

Sociality, Spirituality, and Meaning Making: Chicago Health, Aging, and Social Relations Study

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Scientific theories in the natural sciences posit invisible forces operating with measurable effects on physical bodies, but the scientific study of invisible forces acting on human bodies has made limited progress. The topics of sociality, spirituality, and meaning making are cases in point. The authors discuss some of the possible reasons for this as well as contemporary developments in the social sciences and neurosciences that may make such study possible and productive.

In approximately 600 BCE, the Greek philosopher Heraclitus referred to the mind as an overwhelming space whose boundaries could never be fully comprehended. For the next 2,300 years, little changed in this regard. Indeed, before the enlightenment of the 18th century, scholars generally believed that thought was instantaneous and that action was governed by an indivisible mind separate from the body. As a result of the belief that the mind was infinitely fast and essentially unanalyzable, there was no point in trying to understand it using scientific means. The human spirit—encompassing the qualities of kindness, mercy, empathy, trust, compassion, justice, love, friendship, devotion, and hope—was championed in art, literature, and religion but was at best ignored by the scientific community.

The past three centuries have been a period of unparalleled advance in science. Scientific theories of magnetism, gravity, and dark matter have emerged to posit invisible forces operating with measurable effects on physical bodies. During this same period, the scientific study of invisible forces acting on human bodies has

made limited progress. Research on the dimensions of sociality, spirituality, and meaning making for instance, has been blunted by biases against what were regarded as soft or religious topics, misguided by metaphors such as the human brain as a solitary computer, and overlooked in a funding climate that demands time and attention be given to societal, psychological, and physiological deficits rather than capacities. Although the history and causes of such biases are complex, little is achieved to mitigate these biases when the constructs of sociality, spirituality, and meaning making are defined imprecisely, their predicted effects are not falsifiable or are difficult to replicate, or the underlying mechanisms for such effects are not delineated within a framework that is recognized by the scientific community.

The dawn of the 21st century may herald a paradigm shift in constructs deemed amenable to scientific inquiry. With new developments and instruments in genetics, neuroscience, brain science, and behavioral science, long-standing scientific biases are being challenged by rigorous quantitative analysis. Fueling these challenges is the recognition that the traditional focus by founding and federal funding agencies on maladies and disease misses the mark on some of the most complex yet pressing and enduring questions of humankind.

The guiding metaphors are also undergoing dramatic transformations. Now that the human genome has been sequenced and has been found to involve fewer genes than anticipated, it has become apparent that humans are not inextricably determined by their genotype irrespective of their social environment. In addition, the ex-

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tended period of utter dependency of the human infant has led to the recognition that human genetic transmission is based not on an individual's selfish ability to reproduce but on the success of offspring to reproduce (Dawkins, 1976). Accordingly, we have a better appreciation of how humans have evolved to be an inherently social, meaning-making species.

Moreover, the notion of the solitary computer—the dominant metaphor for the human mind for more than a quarter century—suddenly seems dated. Computers today are massively interconnected devices with capacities that extend far beyond the resident hardware and software of a solitary computer. How ironic that although the telereceptors of the human brain have provided wireless broadband interconnectivity to humans for millennia, it took the advent of technological innovations for it to become patently obvious that the isolated computer is a poor metaphor for the human mind.

The qualities of kindness, mercy, empathy, trust, compassion, justice, love, friendship, devotion, and hope—qualities attributed in art, literature, and religion to the human spirit—did not comport well with the dominant metaphors of the mind in the latter part of the 20th century. Today, these same qualities are simple to incorporate into a metaphor of the mind as a massively networked portable computer, given the recognition that human genetic transmission relies in part on cooperation and nurturance.

Even useful metaphors have limited utility, however, if the constructs under study are poorly defined. In our study of sociality, spirituality, and meaning making, we define sociality as the need for the company of others, measurable as the tendency to form social connections, to react to perceived social isolation, and to exhibit the long-term effects of social connectedness on health, successful aging, and well-being.

By spirituality we mean a theoretical construct that represents what is common in human qualities such as kindness, mercy, virtue, empathy, trust, compassion, justice, love, friendship, devotion, and hope. Accordingly, sociality may underlie spirituality in at least two senses. As we explain subsequently, we posit that the qualities ascribed in art, literature, and religion to the human spirit evolved because humans are fundamentally a social species. Human virtues are social virtues, potentially lending spirituality and sociality a common substrate. In addition,

sociality may serve as a model for spirituality, as when people form a personal relationship with a deity. As in the case of sociality, the nature and existence of the deity with whom a person forms a relationship is less important than the person's mental representations of the deity and relationship to the deity. The measurable effects of spirituality also mirror those for sociality, including the tendency to form a mental representation that relates the self to a deity; to exhibit the long-term effects of such a relationship on health, effective aging, and well-being; and to react to perceived separation from or loss of worth in the eyes of the deity with behavioral, physiological, and emotional responses. Spirituality and sociality overlap in measurable ways such as religious affiliation, church attendance, and church participation; accordingly, these variables are also investigated.

