Articles

Aging and Health: Effects of the Sense of Control

JUDITH RODIN

The relation between health and a sense of control may grow stronger in old age. This could occur through three types of processes: experiences particularly relevant to control may increase markedly in old age; the association between control and some aspect of health may be altered by age; and age may influence the association between control and health-related behaviors or the seeking of medical care. Studies show that there are detrimental effects on the health of older people when their control of their activities is restricted; in contrast, interventions that enhance options for control by nursing home patients promote health. With increasing age, however, variability in preferred amounts of control also increases, and sometimes greater control over activities, circumstances, or health has negative consequences including stress, worry, and self-blame. Mechanisms mediating the control-health relation include feelings of stress, symptom labeling, changes in the neuroendocrine and immune systems, and behavior relevant to health maintenance.

IT HAS BEEN SUGGESTED THAT OLD AGE IS ASSOCIATED WITH biological changes and environmental experiences that affect both a person's perceived competence and range of potentially controllable outcomes (*1–3*). Studies have shown that changes in options for control may profoundly affect emotional and physical health (*4*), possibly by influencing stress resistance, physiological responses, and behavior relevant to health. These possibilities bear special scrutiny in light of projected demographic shifts in the coming years; for example, current projections are that, by the year 2050, a quarter of the U.S. population will be over 65 (*5*).

Evidence is reviewed here for the proposal that the strength of the relation between control and health increases with aging. Effects of restrictions and enhancement of control on the health of older people are then considered. A joint task force of the American medical and nursing associations addressed how to improve health care of the aged chronically ill and concluded that "a sense of purpose and control over one's life is integral to the health of the aged" (*6*). Although several studies support this assertion, there are also potential negative consequences of this new emphasis on increased control. Finally, the behavioral and biological mechanisms by which variations in control affect the mental and physical health of the elderly are examined.

The author is the Philip R. Allen Professor of Psychology and professor of medicine and psychiatry at Yale University, Box 11A Yale Station, New Haven, CT 06520.

The Relation of Control to Health in Old Age

Reasons why the relation between an individual's health and sense of control might grow stronger in old age can be represented by three general categories (*7*). First, it is probable that control is an issue of special relevance for older people either because experiences related to control increase markedly in old age or because these experiences have different social meaning. Loss of friends and family members or retirement, for example, may affect the types of outcomes that actually are attainable in old age or may deprive individuals of regular feedback concerning their competence. Stereotyping of the elderly may influence feelings of control and, for those who behave in ways that confirm the stereotypes of old age, a loss of coping abilities and internalization of a sense of incompetence may result (*8*). Inside and outside of institutions, people in contact with older individuals may be apt to assist with tasks that were formerly implemented independently. Such assistance, although well intentioned, may undermine the individual's sense of control as well as his or her task performance (*9*).

Despite a relation between aging and the increased occurrence of events that influence people's feelings of self-determination, however, the data do not provide clear evidence that perceived control decreases as a function of chronological age. Although some studies show an increase through the middle years and a decline in old age, others suggest that older subjects actually showed the greatest feelings of personal efficacy (*10*). The studies report that there is more variability in perception of and desire for control with advancing age, presumably because of the accumulation of different life experiences.

A second set of factors that may link health and control more strongly in old age relates to the possibility that the association between control and an indicator of health status is notably altered or conditioned by age. For example, since the immune system changes with aging and processes relevant to one's control affect immunologic function (*11*, *12*), it is possible that with age the relation may become closer between lack of control and suppression of the immune system because of a general loss of immunologic competence in the aged. This would suggest that, all other things being equal, the incidence of disease related to immune function would be expected to increase when individuals feel lack of control and to a greater extent in older than in young people. Given other differences between age groups in health status, however, it is often difficult to make a just comparison. Nonetheless, there is considerable evidence that the effects of restrictions in control are detrimental to the health of older people.

