm that measured arterial blood pressure to investigate the model that fire's relaxing influence comes via hypnotic susceptibility (McClenon, 1997, 2002, 2006). Specifically, I hypothesized that just watching a fire without any other sensory stimuli would produce a hypnotic quiescence that would lower blood pressure relative to control conditions. In testing this with two different controls across three different studies, I found little support for a visual-only effect. My next hypothesis was that a combined audiovisual experience of fire would result in lower blood pressure than control conditions, which was supported in studies 2 and 3 through *t*-tests and when controlling for covariates in regression models. A third hypothesis was that the visual fire with sound would be more effective in producing relaxation than the fire without sound, which also was supported in studies 2 and 3. Finally, I predicted that hypnotizability, absorption, and prosociality would interact with the fire stimuli to increase relaxation response and, indeed, found absorption and prosociality predict the greatest degree of relaxation, particularly in the fire-with-sound condition.

Several overall conclusions can be drawn from these findings. First, it appears that fire with sound consistently produces reductions in systolic and diastolic blood pressure, and reductions grow stronger with temporal exposure. Second, muted fire produces an inconsistent effect, resulting in decreases in blood pressures in studies 1 and 2 but not much more—and sometimes less—than control conditions. It appears that initial relaxation in the muted-fire condition may get counteracted as participants grow bored or annoyed. Finally, there does not appear to be a steady linear increase in relaxation effect in moving from a blank screen as control (no visual pattern, no movement, no sound) to a static image (visual pattern, no movement, no sound) to muted fire (visual pattern, movement, no sound) to auditory fire (visual pattern, movement, sound). Instead, it seems that a blank screen leads to modest relaxation, a static image has no relaxation effect, muted fire has variable effects, and fire with sound is consistently relaxing and increasingly so with greater exposure.

The blank screen appears to allow viewers to focus their attention and use their imaginations for relaxation, whereas the static image seems confusing and meaningless, leading to cognitive dissonance. Muted fire seems to allow for the visual focusing of attention, but the lack of sound may be distracting, leading viewers to listen for external sounds or get caught up in their own thinking and planning, since the experiments took place during the day in the midst of classes. This distraction effect likely increased with time, resulting in the increased pre-posttest blood pressures of Study 3. Fire with sound is visually and aurally naturalistic, allowing for multisensory absorption into the experience, and thereby provided the greatest relaxation effect. This was supported by the significant associations with absorption in Study 3 and greater relaxation for people higher in absorption, particularly in the fire-with-sound condition. Nevertheless, pre-posttest reduction in systolic pressure was observed across all three studies.

Greater variability in systolic than diastolic pressure is consistent with blood pressure research (Littler, West, Honour, and Sleight, 1978; Watson, Stallard, Flinn, and Littler, 1980), supporting the general hypothesis that sitting in front of a fire benefits relaxation response, but such fireside relaxation may be enhanced in social settings. Subjects were largely alone in this study, but those scoring higher in prosociality received greater relaxation benefits, supporting Wrangham's (2009) suggestion that manning fires may be functionally related to social gregariousness. Future research should consider fireside relaxation effects under varying social circumstances.

Stress reduction in the fire-with-sound condition also lends credence to the theory that fireside healing rituals could have benefited dissociative genotypes (McClenon, 1997, 2002, 2006). Although still speculative, understanding the relaxing influences of fire could be critical to unraveling mysteries of human cognitive evolution. For instance, selection to suppress prepotent selfish impulses in favor of cooperative planning and maintenance of fires (Rossano, 2007, 2010; Twomey, 2013) could have been abetted by relaxation effects (Hudetz, Hudetz, and Reddy, 2004). Susceptibility to relaxation appears to vary by circadian phase (Gorman and Lee, 2002) and, therefore, could be affected by time of day and fire-influenced phase shifts. Future tests can address this by controlling for time and varying the intensity of blue light (Vandewalle et al., 2007, 2010) and lux entering the eye (Burton, 2009).