Central to sociality and spirituality is meaning making, defined as the construction of an account or recital of an event or a series of events, either true or fictitious, that serves to organize or structure life. Our definition of meaning making is compatible with current theory in perception and cognition, in which even visual percepts are generated according to a wholly empirical strategy that signifies to the individual the empirical significance of the stimulus rather than its properties as such (Purves, Lotto, & Nundy, 2002).

We begin with a brief evolutionary argument for the importance of sociality in the survival of the human species. We then describe a neuroscientific approach to the study of molar constructs such as sociality, spirituality, and meaning making, and we review recent findings from our program of research on social isolation and loneliness.

Sociality, Spirituality, and Meaning Making as Components of Human Nature

The genetic constitution of *Homo sapiens* derives not simply from an individual's reproductive success but more critically from the success of one's children to reproduce. The human infant is born to an extended period of complete dependency. If infants do not elicit nurturance and protection from caregivers, or if caregivers are not motivated to provide such care over an extended period of time, the infants perish along with the genetic legacy of the parents. Hunter/gatherers who, in times of danger

or famine, chose not to return to share their food with mother and child may have survived to hunt another day, but the genetic constitution that enabled them to feel so little humanity also made it less likely their genes were propagated. In contrast, those who yearned to return despite personal hardship, and individuals who protected and nurtured those close to them, were more likely to have offspring who survived to propagate.

Even as adults, humans are not particularly stealthy, strong, or fast relative to other species. It is their collective action—their ability to think, communicate, and work together—that makes *Homo sapiens* such a formidable species. Because human collective action provides an evolutionary advantage over other species and because genetic transmission is based not on one's ability to reproduce but on the success of one's children to reproduce, *Homo sapiens* are thought to have evolved to be an inherently social, meaning-making species with qualities ascribed in art, literature, and religion to a human spirit. In short, we posit that tens of thousands of years of evolution have deeply planted sociality, spirituality, and meaning making in our genome and in our societies. Accordingly, humans are posited to have evolved a brain and biology whose functioning benefits from the formation and maintenance of social bonds, human/social virtues, and organizational life narratives. The deprivation of any of these ingredients—such as ruptures of social connectedness that result from relocation distant from friends and family—produces feelings of isolation and dysphoria, physiological alterations, and a motivation to reinstate connections. Given the evolutionary origins of these effects, there should also be heritable individual differences in the extent to which social disconnectedness produces such effects.

The extant evidence clearly shows that humans quickly learn to attend to faces, perceive communicative displays, comprehend social hierarchies, and form causal attributions (see Cacioppo & Berntson, 2004). People develop a theory of mind by which the traits, intentions, and emotions of others are inferred; they communicate with others and they sometimes hide or miscommunicate their own mental contents from others; they form relationships, unions, and alliances; and they search for meaning in events and patterns. Meaning making and sociality are such fundamental components of hu-

man nature that people perceive these characteristics in the movements of simple inanimate objects. Heider and Simmel (1944), for instance, produced a short film of the movement of a small triangle, a small circle, and a large triangle around and into a large rectangle. The animated film consisted only of these geometric shapes, yet everyone who viewed the film “saw” a social drama complete with intentions, plans, and emotions. Only SM, an individual without functioning amygdala—an almond-shaped pair of nuclei deep in the medial temporal lobes of the brain—failed to perceive these movements as occurring within a social arena (Adolphs, 1999).

Given our evolutionary history, we would contend that people's conceptual representation of sociality has a specifiable, generalizable, and possibly universal structure (Hawkey, Browne, & Cacioppo, 2004). In the first study underlying this claim, 2,531 undergraduates completed a scale consisting of 20 questions that differentiated people who perceived themselves to be socially isolated from those who perceived themselves to be socially integrated (Hawkey et al., 2004). An exploratory factor analysis on half of the sample revealed three correlated dimensions generalizable across gender, and a confirmatory factor analysis on the other half of the sample corroborated this finding: The college students' beliefs, feelings, and ideas about their social connectedness were structured as three separable but related (oblique) dimensions: isolation, relational connectedness, and collective connectedness.

In a population-based follow-up study, we tested a very different sample of individuals, a statistically representative sample of 230 men and women (one third African American, one third Hispanic, one third Caucasian) from Cook County, Illinois, born between 1935 and 1952 (M age = 57.5 years; Hawkey et al., 2004). Despite the fact that this sample was an older urban sample of varying ethnic backgrounds, socioeconomic status (SES), and occupations, the confirmatory factor analysis supported the same three-factor structure found for the college students. Their feelings of social disconnectedness consisted of three related factors: feelings of isolation/intimate connectedness, feelings of relational connectedness, and feelings of collective connectedness.