Finally, age may influence the relation between the sense of

control and health maintenance behaviors or the seeking of medical care. In general, an older person has more frequent contact with the health care system than a younger person. Medical care may restrict opportunities for control at any age, but more frequent contact with the health care system may heighten the effects of this restriction. Professional helpers have until recently appeared to prefer the most manageable (conforming, obedient, and deferential) and treatable patients (highly receptive to the efforts of the staff to help them) (*13*). In some nursing homes dependency and lack of control are fostered in the elderly in order to enhance patient manageability and treatability (*14*).

Despite some evidence supporting each of these three categories of reasons why the relation between health and control-relevant processes might grow stronger in old age, there have been few studies directly comparing the health of the elderly and other age groups as a function of the enhancement or restriction of control. The studies discussed below, some of which focus on the elderly, suggest that the health of older people is strongly affected by control-enhancing interventions and control-restricting life circumstances.

Principles of Gerontological Research

Before considering the studies that link aging with the effects of an individual's sense of control on health, it is important to outline briefly certain perspectives on gerontological research that must inform how studies of aging are interpreted. First, almost all data in the area of gerontology—physiological and psychological—show increasing variability with aging. Thus it is extremely difficult to characterize the typical older person. Second, changes that appear to be related to biological aging actually may result from factors that are associated with being old, such as increased disease or widowhood. Third, the outcome of the aging process is not always decline. Some diseases, such as autoimmune disease, are less likely to occur in old age. The impact of many life events such as the death of a spouse is often less in old age because the events are "on time" for an older person (*15*). Fourth, successive cohorts of elderly appear so strikingly different that it is often difficult to generalize to today's elderly from studies done 25 years ago, and work appearing today may tell us little about what to expect for older people in the future.

Restrictions in Control in Old Age

Several investigators have examined the impact on older people of involuntary relocation within the community, institutionalizations and institutional transfers, and retirement. Older people are not as successful as young people in anticipating and managing events associated with moving (*16*). There are too few longitudinal and fully prospective studies to determine the total health impact of involuntary moving. One prospective analysis examined forced relocation of people from a deteriorating neighborhood to federally subsidized housing that represented a clear residential improvement (*17*). Despite the better housing, there were more adverse health outcomes among those moved than in a control group: more hospitalizations and nursing home admissions, greater incidence of stroke and angina pectoris, and poorer self-assessed health. The adverse health outcomes were worse among those who expected the move to be problematic even though the benefits of the new residential domain were seen.

Although retirement, especially forced retirement, may increase stress and therefore affect health adversely, differences between the effects of forced and voluntary retirement have not yet been well documented (*18*). Theoretically, people with high job involvement and with the greatest self-determination in their jobs might be expected to experience the greatest loss after retirement. But such individuals are also usually among the privileged, with the resources to adapt to the transition.

Control-Enhancing Intervention Studies

On the basis of findings that control may be a resource that aids in resisting stress, some investigators experimented with increasing options for self-determination among older people whose health or life circumstances had led to a restriction in choice and control. Reevaluation of studies reporting increased morbidity and mortality as a function of relocation of the institutionalized aged has suggested that response to the stress of relocation is determined largely by the perceived ability to control and predict the move, as well as by differences in the degree of control in the environments before and after relocation (*19*). To test this, perceived control was manipulated by enhancing the predictability of the new institutional setting, giving patients a choice about when and where to move or about various aspects of their new living arrangements (*20*). Little decline in health or psychological status was found after relocation in people who were exposed to any form of control-enhancing manipulation.

The provision of opportunities for controlling their circumstances for patients already in nursing homes, some for substantial periods of time, has also been examined. It has been suggested that nursing homes create a set of iatrogenic difficulties, including increased dependency, depression, and social isolation among the aged (*14*). Using direct observations of the types of patient behavior encouraged by nursing home staff, Baltes and her co-workers found significant direct reinforcement by staff of dependent behavior and either no response or punishment for independent behavior (*21*).

Several intervention studies have been conducted in nursing homes. In these studies subjects were usually matched as closely as possible for age, sex, illness severity, and length of time in the nursing home, then assigned at random to a treatment or no-treatment condition. Efforts were also made to have a comparison group that was given equal amounts of attention. There are limitations to generalizability based on the specific samples or procedures used in each study, but together they suggest that increased control does affect psychological and physical health.