Furthermore, given the theoretical role of fireside relaxation in enhancing dissociative phenotypes (McClenon, 1997, 2002) and associations among hypnotizability, absorption, and anomalous experience (Cardeña and Terhune, 2008), I expected to see an interaction between the experimental condition and hypnotizability and absorption, which are both aspects of or closely related to dissociation (e.g., Granqvist, Reijman, and Cardeña, 2011; Luhrmann, 2005; Snodgrass, Lacy, Dengah, Fagan, and Most, 2011; Winkelman, 2011). Consistent with Glisky et al. (1991), hypnotizability and absorption were positively associated in this study, but a significant effect was observed only with regard to absorption. Yet hypnotizability and absorption differ in that the former is more associated with suggestibility and the latter subject to conditioning (Zachariae, Jorgensen, and Bjerring, 2000; Zachariae et al., 2007). People high in absorption may be more sensitive to minute psychological and physiological changes associated with autonomic nervous system activity (Zachariae et al., 2000), which may lead them to be more prosocial, whereas absorption has been associated with "personal mental thin boundaries, but not to 'world' boundaries such as opinion of others" (Cardeña and Terhune, 2008; p. 61). My findings in this regard are inconclusive because of the low reliability of the eye-roll technique, but the significance of this line of inquiry is that hypnosis and hypnotic guided imagery therapy have been associated with psychoneuroimmunological benefits (Zachariae, 2009). More reliable methodology might confirm similar autonomic effects for firelight.

Several caveats should be borne in mind when considering these interpretations. The sound of fire may be more influential than the visual component, so future efforts should test sound-only conditions. The significantly elevated blood pressure for the fire-with-sound pretest condition in studies 2 and 3 is a concern. This anomaly cannot be explained by trial sequence or experiment priming, since conditions were randomized and posttest measures of the preceding condition were pretest measures of the following, but it should be investigated. Also, despite controlling for factors that would influence relaxation response, a fire on a computer screen presents a number of obvious limitations, not the least of which are the lack of fire's warmth and smell and the awkwardness of sitting alone or in a room with an experimenter, knowing that one is under surveillance. In the future, the influences of heat, smell, and social context will have to be tested to minimize these impediments. The social effect of sitting around a fire and conversing is doubtless very important in fireside relaxation and the evolution of cooperation.

Conclusion

Hearth and campfires are widely held to influence a relaxation effect. Although the importance of controlled fires in human evolution is indisputable, the relaxation aspect had remained uninvestigated. In the course of three studies with varying sensory conditions, I found significant reductions in blood pressure associated with fire with a naturalistic auditory component, confirming commonly perceived relaxation effects of hearth and campfires. However, lack of significant relaxation effects when subjects watch a flickering fire but are deprived of its sound indicate the influence of fire is not a visual "trance-inducing" effect alone. Furthermore, the combined audiovisual relaxation effect of fire is enhanced among those with greater capacities for absorption and prosociality. These findings complement models of human cognitive evolution with regard to fire control and use and warrant further research to assess more fine-grained psychophysiological influences, as well as evolutionary and therapeutic implications, especially with regard to the communal influences of fires at group levels.

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References

Alexander, R. D. (1989). Evolution of the human psyche. In P. Mellars, and C. B. Stringer (Eds.), *The human revolution: Behavioral and biological perspectives on the origins of modern humans* (pp. 455–513). Edinburgh: Edinburgh University Press.

Ambrose, S. H. (1998). Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans. *Journal of Human Evolution, 34*, 623–651.

Benson, H., and Klipper, M. Z. (2000). *The relaxation response*. New York: HarperCollins.

Berna, F., Goldberg, P., Horwitz, L. K., Brink, J., Holt, S., Bamford, M., and Chazan, M. (2012). Microstratigraphic evidence of in situ fire in the Acheulean strata of Wonderwerk Cave, Northern Cape province, South Africa. *Proceedings of the National Academy of Sciences*, *109*, E1215–E1220.