Importantly, we also found statistically separable predictors of each of these facets of soci-

ality. In our urban sample of older adults, we found marital status to predict feelings of isolation, contact with friends and family to predict feelings of relational connectedness, and membership in voluntary groups to predict collective connectedness (Hawkley et al., 2004). Tests of the universality of this structure (isolation, relational connections, collective connections) are needed, but it is worth noting that psychological theories of the self, which traditionally have focused on a person's sense of unique identity differentiated from others, now distinguish among the personal self (individual level of analysis), relational self (interpersonal level of analysis), and collective self (group level of analysis; Brewer & Gardner, 1996).

Individuals who score low on personal, relational, and collective dimensions of sociality also perceive themselves to be social isolates and report intense feelings of loneliness and dysphoria (Cacioppo, Ernst, et al., 2000; Cacioppo et al., in press; Russell, Peplau, & Cutrona, 1980). Individual differences in the net content of this structure are about 50% heritable and 50% environmental (Boomsma, Willemsen, Hawkley, & Cacioppo, 2004; S. McGuire & Clifford, 2000). In an early study of the origins of these feelings, S. McGuire and Clifford (2000) examined the heritability of loneliness in children. In their first study, 69 biologically related sibling pairs and 64 unrelated pairs in adoptive families in the Colorado Adoption Project completed an 8-item loneliness scale when they were 9, 10, 11, and 12 years of age. In a second study, 22 monozygotic twins, 40 dizygotic twins, and 80 full siblings 8–14 years of age completed a 16-item scale to assess loneliness in relation to their schoolmates. Results revealed significant genetic (h^2 values of 55% and 48%, respectively, in Studies 1 and 2) and unshared environmental contributions to individual differences in loneliness.

In the S. McGuire and Clifford (2000) studies, the sample sizes were relatively small, and because the studies involved adopted children, the representativeness of the sample for a population estimate is uncertain. Moreover, heritability estimates of complex traits such as loneliness may change across the life span as the frequency, duration, and range of exposure to environmental influences accrue. We therefore extended this work using data from the Netherlands Twin Register Study (Boomsma, Cacioppo et al., 2004). Data on loneliness

from 7,665 young adult and adult Dutch twins (average age: 24 years) were analyzed with genetic structural equation models. The estimate of genetic contributions to variation in loneliness in adults was 47%, with the remaining variance explained by unique environmental factors. Thus, the heritability estimates in adults were similar to those found previously in children, and no evidence was found for sex or age differences in genetic architecture or configural effects of the genes. In an ongoing effort to more specifically identify the genetic locus, Boomsma, Willemsen, Dolan, Hawkley, and Cacioppo (in press) conducted a complete genome scan and found evidence for two quantitative trait loci, suggesting that at least two sets of genes with additive effects are involved.

The striking development of the human cerebral cortex, especially the frontal and temporal regions, is believed to be largely responsible for evolutionary advances in social and cognitive capacities. The cerebral cortex is a mantle of between 2.6 and 16 billion neurons, with each neuron receiving 10,000 to 100,000 connections from other neurons (e.g., Pakkenberg, 1966). The human frontal (front part of the brain) and temporal (right and left sides) lobes constitute 32% and 23% of the cerebral cortex, respectively, arguably rendering the sensorimotor cortices that dominate most mammalian brains to minority status in the human brain. The expansion of the frontal regions in the human brain is largely responsible for the human capacity for reasoning, planning, and performing mental simulations, and an intact frontal region contributes to the human ability to reason, remember, and work together, thereby contributing to the evolutionary success of humans (Bar-On, Tranel, Denburg, & Bechara, 2003; Krin-gelbach & Rolls, 2004). The temporal and parietal regions, in turn, play essential roles in social perception, social reasoning, and communication (cf. Adolphs, 1999, 2001; Berntson, Boysen, & Cacioppo, 1993; Saxe & Kanwisher, 2003).

Despite these evolutionary advances, human cognition and meaning making are often biased and counterfactual. The sensory load from the physical environment is minor in comparison with the quantity and complexity of the information that comes from other individuals, groups, alliances, and cultures, including the potential for benevolence or treachery posed by each. Human cognition is not an objective in-

formation process but instead is rife with the operation of self-interest, self-enhancement, and self-protective processes. Because humans encounter more information than can possibly be processed, they tend to economize on thought when forming beliefs that are not personally relevant (Petty & Cacioppo, 1986) and tend to search for and attend to evidence that confirms what they already believe to be true (Snyder & Swann, 1978).