Langer and Rodin (*22*) designed a study to encourage elderly convalescent-home residents to make a greater number of choices and to have more control of day-to-day events. Immediately after the intervention and at an 18-month follow-up period, the group given more responsibility became more alert and active and reported feeling happier than the group of residents who were encouraged to feel that the staff would care for them and try to satisfy their needs. These results have been supported in other studies (*23*). From physicians' evaluations of the patient medical records, the "responsible" patients also showed a significantly greater improvement in health than the comparable patients in the "attention" group at a follow-up assessment 18 months after the intervention. Finally, compared to a 25% mortality rate in that nursing home in the 18 months before intervention, only 15% of subjects in the intervention group died, whereas 30% in the comparison group died (*2*).

Schulz and co-workers also showed that experimental manipulations involving increased prediction and control over a series of visits from local college students had a significant positive impact on the activity, satisfaction, and health of elderly people in nursing homes immediately after the intervention (*24*). They found, however, that long-term benefits depend on the ability to continue to exert

control after the experimental manipulation. Termination of the visits inadvertently served to make the loss of control salient, leading to even greater debilitation in health than among subjects never exposed to the control-relevant intervention.

Recent work has also shown that older persons can benefit from explicit training to develop skills for coping with daily stress (*25*). Learning effective coping skills increased feelings of control and the percentage of time spent in energetic activities. Subjects reported less stress and experienced less difficulty with problems that commonly arose in the nursing home. In the same study, changes in cortisol levels and physician-judged health were examined. All subjects who received some type of attention showed substantial reductions in cortisol levels (presumably as a function of reduced stress) during the period from before intervention measures until after them, but only the group that learned coping skills maintained lower cortisol levels after 18 months. Maintenance of the decline in cortisol levels was related to subjects' increased participation in active and planned activities, increased energy, perceived freedom to effect change in the environment, and perceived say in determining outcomes. One month after the intervention, no group was judged by physicians to be significantly changed in health, but 18 months later the group with coping skills was judged as showing improvement relative to the others (*26*).

Investigators have also tried to determine whether apparent memory loss in older persons could be reversed by manipulations that varied control (*27*). The hypothesis was that social and environmental restrictions in self-determination may impact on information processing directly, leading to real deficits that may only look as if they are biologically determined because they are age-related. Enhanced control led to improvements in memory, satisfaction, and physical health (*27*).

The results from the control intervention studies in nursing homes support two broad conclusions. First, increased opportunities for control and a greater sense of personal efficacy can have a positive effect on the physical and psychological status of the institutionalized aged (*28*). Second, this effect was obtainable with different interventions, although all successful ones had many features in common. For example, the options for control and skills taught to patients for exercising control were not terminated by the completion of the intervention. This is crucial since it appears that loss of control may be more aversive than the initial lack of control (*24, 25, 29*). In successful interventions subjects were encouraged to believe that their ability to control events would persist and be effective in different situations. Control may only have positive effects when the locus of control is attributed to personal and stable sources (*30*). Finally, there must be opportunities to exhibit one's competence. In all the successful interventions, expectations for control were not raised beyond available opportunities. Indeed, in many cases, the environment may need to be altered in order to increase opportunities for competent behaviors or to decrease the difficulty level of required behaviors.

There are important implications of the control-health-aging link suggested by these studies. If psychosocial factors associated with loss of control affect health, especially in the ill elderly, we may have been led to overestimate the extent to which there is decline associated with advancing age per se. Further, interventions that affect control positively appear to lead to health improvement under certain conditions. It should be emphasized, however, that the generalizability of these findings has not been extensively measured. Most studies testing control-enhancing interventions have been conducted with ill older people, primarily in nursing homes. It therefore remains uncertain at present whether the outcomes discussed are linked to age or whether they are the product of the highly restricted circumstances in which the elderly have been studied, such as in nursing homes. There are also limits to the beneficial effects of control, and studies have begun to reveal conditions under which having or seeking control may be maladaptive.