Blake, R. L., and McKay, D. A. (1986). A single-item measure of social supports as a predictor of morbidity. *Journal of Family Practice, 22*, 82–84.

Burton, F. D. (2009). *Fire: The spark that ignited human evolution*. Albuquerque: University of New Mexico Press.

Caputo, G. B. (2010). Strange-face-in-the-mirror illusion. *Perception, 39*, 1007–1008.

Cardeña, E., and Terhune, D. (2008). A distinct personality trait? The relationship between hypnotizability, absorption, self-transcendence, and mental boundaries. Paper presented at the *Proceedings of the 51st Annual Convention of the Parapsychological Association,* 61–73.

Cohen, S., and Williamson, G. M. (1988). Perceived stress in a probability sample of the United States. In S. Spacapan and S. Oskamp (Eds.), *The social psychology of health* (pp. 31–67). Newbury Park, CA: Sage.

Dunbar, R. I. M. (1993). Coevolution of neocortical size, group size and language in humans. *Behavioral and Brain Sciences*, *16*, 681–735.

Esch, T., Fricchione, G. L., and Stefano, G. B. (2003). The therapeutic use of the relaxation response in stress-related diseases. *Medical Science Monitor, 9*, RA23–RA34.

Esch, T., Stefano, G. B., Fricchione, G. L., and Benson, H. (2002). Stress-related diseases—A potential role for nitric oxide. *Medical Science Monitor*, *8*, RA103–RA118.

Flinn, M. V., Nepomnaschy, P. A., Muehlenbein, M. P., and Ponzi, D. (2011). Evolutionary functions of early social modulation of hypothalamic-pituitary-adrenal axis development in humans. *Neuroscience and Biobehavioral Reviews, 35*, 1611–1629.

Franklin, S. S., Gustin, W., Wong, N. D., Larson, M. G., Weber, M. A., Kannel, W. B., and Levy, D. (1997). Hemodynamic patterns of age-related changes in blood pressure: The Framingham Heart Study. *Circulation, 96*, 308–315.

Gamble, C., Gowlett, J. A. J., and Dunbar, R. (2011). The social brain and the shape of the Palaeolithic. *Cambridge Archaeological Journal, 21*, 115–136.

Glisky, M. L., Tataryn, D. J., Tobias, B. A., Kihlstrom, J. F., and McConkey, K. M. (1991). Absorption, openness to experience, and hypnotizability. *Journal of Personality and Social Psychology*, *60*, 263.

Gorman, M. R., and Lee, T. M. (2002). Hormones and biological rhythms. In J. B. Becker, S. M. Breedlove, D. Crews, and M. M. McCarthy (Eds.), *Behavioral endocrinology* (pp. 451–494). Cambridge: MIT Press.

Gowlett, J. A. J. (2006). The early settlement of northern Europe: Fire history in the context of climate change and the social brain. *Comptes Rendus Palevol*, *5*(1–2), 299–310.

Gowlett, J. A. J. (2010). Firing up the social brain. *Proceedings of the British Academy, 158*, 341–366.

Granqvist, P., Reijman, S., and Cardeña, E. (2011). Altered consciousness and human development. *Altering Consciousness. Multidisciplinary Perspectives. Volume II. Biological and Psychological Perspectives, 2,* 211–234.

Hilgard, E. R. (1981). The eye roll sign and other scores of the Hypnotic Induction Profile (HIP) as related to the Stanford Hypnotic Susceptibility scale, form C (SHSS: C): A critical discussion of a study by Frischholz and others. *American Journal of Clinical Hypnosis*, *24*, 89–97.

Hilgard, E. R. (1982). Illusion that the eye-roll sign is related to hypnotizability. *Archives of General Psychiatry, 39,* 963–966.

Hudetz, J. A., Hudetz, A. G., and Reddy, D. M. (2004). Effect of relaxation on working memory and the bispectral index of the EEG. *Psychological Reports*, *95*, 53–70.