Information processing is also biased in ways that protect the self from symbolic as well as actual threats and that promote reproductive success (e.g., Jones & Berglas, 1978). In fact, people are not particularly good at knowing the causes of their feelings or behavior (Nisbett & Wilson, 1977). People overestimate their strengths and underestimate their faults (M. Ross & Sicoly, 1979). They overestimate the importance of their input, the pervasiveness of their beliefs, and the likelihood that a desired event will occur (W. J. McGuire, 1981), all while underestimating the contributions of others and the likelihood that risks in the world apply to them (L. Ross, Greene, & House, 1977). Events that unfold unexpectedly are not reasoned as much as they are rationalized (Aronson, 1968), and the act of remembering is far more of a biased reconstruction than an accurate record of actual events (McDonald & Hirt, 1997; Roediger, Buckner, & McDermott, 1999). Many of these biases in social cognition are spontaneous, do not require cognitive effort, and represent normative processing.

A crucial consequence of the nuances of the biased fashion in which humans make meaning is that humans have much more influence in the creation of their lives and social relationships than most realize (Downey, Freitas, Michaelis, & Khouri, 1998; Murray, Holmes, & Griffin, 1996). If an individual is led to believe a new acquaintance is fun and nice, for instance, the individual behaves in a fashion that draws out pleasant and enjoyable behaviors from the person. If an individual is led to think a child is intelligent, the individual does and says things that make a smarter child than would result if the individual was led to believe the child was of average intelligence. Another instance of biased meaning making is the tendency of people to self-handicap when they think they will fail at an important task. By subtly producing insurmountable obstacles to success, they can at-

tribute their subsequent failure to these obstacles rather than to themselves.

Importantly in the present context, bias in social cognition is also at work when people who feel socially connected construe the world as presenting challenges to be overcome with the aid of others and react to interpersonal conflicts in peaceful and constructive rather than offensive and aggressive ways, thereby producing an environment that others want to inhabit (Cacioppo & Hawkley, *in press*). In contrast, lonely individuals are more likely to construe their world (including the behavior of others) as potentially threatening or punitive. Consequently, lonely individuals are more likely to be socially anxious, hold more negative expectations for their treatment by others, and adopt a prevention focus rather than a promotion focus in their social interactions. These individuals are also more likely to appraise stressors as threats rather than challenges and to cope with stressors in a passive, isolative fashion rather than an active fashion that includes actively seeking the help and support of others. Together, these differences in social cognition predictably result in an increased likelihood of lonely individuals acting in self-protective and, paradoxically, self-defeating ways (Cacioppo & Hawkley, *in press*). In each instance, the individuals may be oblivious to the fact that the way in which they perceived and thought about their social world contributed to their social realities.

We noted at the outset that biases against the scientific study of constructs such as sociality, spirituality, and meaning making are attributable to imprecise definitions, nonfalsifiable or nonreplicable effects, a focus on associations rather than underlying mechanisms, and the absence of a broad scientific framework within which to study abstract constructs of this sort. We next address the latter issue. Specifically, we argue that a neuroscience perspective may provide a framework that allows theoretical constructs and associations to be rigorously defined, tested, and parsed so as to investigate their underlying mechanisms.

Social Neuroscience Perspective

During the latter half of the 20th century, the nature of the human mind was plumbed through clever experimental designs that used measures of verbal reports, judgments, and reaction time. These methodologies proved limited, however.

Social cognition and interactions range from affect laden to habitual, and nuances deriving from these features may prove difficult to capture fully using subjective measures and response latencies to semantic (e.g., lexical decision) tasks alone (LeDoux, 2000; Zajonc, 1980). A new approach, termed *social neuroscience*, first introduced just over a decade ago (Cacioppo & Berntson, 1992), represents a new development in the study of the human mind, including how sociality, spirituality, and the meaning of life might modulate brain and biology.

Human nature is recognized as being complex. To simplify the study of human nature, neuroscientists in the past century tended to ignore or hold constant social influences, whereas cognitive and social scientists tended to ignore the biological constraints on and mechanisms through which cognition, affect, and conation are expressed. In the neurosciences, the architects of development and behavior were conceived as anatomical structures and genetic strings sculpted by the forces of evolution operating over millennia, the builders were cast as encapsulated within living cells far from the reach of social influences, and the brain was treated as an analytical information-processing machine. The additional information that might be attributable to the social world was thought to be best considered last, if the need arose. Social factors, the reasoning often went, had minimal implications for basic development, structure, or processes of the brain or mind, in which case the consideration of social factors is entirely irrelevant. And even if relevant, consideration of social factors may render the study of the human mind and behavior too complicated to sustain scientific progress.

The attitude toward the neurosciences among cognitive and social scientists throughout most of the 20th century was no less antagonistic (Berntson & Cacioppo, 2000; Cacioppo, 2002). World wars, the Great Depression, and civil injustices made it amply clear that social and cultural forces were too important to address to await the full explication of cellular and molecular mechanisms. Biological constraints, mechanisms, and insights tended to be ignored, often under the misguided auspice of protecting the behavioral sciences from the onslaught of reductionism. The specialized knowledge and fundamental research that were required to cultivate descriptive taxonomies, theoretical for-

mulations, and methodologies—coupled with an early emphasis on isolated scientific work—all but ensured that social and biological perspectives would evolve insulated from developments in the other.