Limits of Control-Enhancing Options

Individual preferences for control differ widely and variability in optimal or preferred levels of control may increase with age, in line with increasing variability in perceptions of control (*31*). In laboratory studies, there are always some subjects who opt for uncontrollable rather than controllable aversive events when they are given a choice (*32*). Field experiments in a variety of health care settings, including nursing homes, have shown that some individuals benefit more than others from being highly informed about and involved in their own medical treatment. In studies in which patients were required to be more active in their treatment, in studies that heightened patients' sense of choice, and in those studies in which there was self-monitoring or self-care, there were substantial individual differences in reactions to treatment interventions (*33, 34*). Research indicates that medical patients of all ages whose treatment offers options congruent with their beliefs about control show the best psychological and physical adjustment (*34, 35*). Complicating the issue is the possibility that people's preferences for control become increasingly more variable in old age.

There are specific conditions under which perceived control is more likely to have negative than positive effects. At the psychological level, excessive feelings of responsibility may be aversive, and personal control often places heavy demands on people in the form of a high investment of time, effort, resources, and the risk of the consequences of failure (*36*). Lack of sufficient information to support effective control over an outcome has been shown to decrease the desirability of control (*37*). Also notable are suggestions that attributing greater control to patients may foster erroneous attributions of blame for causing their health-related problems, leading to guilt and perhaps poor care (*38*). I know of no studies that have specifically tested whether older people are more likely to show these negative effects than younger people.

The possible physiological costs of efforts to exert control also merit attention. Glass (*39*), for example, has suggested that type A individuals try to exercise control even in the face of maladaptive outcomes or uncontrollable situations and that this repeated and frustrated desire for control may be related to increased catecholamine output, which in turn contributes to atherosclerosis. In animals, control over shock that involves conflict or considerable effort produces larger or more numerous gastric lesions relative to animals with uncontrollable stress (*40*). Again, there have not been tests of how these effects vary as a function of the subjects' age.

Mechanisms Mediating the Effects of Control on Health

Stress reduction. Having control modulates the physiological and psychological impact of various stress-provoking stimuli, even when the objective intensity of the stressor is unchanged (*41*). Temporal factors influence this effect. For example, by definition one must confront the environment and be vigilant in order to exercise control. Immediately after some stressful event, denial, involving failure to confront the situation, may actually be related to more successful coping under certain circumstances. Before a stressor, increased control appears more beneficial (*42*).

In some situations, variations in control also determine whether an event is even judged to be stressful since appraisal is influenced by older people's beliefs about whether or not they have effective resources for handling difficult situations (*43*). Beliefs about control also affect stress because they influence coping. To the extent that people believe that they can prevent, terminate, or lessen the severity of aversive events, they have less reason to be perturbed by them (*43, 44*).

There is no direct evidence that older people feel that they can exercise less choice or control in stressful situations, but it has been assumed that older people are more adversely affected if they experience uncontrollable stress (*45*). For example, many older people are undergoing physiological changes that may make them more vulnerable to the effects of uncontrollable stress—immune system depression, decline in the metabolism of adrenocortical hormones, and increase in chronic illness. Some data also suggest that older people's perceived and actual range of coping options are narrower and are seen by them as more ineffective (*46*).

When people have some control over events their environment is more predictable, and predictability has a strong positive effect on stress reduction (*40, 47*). Predictability appears to reduce the psychological distress associated with uncontrollability, but its effects on physiological well-being are less straightforward. In general, nonpredictable conditions appear to be physiologically more stressful than predictable conditions when subjects are exposed to them for one or a few sessions and parameters of stress are relatively severe. However, predictable conditions may be more stressful than unpredictable conditions when sessions are long and extend for days and parameters of stress are less severe (*48*).

Symptom labeling. A cognitive mechanism by which control may be linked to health involves the labeling of symptoms. Control appears to be one variable that influences how people of all ages come to experience and label bodily sensations as symptoms relevant to health or illness (*49, 50*). When the level of perceived control over environmental events is manipulated experimentally, subjects who are given little or no control report more physical symptoms than those who feel more in control (*51*). Whether the individual's experience of symptoms and self-appraisals of health status are differentially altered by variations in control for older and younger people has not been tested. Certainly, the age of a person has a strong effect on these variables.