Jumby Bay Studios (Producer). (2006). *Ambient fire: The ultimate video fireplace* (4th ed.) [DVD]. Available from http://www.firedvd.com/

Kalia, M. (2002). Assessing the economic impact of stress—The modern day hidden epidemic. *Metabolism*, *51*, 49–53.

Keenan, J. P., Gallup, G. G., Jr., and Falk, D. (2003). *The face in the mirror: How we know who we are*. New York: HarperCollins.

Kirmayer, L. J. (1994). Pacing the void: Social and cultural dimensions of dissociation. In D. Spiegel (Ed.), *Dissociation: Culture, mind, and body* (pp. 91–122). Washington, DC: American Psychiatric Press.

Konner, M. (1985). Transcendental medication. *Sciences*, *25*, 2–4.

Koolhaas, J. M., Bartolomucci, A., Buwalda, B., de Boer, S. F., Flügge, G., Korte, S. M., . . . Fuchs, E. (2011). Stress revisited: A critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews*, *35*, 1291–1301.

Littler, W. A., West, M. J., Honour, A. J., and Sleight, P. (1978). The variability of arterial pressure. *American Heart Journal*, *95*, 180–186.

Ludwig, A. M. (1983). The psychobiological functions of dissociation. *American Journal of Clinical Hypnosis*, *26*, 93–99.

Luhrmann, T. M. (2005). The art of hearing God: Absorption, dissociation, and contemporary American spirituality. *Spiritus: A Journal of Christian Spirituality, 5,* 133–157.

Lynn, C. D. (2005). Adaptive and maladaptive dissociation: An epidemiological and anthropological comparison and proposition for an expanded dissociation model. *Anthropology of Consciousness, 16*, 16–49.

McClenon, J. (1997). Shamanic healing, human evolution, and the origin of religion. *Journal for the Scientific Study of Religion*, *36*, 345–354.

McClenon, J. (2002). *Wondrous healing: Shamanism, human evolution, and the origin of religion*. Dekalb: Northern Illinois University Press.

McClenon, J. (2006). The ritual healing theory: Therapeutic suggestion and the origin of religion. In P. McNamara and J. H. Ellens (Eds.), *Where God and science meet: How brain and evolutionary studies alter our understanding of religion* (pp. 135–158). Westport, CT: Praeger.

Myers, I. B., and McCaulley, M. H. (1988). *Myers-Briggs type indicator: MBTI.* Consulting Psychologists Press.

Rushton, J. P., Chrisjohn, R. D., and Fekken, G. C. (1981). The altruistic personality and the self-report altruism scale. *Personality and Individual Differences, 2*, 293–302.

Riva, G., Gaggioli, A., Pallavicini, F., Algeri, D., Gorini, A., and Repetto, C. (2010). Ubiquitous health for the treatment of generalized anxiety disorders. Paper presented at the *Ubicomp '10: The 2010 ACM Conference on Ubiquitous Computing*, Copenhagen, Denmark. Retrieved from http://www.create-net.org/ubint/ubihealth/papers/Riva_Ubicomp2010_GAD_treatment.pdf

Rohrbaugh, J., and Jessor, R. (1975). Religiosity in youth: A personal control against deviant behavior. *Journal of Personality*, *43*, 136–155.

Rossano, M. J. (2007). Did meditating make us human? *Cambridge Archaeological Journal*, *17*, 47–58.

Rossano, M. J. (2010). *Supernatural selection: How religion evolved*. New York: Oxford University Press.

Rotch, A., Dean, J., Kendrach, M., Wright, S., and Woolley, T. (2001). Blood pressure monitoring with home monitors versus mercury sphygmomanometer. *The Annals of Pharmacotherapy, 35*, 817–822.

Sapolsky, R. M. (1998). *Why zebras don't get ulcers, 2nd edition: An updated guide to stress, stress related diseases, and coping*. New York: W. H. Freeman.