For decades, the central precept of molecular biology was that all of the information we need to construct a mammalian body, whether man or mouse, is contained in the approximately hundred thousand genes of mammalian DNA and that a set of master genes activates the DNA necessary to produce the appropriate proteins for development and behavior (Crick, 1970; Panksepp, 1998). In this scheme, DNA encodes the sequence of amino acids in proteins and peptides using the sequence of nucleotides in the gene as a template. The DNA sequential code is transferred to messenger RNA (mRNA) via transcription, a process involving enzymes (RNA polymerases), followed by translation from mRNA to polypeptide chains (protein pieces) and proteins. The process of DNA to RNA transcription has been assumed to be restricted to the confines of living cells outside the influence of personal and social ties.

As neuroscientific approaches have been applied to more complex questions, however, these presumably basic principles have begun to be questioned. Recent research suggests that even DNA to RNA transcription can be subject to modulation by the social environment (Cacioppo, Berntson, Sheridan, & McClintock, 2000). In an illustrative study, we investigated the DNA to RNA transcription for a growth hormone that occurs within a type of immune cell called a lymphocyte. The production of this growth hormone is of interest because it is thought to be involved in the effectiveness of lymphocytes to combat pathogens. We recently found that caregivers of spouses with Alzheimer's disease (AD) had markedly suppressed lymphocyte growth hormone mRNA levels relative to age- and gender-matched controls (Wu et al., 1999). It is reasonable to assume that the spouses of AD patients were essentially randomly assigned to caregiver or noncaregiver roles by their spouse's unexpected development of AD, in which case these results indicate that social roles can modulate DNA to RNA transcription processes.

The behavior of strains of mice with specific genes inactivated (i.e., knockout mice) has been known to depend on genetic background, whereas the effects of the social context have

been thought to be unimportant. Contrary to this latter belief, however, Crabbe, Wahlsten, and Dudek (1999) found that the specific behavioral effects associated with a given knockout could vary dramatically across experimenters, testing environments, and laboratories. The implication of these and related studies is that aspects of genetic expression, which were thought to be encapsulated within each living cell far from the reach of personal ties or social influences, are in fact subject to modulation by the social environment.

In the twilight of the 20th century, neuroscientists and cognitive scientists began to collaborate more systematically, united by the common view that information processing could best be understood by appeal to the brain as well as its emergent manifestation in mind and by the goal of understanding how the mind works. These collaborations have helped unravel puzzles of the mind including aspects of perception, imagery, attention, and memory. Many aspects of human nature require a more comprehensive approach, however. These include aspects of the human spirit such as sociality, altruism, affiliation, attachment, kin recognition, social identification, communication, cooperation, commerce, empathy, morality, contagion, love, nurturance, kindness, mercy, compassion, justice, friendship, and hope. All can be conceptualized as invisible forces emanating from the operation of the human brain within a social arena with measurable effects not only on subjective well-being but on brain, biology, and health.

Brain imaging studies clearly point to the attention given to social stimuli. If an individual views a novel picture of an evocative image (e.g., snowcapped mountains) or an equally pleasant, arousing, and statistically infrequent image of a person (e.g., a smiling baby), the social stimulus elicits a larger amplitude late positive electrocortical (event-related brain) potential that peaks about 550 ms after stimulus onset (Ito & Cacioppo, 2000). In addition, the differential event-related response emerges even when the task is simply to classify whether the picture is pleasant or unpleasant. That is, the brain is spontaneously extracting information about the presence of conspecifics even when the explicit task has nothing to do with this distinction (Ito & Cacioppo, 2000). Functional magnetic resonance imaging studies have similarly suggested that social perception and social reasoning are robust elicitors of localized re-

gions of brain activation and reflect distinct aspects of social and emotional processing (e.g., see Blakemore, Winston, & Frith, 2004; Cacioppo & Berntson, 2004).

The field of social neuroscience, of course, stretches far beyond social cognition, human studies, or brain imaging methodologies (see Cacioppo & Berntson, *in press-b*; Cacioppo, Berntson, et al., 2002). As the 21st century dawns, there is a recognition that much of the groundwork for multidisciplinary scientific collaborations has been laid by the giants of the preceding three centuries. Neuroscientists, cognitive scientists, and social scientists are moving beyond simplifying assumptions and are placing less emphasis on the arbitrary division between the social and the biological sciences to work collaboratively toward developing more comprehensive theories of mind, brain, biology, and behavior. Through the efforts of such individuals, the broad multidisciplinary perspective of social neuroscience is gaining momentum, making more feasible the rigorous scientific study of questions such as how sociality, spirituality, and the meaning of life operate. Throughout this article, we have described such examples from our own research, ranging from behavioral genetics to brain imaging. In the remainder of the article, we survey results from our multidisciplinary research to examine the mechanisms underlying the association between social connectedness and longevity and well-being.