Physiological mechanisms. The proposal that variations in control may directly affect physiology has been supported by laboratory studies. Perceived control over aversive events decreases autonomic reactivity in animals and humans, and reduces gastric ulceration and weight loss in animals exposed to severe stress (*40, 52–54*). An association between central and peripheral catecholamine levels and control has also been demonstrated in animal and in human studies (*53–56*). Subjects display high circulating levels of epinephrine and norepinephrine while attempting to complete novel and difficult tasks, but, as their ability to perform these tasks grows, their catecholamine reactivity subsides (*57*). High levels of catecholamine are associated with increased blood pressure and heart rate, elevation of blood lipids, and ventricular arrythmia; these physiological outcomes have led to the suggestion that increased catecholamine in response to lack of control may be one mechanism accounting for the reported relation between coronary disease and control-related variables (*58*).

There also appears to be a strong relation between control and level of plasma corticosteroids in both animals and humans (*29, 59*). Corticosteroids regulate the metabolism of cholesterol and other lipids involved in the atherosclerotic process and play a role in regulating electrolyte balance and blood pressure. Since corticosteroids are elevated in response to lack of control, they may mediate the control-disease relation.

The psychoendocrine effects of variations in control have been supported and extended by several different laboratories. The relation between control and responses of the immune system is not as well understood. Animal studies have shown a direct effect of uncontrollable as compared to controllable stress on the immune system. In the first study (*11*), two groups of animals were given equal amounts of shock, but one group could control the termination of the shocks and the other could not. Only the latter group showed suppressed lymphocyte proliferation and response to the mitogens phytohemagglutinin and concanavalin A; the researchers suggested that the ability to control the stressor can modulate immune functioning (*11*). A link between uncontrollable stress and tumor growth and proliferation has also been reported (*60*).

If there is a relation between variations in control and the immune system, it may play a role in the health of aged people in particular. Environmental and psychosocial stressors that have been shown to affect immunity may be more common among the elderly than among other age groups; bereavement is one example (*61*). The immune system itself also clearly changes with aging (*12*). In general, the loss of immunologic competence in the aged reflects both intrinsic deficiencies in the competence of specific cell populations and extrinsic deficiencies in the environment of the cells. For example, it has been suggested that suppressor T cells (thymus-dependent cells with immunosuppressive properties) increase in number or activity, or both, with age and that this increase plays a major role in the age-related decline of immune potential. Whereas the response to exogenous antigens decreases with age, the reverse occurs with respect to endogenous antigens, leading to an increase in the circulating autoantibodies with age. There is evidence of stronger effects of uncontrollable stress on the immune system of elderly people (*62, 63*).

Health-relevant behavior. Although the studies discussed above indicate that increased control may have direct effects on health status by altering pathophysiological processes, it is also possible that people high in perceived control may have better health because they are more likely to take health-enhancing action. For example, perceptions of control influence whether people try to prevent and remedy their own health problems. These include gathering health-related information, engaging in self-care behaviors, being active in interactions with medical providers, and showing better adherence to medical regimens (*64*).

There is empirical support for the proposal that individuals with higher levels of perceived control take greater responsibility for meeting their health needs in a variety of domains (*65*). Reciprocally, individuals lower in perceived control appear to engage in fewer health-promoting behaviors. This relation may become stronger in old age when physical decline is often viewed as an unalterable part of the aging process (*1*). Quite possibly variations in feelings of control among subjects in different studies explain the large body of contradictory findings in the literature regarding the influence of age on medical care behavior.

Social status. Low social status correlates both with a reduced sense of control (*66*) and poor health (*67*). These relations, found in much research, could spuriously raise the correlations obtained between health and control. This does not lead to the conclusion that the relation between health and a sense of control is not real and substantial; the experimental studies attest to this. Nevertheless, we have yet to determine whether it is easier to maintain or enhance the sense of control in better-educated, middle-class older persons than in less well-educated, working-class persons. Alternatively, those of lower socioeconomic status might be more positively affected by control-relevant interventions since they have experienced relatively fewer opportunities to exercise control.