Schauer, M., and Elbert, T. (2010). Dissociation following traumatic stress. *Zeitschrift Für Psychologie/Journal of Psychology*, *218*, 109–127.

Seligman, R., and Kirmayer, L. J. (2008). Dissociative experience and cultural neuroscience: Narrative, metaphor and mechanism. *Culture, Medicine and Psychiatry*, *32*, 31–64.

Simmons, J. P., Nelson, L. D., and Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collect and analysis allows presenting anything as significant. *Psychological Science, 22*, 1359–1366.

Singh-Manoux, A., Adler, N. E., and Marmot, M. G. (2003). Subjective social status: Its determinants and its association with measures of ill-health in the Whitehall II Study. *Social Science and Medicine, 56*, 1321–1333.

Snodgrass, J., Lacy, M., Dengah, H. F., Fagan, J., and Most, D. (2011). Magical flight and monstrous stress: Technologies of absorption and mental wellness in Azeroth. *Culture, Medicine and Psychiatry, 35*, 26–62.

Spiegel, H. (1972). An eye-roll test for hypnotizability. *American Journal of Clinical Hypnosis*, *15*, 25–28.

Spielberger, C. D., and Gorsuch, R. L. (1983). *Manual for the state-trait anxiety inventory (form Y) ("self-evaluation questionnaire")*. Palo Alto, CA: Consulting Psychologists Press.

Stefano, G. B., Esch, T., Cadet, P., Zhu, W., Mantione, K., and Benson, H. (2003).

Endocannabinoids as autoregulatory signaling molecules: Coupling to nitric oxide and a possible association with the relaxation response. *Medical Science Monitor, 9*, RA63–RA75.
Tellegen, A., and Atkinson, G. (1974). Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. *Journal of Abnormal Psychology, 83*, 268–277.
Twomey, T. (2013). The cognitive implications of controlled fire use by early humans. *Cambridge Archaeological Journal*, *23*, 113–128.
Vandewalle, G., Gais, S., Schabus, M., Balteau, E., Carrier, J., Darsaud, A., . . . Maquet, P. (2007). Wavelength-dependent modulation of brain responses to a working memory task by daytime light exposure. *Cerebral Cortex*, *17*, 2788–2795.
Vandewalle, G., Schwartz, S., Grandjean, D., Wuillaume, C., Balteau, E., Degueldre, C., . . . Maquet, P. (2010). Spectral quality of light modulates emotional brain responses in humans. *Proceedings of the National Academy of Sciences*, *107*, 19549–19554.
Watson, R. D., Stallard, T. J., Flinn, R. M., and Littler, W. A. (1980). Factors determining direct arterial pressure and its variability in hypertensive man. *Hypertension, 2*(3), 333–341.
Wilson, E. O. (2012). *The social conquest of earth*. New York: Liveright Pub. Corp.
Winkelman, M. (2011). A paradigm for understanding altered consciousness: The integrative mode of consciousness. *Altering Consciousness: Multidisciplinary Perspectives*, *1*, 23–41.
Wrangham, R. W. (2009). *Catching fire: How cooking made us human*. New York: Basic Books.
Zachariae, R. (2009). Psychoneuroimmunology: A bio-psycho-social approach to health and disease. *Scandinavian Journal of Psychology*, *50*, 645–651.
Zachariae, R., Jorgensen, M. M., and Bjerring, P. (2000). Autonomic and psychological responses to an acute psychological stressor and relaxation: The influence of hypnotizability and absorption. *International Journal of Clinical and Experimental Hypnosis, 48*, 388–403.
Zachariae, R., Paulsen, K., Mehlsen, M., Jensen, A. B., Johansson, A., and Von Der Maase, H. (2007). Anticipatory nausea: The role of individual differences related to sensory perception and autonomic reactivity. *Annals of Behavioral Medicine, 33*, 69–79.