Chicago Health, Aging, and Social Relations Study

In 2002, we began a population-based longitudinal study of 230 English-speaking Blacks/African Americans, non-Black Hispanics, and non-Hispanic Caucasians between the ages of 50 and 67 years from Cook County, Illinois, to investigate the social, behavioral, cognitive, emotional, brain, autonomic, neuroendocrine, cellular, and molecular transduction pathways by which the social world affects well-being and health (e.g., Cacioppo & Berntson, *in press-a*, *in press-b*; Cacioppo & Hawkley, 2003; Cacioppo, Hawkley, & Berntson, 2003). The Chicago Health, Aging, and Social Relations Study (CHASRS) was built on our previous research on thousands of young adults (Cacioppo, Ernst, et al., 2000; Cacioppo, Hawkley, Berntson, et al., 2002; Cacioppo, Hawkley,

Crawford, et al., 2002; Hawkley et al., 2004) and older adults (Cacioppo et al., 1998; Uchino, Kiecolt-Glaser, & Cacioppo, 1994) and on meta-analyses of the literature (e.g., Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

Among our findings from this earlier work was that socially connected individuals are more likely to meet everyday stressors by active coping and recruiting others' help. Individuals who feel socially isolated are more likely to construe their world (including the behavior of others) as threatening or punitive. They are more likely to appraise stressors as threats rather than challenges and to cope with stressors in a passive fashion by isolating themselves from others and withdrawing from the problem situation. Together, these differences in meaning making result in an increased likelihood of socially connected individuals acting in a humane, selfless fashion, reinforcing their connections with others and enhancing their self-esteem, and of lonely individuals acting in self-protective and, paradoxically, socially acidic and self-defeating ways (Cacioppo, Ernst, et al., 2000; Cacioppo & Hawkley, in press; Hawkley, Burleson, Berntson, & Cacioppo, 2003).

Why might lonely individuals be more emotionally withdrawn in social settings? Personality differences such as shyness, sociability, negativity, and fear of negative evaluation may provide a partial explanation. In addition, because social settings can be overwhelming, social effectiveness depends on an individual's ability to exert voluntary control over his or her attentional focus. Moreover, regulating one's attention can help one garner social approval. Do lonely individuals differ in their ability to voluntarily control their attentional focus? As a means of exploring self-regulation, participants in our study of loneliness in young adults performed a dichotic listening task while at the clinical research center. The dichotic listening task required that participants identify the consonant-vowel pair presented to their right or left ear. Because the auditory system is predominantly crossed and because language is left-lateralized in most right-handed individuals, right-handed individuals tend to perform better when verbal stimuli are presented to the right than left ear. (All of the participants in this study were right-handed.) Superimposed on this general right-ear advantage, however, are the effects of attention, as individuals generally perform better when verbal stimuli are presented to

the ear to which they are focusing their attention. The former effect is said to be data driven or bottom-up, whereas the latter is said to be conceptually driven or top-down.

As predicted, we found an overall right-ear advantage across loneliness groups (lonely, normal, and nonlonely) and instructional conditions (Cacioppo, Ernst, et al., 2000). In addition, however, a significant main effect of attentional instruction showed that individuals performed better with left-ear stimuli when they were instructed to focus on the stimuli presented to their left ear than in the other conditions. Moreover, lonely individuals tended to show the strongest right-ear advantage in the no-instruction condition, presumably reflecting the potency of bottom-up (stimulus-driven) attentional processing, but failed to shift to the left-ear advantage when instructed to focus on their left ear. Specific planned contrasts confirmed that all three groups showed a significant right-ear advantage during the focus on right-ear condition, but only the normal and nonlonely individuals were able to shift to a significant left-ear advantage in the focus on left-ear condition.

Together, these results are consistent with the notion that attentional control appears comparable in lonely and nonlonely individuals until voluntary attentional control conflicts with automatic attentional processes, at which point lonely individuals show an attentional deficit. This result raises the possibility that lonely individuals may feel threatened or overwhelmed and therefore withdraw from the social environment, especially new or complex social environments, because they have less control over the focus of their attention than nonlonely individuals. In fact, Baumeister and colleagues recently found that experimental manipulations of social exclusion could produce a similar effect on dichotic listening and self-regulation (Baumeister & DeWall, in press).

A measure of the importance of social connectedness is that it predicts morbidity and mortality from broad-based causes (e.g., Seeman, 2000). The reasons for this effect remain unclear. As noted earlier, few differences in traditional health behaviors (e.g., smoking, exercise, or nutrition) have been found to differentiate lonely and nonlonely individuals, for instance (Cacioppo, Hawkley, Crawford, et al., 2002; Seeman, 2000). We therefore have explored other possible mechanisms by which loneliness may have deleterious effects on health: health

behaviors, cardiovascular activation, cortisol levels, and sleep (Cacioppo et al., 2003).