Conclusions

Although forward-looking health planners and practitioners may recognize the value of increased self-management for older people, the health care and social service systems have traditionally functioned on principles that often oppose control by the patient. Thus there is undoubtedly a need to exact substantial and important changes in the social and health care systems as they affect older people. The great challenge will be in finding ways to provide but not impose opportunities, however. The need for self-determination, it must be remembered, also calls for the opportunity to choose not to exercise control, especially since control has been shown to have negative psychological and physical effects in some cases. Since enhancement of control appears to have strikingly positive effects as well on the health and well-being of older people, those who plan and implement change must be mindful of the specific conditions in which positive or negative outcomes may be expected.

REFERENCES AND NOTES

1. V. L. Bengston, *Geriatrics* **28**, 118 (1973); R. Butler, *Am. J. Psychiatry* **123**, 1233 (1967); ——— and M. I. Lewis, *Aging and Mental Health* (Mosby, St. Louis, 1982).
2. J. Rodin and E. J. Langer, *J. Pers. Soc. Psychol.* **35**, 897 (1977).
3. J. Rodin, in *Aging and the Psychology of Control*, M. M. Baltes and P. B. Baltes, Eds. (Erlbaum, Hillsdale, NJ, in press). The simplest definition of control is the act of causing an intended event and avoiding unintended events [E. Deci and R. Ryan, *Intrinsic Motivation and Self-Determination in Human Behavior* (Plenum, New York, 1985); J. R. Weisz, in *Minnesota Symposium on Child Psychology*, M. Perlmutter, Ed. (Erlbaum, Hillsdale, NJ, in press), vol. 18]. Efficacy or perceived control depends on the individual's belief that he or she can cause an intended event to occur and can organize and carry out courses of behavior necessary to cope with various situations. It has also been suggested that effective control requires the conviction that the environment will be responsive to one's efforts to control it [A. Bandura, *Psychol. Rev.* **84**, 191 (1977); R. Baron and J. Rodin, in *The Urban Environment*, vol. 1 of *Advances in Environmental Psychology*, A. Baum, J. E. Singer, S. Valins, Eds. (Erlbaum, Hillsdale, NJ, 1978), pp. 145–192]. It is recognized that control may best be thought of in the more neutral term, self-determination, to convey the fact that individuals also may choose not to exercise direct control in certain instances and may still feel great freedom as a result of making this decision.
4. G. L. Engel, *Ann. Intern. Med.* **69**, 293 (1968); A. H. Schmale and G. L. Engel, *Arch. Behav. Psychol.* **17**, 135 (1967); D. C. Glass, *Am. Sci.* **65**, 177 (1977); J. M. Weiss in (*53*); U. Lundberg and M. Frankenhaeuser in (*56*); I. L. Janis and J. Rodin, in *Health Psychology*, G. C. Stone, F. Cohen, N. E. Adler, Eds. (Jossey-Bass, San Francisco, 1979), p. 487; S. E. Taylor, *J. Soc. Issues* **35**, 156 (1979).
5. Bureau of the Census, *Series P-25, No. 922* (Government Printing Office, Washington, DC, 1982).
6. Report of the Joint American Medical Association–American Nursing Association Task Force on "The improvement of health care of the aged chronically ill" (American Medical Association–American Nursing Association, Kansas City, MO, 1983).
7. S. V. Kasl and L. F. Berkman, in *Aging, Biology, and Behavior* (Academic Press, New York, 1981) pp. 345–385.