In one study, we assessed autonomic activity, salivary cortisol levels, sleep quality, and health behaviors in undergraduate students selected, on the basis of pretests, to be among the top or bottom quintile in feelings of loneliness (Cacioppo, Hawkley, Crawford, et al., 2002). We found that the total peripheral resistance to blood flow through the circulatory system in the body was higher in lonely than nonlonely participants, whereas cardiac contractility (the force of a heartbeat), heart rate, and cardiac output were higher in nonlonely than lonely participants. Such differences, although not detrimental in the robust cardiovascular system of young adults, may constitute a source of wear and tear on the vascular system and on regulatory controls of blood pressure, with cardiovascular dysfunctions not appearing until later in life. We also found that lonely individuals reported poorer sleep than nonlonely individuals. Differences in sleep efficiency in young adults, as with differences in cardiovascular function, may have minimal health consequences in the short term but may influence significant health outcomes over time, especially in later life when physiological functions become more fragile.

In a follow-up study, we assessed blood pressure, heart rate, salivary cortisol levels, sleep quality, and health behaviors in older adults whose loneliness was assessed at the time of testing at their residence (Cacioppo, Hawkley, Crawford, et al., 2002). Results indicated greater age-related increases in blood pressure and poorer sleep quality in lonely than nonlonely older adults. These results suggest that the stress and dysphoria associated with feeling isolated contribute to wear and tear on the body and, over time, to the degradation of central and peripheral regulatory systems.

Humans are not static mechanical devices that simply wear out, but instead, human physiology includes anabolic processes that promote repair and maintenance (e.g., wound healing) and growth (e.g., muscular development) in response to stressors. Sleep is the quintessential restorative behavior, however, and sleep involves no obvious social interaction. We therefore next asked whether the restorative power of sleep was greater for people who felt low rather than high levels of loneliness (Cacioppo, Hawkley, Bertson, et al., 2002). All participants

were tested one night in the clinical research center of an academic hospital and several additional nights in their residence. Results revealed that lonely and nonlonely individuals allocated the same amount of time in bed for sleep, but lonely individuals evinced poorer sleep efficiency and more time awake after sleep onset than nonlonely individuals. These results suggest that lonely individuals may be less resilient than nonlonely individuals in part because they sleep more poorly. These results also raise the possibility that feelings of social connectedness may influence the extent to which wear and tear on the brain and body can be slowed or reversed by inherent anabolic processes. That is, sociality not only may influence the selection of health behaviors but may modulate the salubrity of restorative behaviors.

We designed the CHASRS to include detailed medical histories, health assessments, measures of health care use, health behavior measures (both self-report and objective), sleep quality indexes, personality measures (e.g., Big Five), life event assessments, nutrition and exercise measures, markers of metabolic and inflammatory processes, endocrine and immune assays, baseline autonomic (especially cardiovascular) assessments and tests, tests of memory and cognitive function, exposure and reactivity to stressors, mood, volunteerism, optimism, hopefulness, church attendance, and religiosity. Finally, economic and sociological components (e.g., neighborhood characteristics, education, income, and social networks) have been incorporated into the design of the CHASRS. We have used these data, for instance, to examine the social, behavioral, cognitive, and emotional pathways through which neighborhoods affect health and well-being. Using data from the CHASRS, we recently found that neighborhood contexts predict self-reported health in older adulthood even after controlling for age and gender (Wen, Hawkley, & Cacioppo, 2004). More important, we found that the impact of neighborhood SES (e.g., education and income) on health was mediated in our population-based study through the subjective perception (meaning making) of neighborhood. The data further showed that these neighborhood effects on health were mediated independently by individual SES, loneliness/connectedness, and depression but not by size of social networks or perceived support.

As a complement to the Chicago population-based longitudinal study and in collaboration with Linda Waite and M. E. Hughes, a three-item measure of loneliness was included in the 2002 wave of the Health and Retirement Study, a longitudinal study of the later life course in a nationally representative sample of individuals born in 1947 or earlier (e.g., Hughes, Waite, Hawkley, & Cacioppo, 2004). At each wave (interview), detailed information is collected about the respondent's health, family relationships, employment, income and wealth, and demographic background. A nationally representative sample of 2,182 individuals completed the module administered as part of the CHASRS. The three-item survey scale of loneliness was found to have adequate internal consistency and to correlate highly with the full revised UCLA Loneliness Scale (Hughes et al., 2004).