8. A. Bandura, in *Social Cognitive Development: Frontiers and Possible Futures*, J. H. Flavell and L. Ross, Eds. (Cambridge Univ. Press, New York, 1981), p. 200; J. A. Kuypers and V. L. Bengston, *Hum. Dev.* **16**, 181 (1973); J. Rodin and E. J. Langer, *J. Soc. Issues* **36**, 12 (1980).
9. J. Avorn and E. J. Langer, *J. Am. Geriatr. Soc.* **30**, 397 (1982); E. J. Langer and L. Imber, *J. Pers. Soc. Psychol.* **37**, 2014 (1979).
10. Analysis of these studies [J. Rodin, C. Timko, S. Harris, *Annu. Rev. Gerontol. Geriatr.* **5**, 1 (1985)] indicates that the diversity of findings is also due to differences in the scales used to measure control, including the types of control measured, difficulties in comparing cross-sectional and longitudinal data, and general cohort shifts in desire for control or options for control. Judgments about responsiveness of the environment varied not only across the lifespan, but also as a function of the domain being tested.
11. M. L. Laudenslager, S. M. Ryan, R. C. Drugan, R. L. Hyson, S. F. Maier, *Science* **221**, 568 (1983).
12. G. Siskind, *Natl. Inst. Health (NIH) Publ. 81-2194* (National Institutes of Health, Bethesda, MD, 1981), p. 455; P. S. Timiras, *Developmental Physiology and Aging* (Macmillan, New York, 1972).
13. J. Lorber, *J. Health Soc. Behav.* **16**, 213 (1975); S. E. Taylor, *J. Soc. Issues* **35**, 156 (1979); T. A. Wills, *Psychol. Bull.* **85**, 968 (1978).
14. R. L. Kane and R. A. Kane, *Science* **200**, 913 (1978); J. Wack and J. Rodin, *J. Soc. Issues* **34**, 6 (1978).
15. B. Neugarten, *J. Geriatr. Psychiatry* **4**, 71 (1970).
16. F. M. Carp, in *Handbook of Aging and the Social Sciences*, R. H. Binstock and E. Shanas, Eds. (Van Nostrand Reinhold, New York, 1976), pp. 224–271; M. P. Lawton, in *Handbook of the Psychology of Aging*, J. E. Birren and K. W. Shaie, Eds. (Van Nostrand Reinhold, New York, 1977), pp. 276–301.
17. S. V. Kasl, A. M. Ostfeld, G. M. Brody, L. Snell, C. A. Price, in *Second Conference on the Epidemiology of Aging*, S. G. Haynes and M. Feinleib, Eds. [Natl. Inst. Health (NIH) Publ. No. 80-969, U.S. Department of Health and Human Services, Bethesda, MD, 1980], pp. 211–236.
18. S. V. Kasl and L. F. Berkman (*7*) stress that few studies have used appropriate groups. For example, they note that research with retired or about to be retired workers who wished to work for financial reasons, resulted in a study that is more about the effects of inadequate financial circumstances than about deprivation of the work role. When one contrasts a cross section of retirees who label themselves voluntarily versus involuntarily retired, the division tends to load into the latter group those who are in poor health or poor financial circumstances or who have had a more irregular work history, including recent layoffs or job loss.
19. R. Schulz and G. Brenner, *J. Gerontol.* **32**, 323 (1977).
20. D. Krantz and R. Schulz, in *Applications of Personal Control*, vol. 2 of *Advances in Environmental Psychology*, A. Baum and J. E. Singer, Eds. (Erlbaum, Hillsdale, NJ, 1980), pp. 25–59.
21. M. M. Baltes, in *Basic Processes in Helping Relationships*, T. Wills, Ed. (Academic Press, New York, 1982), p. 405; ———, R. L. Burgess, R. Stewart, *Int. J. Behav. Dev.* **3**, 489 (1980).
22. E. J. Langer and J. Rodin, *J. Pers. Soc. Psychol.* **34**, 191 (1976).
23. G. Banziger and S. Roush, *Gerontologist* **23**, 527 (1983); S. Mercer and R. A. Kane, *Health Soc. Work* **4**, 90 (1979).