Analyses of the Health and Retirement Study and the Chicago population-based sample further indicated that objective social isolation and loneliness are related and that loneliness in both samples was similarly associated with poorer self-reported health, poorer self-reported emotional health, and a greater number of chronic health conditions. As noted earlier, the hypothesis that the health behaviors of patients account for higher levels of morbidity and mortality among lonely or isolated individuals has received weak support. Care for patients has come under scrutiny in the past decade because studies have shown that health care in the United States falls short of basic quality standards and that health care provision is influenced subtly by various extraneous factors such as gender, race, and age. We reasoned that if the health care provided to patients who appear to be socially isolated is of lower quality than that provided to patients with family and friends, then at least part of the explanation for the morbidity/mortality relationship may be attributable to the decisions and behaviors of health care providers rather than to the health behaviors of the patients themselves (Cacioppo, Brown, & Hawkley, 2004).

As an initial exploration of this hypothesis, we conducted a national study, randomly sampling 600 physicians whose practice centers on the treatment of older adults. The physicians were asked a series of questions comparing the care of hospital inpatients with constructive and involved family members or friends and inpa-

tients who were socially isolated, along with another series of questions comparing the care of inpatients with difficult or hostile family members or friends and inpatients who were socially isolated. In each series of questions, the physicians indicated the health care they observed to be provided by nurses, doctors, ancillary staff (e.g., physical therapists and nurses aides), and themselves. To allow the same survey question to be used for physicians from different medical specialties and to address the care provided by various health care agents (doctors, nurses, and ancillary staff), respondents were asked simply to indicate who received "better care." Finally, we assessed attributes of the physicians such as medical specialty, region of the country in which they practiced, years of experience, and type of medical facility (e.g., hospital) to determine whether these factors moderated physicians' beliefs about the effects of their patients' social milieu on health care provision.

Survey results indicated that physicians reported that they and other physicians, nurses, and ancillary staff provide better medical care to inpatients with constructive family and friends than inpatients without family or friends, whereas inpatients with hostile family and friends receive treatment comparable to that received by socially isolated inpatients. These findings held for outpatients as well as inpatients and regardless of the physician's medical specialty, type of hospital in which the physician practiced, years of experience, and region of the country. These results indicate that social isolation may be associated with broad-based morbidity and mortality at least in part because the care provided by physicians and health care professionals differs.

Results from the CHASRS also confirmed that sociality has profound effects on physiological functioning and sleep. As in our earlier studies, we have observed that lonely older adults exhibit evidence of chronically elevated sympathetic activation (e.g., higher overnight urinary epinephrine and resting blood pressure), greater arterial stiffness, and less efficient or effective sleep. These results suggest that social isolation and loneliness have the potential to simultaneously increase physiological load via sympathetic activation and decrease the capacity to recover from that load via reduced quality of sleep.

Conclusion

Although the ancestral heritage of *Homo sapiens* has placed an emphasis on sociality, Western thought and culture value individual excellence over collective achievement. The evidence we have reviewed suggests our ancestral heritage is not easily ignored even if its effects are not immediately obvious. Specifically, we have argued that the human brain has evolved to facilitate social information processing and action and that human contact and nurturance are necessary for normal brain development and function. Loneliness is in part heritable, with individual differences in the level of social connectedness required to feel right. Feelings of social connectedness, or the lack thereof (i.e., loneliness), were further found to be represented conceptually as three facets of a single overarching construct, the facets being isolation/intimate connectedness, relational connectedness, and collective connectedness. These facets are correlated but are nevertheless related distinctively and predictably to life circumstances. In addition, data from the CHASRS indicate that an individual's self-esteem and sense of purpose in life reflect the individual's perceived intimate, relational, and collective connectedness. Dysphoria/depression, too, has been found to be a distinct but related theoretical construct commonly triggered by social rejection or disturbances (Cacioppo et al., in press).

How we think about people in everyday life may be profoundly affected by feelings of social connectedness as well. For instance, lonely individuals are more likely than nonlonely individuals to construe their world, including the behavior of others, as threatening or punitive. Consequently, lonely individuals are more likely to be socially anxious, hold more negative expectations for their treatment by others, and adopt a prevention focus rather than a promotion focus in their social interactions. Lonely, relative to nonlonely, individuals are also more likely to appraise stressors as threats rather than challenges and to cope with stressors in a passive, isolative fashion rather than an active fashion that includes actively seeking the help and support of others. Together, these differences in social cognition result predictably in an increased likelihood of lonely individuals acting in self-protective and, paradoxically, self-defeating ways. These dispositions, in turn,

activate social neurobehavioral mechanisms that may contribute to the association between loneliness and mortality.

In summary, we would argue that it is time to move beyond the solitary computer as a metaphor for the human mind. Computers today are massively interconnected devices with capacities that extend far beyond the resident hardware and software of a solitary computer. In this development, contemporary computers are becoming a better metaphor for the human mind, as the telereceptors of the brain have provided wireless broadband interconnectivity to humans for millennia.

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