24. R. Schulz, *J. Pers. Soc. Psychol.* **33**, 563 (1976); ——— and B. H. Hanusa, *ibid.* **36**, 1194 (1978).
25. J. Rodin, *Int. Rev. Appl. Psychol.* **32**, 153 (1983).
26. Increased control is not the only psychological variable shown to have beneficial effects on physical health indicators in the elderly. Interventions to reduce the stress of loneliness and understimulation by increasing activity and social support appear to influence carbohydrate metabolism [B. B. Arnetz, *J. Gerontol.* **39**, 424 (1984)] and immunologic activity [J. Kiecolt-Glaser *et al.*, *Health Psychol.* **4**, 15 (1985)].
27. E. J. Langer, J. Rodin, P. Beck, C. Weinman, L. Spitzer, *J. Pers. Soc. Psychol.* **37**, 2003 (1979). Rather than look for either a description of the memory deficit or for methodological artifacts that may explain away purported differences, as some investigators had already done [P. B. Baltes and K. W. Schaie, *Am. Psychol.* **32**, 720 (1976); J. L. Horn and G. Donaldson, *ibid.*, p. 369], we suggested another focus of analysis—one where deficits were seen as possible, but environmental factors were seen as determining or at least masking the cognitive abilities of older persons.
28. The same relations may be true for older people who are not institutionalized. For example, C. K. Holahan, C. J. Holahan, and S. S. Beck [*Health Psychol.* **3**, 315 (1984)] found that perceptions of personal efficacy in dealing with daily annoyances and negative life events were associated with lower levels of depression for both sexes, with lower levels of other measures of psychological distress for women, and with fewer psychosomatic complaints for men.
29. J. D. Hanson, M. E. Larson, C. T. Snowden, *Behav. Biol.* **16**, 333 (1976).
30. L. Y. Abramson, M. E. P. Seligman, J. D. Teasdale, *J. Abnormal Psychol.* **87**, 49 (1978); B. Weiner, in *Achievement Motivation and Attribution Theory*, B. Weiner, compiler (General Learning Press, Morristown, NJ, 1974), p. 3.
31. M. E. Lachman, in *Life-Course Dynamics: Trajectories and Transitions, 1968–1980*, G. H. Elder, Ed. (Cornell Univ. Press, Ithaca, NY, in press).
32. J. R. Averill and M. Rosenn, *J. Pers. Soc. Psychol.* **23**, 128 (1972).
33. A. O. Berg and J. P. LoGerfo, *N. Engl. J. Med.* **300**, 535 (1979); R. T. Mills and D. S. Krantz, *J. Pers. Soc. Psychol.* **37**, 608 (1979).
34. R. L. Cromwell, D. C. Butterfield, F. M. Brayfield, J. J. Curry, *Acute Myocardial Infarction: Reaction and Recovery* (Mosby, St. Louis, 1977).
35. B. S. Wallston, K. A. Wallston, G. D. Kaplan, S. A. Maides, *J. Consult. Clin. Psychol.* **44**, 580 (1976).
36. J. R. Averill, *Psychol. Bull.* **80**, 286 (1973).
37. J. Rodin, K. Rennert, S. K. Solomon, in *Applications of Personal Control*, vol. 2 of *Advances in Environmental Psychology*, A. Baum and J. E. Singer, Eds. (Erlbaum, Hillsdale, NJ, 1980), pp. 131–151.
38. P. Brickman *et al.*, *Am. Psychol.* **37**, 368 (1982); M. Millman, in *Contemporary Health Services: Social Science Perspectives*, N. Johnson, O. Grusky, B. Raven, Eds. (Auburn House, Boston, MA, 1982), pp. 83–91.
39. D. C. Glass, in *Behavior Patterns, Stress and Coronary Disease* (Erlbaum, Hillsdale, NJ, 1977).
40. J. M. Weiss, *J. Comp. Physiol. Psychol.* **77**, 22 (1971); A. Tsuda and H. Hirai, *Jpn. Psychol. Res.* **17**, 119 (1975).
41. K. S. Bowers, *J. Consult. Clin. Psychol.* **32**, 596 (1968); B. K. Houston, *J. Pers. Soc. Psychol.* **21**, 249 (1972); M. Pranulis, J. Dabbs, J. Johnson, *Soc. Behav. Pers.* **3**, 49 (1975); E. Staub, B. Tursky, G. E. Schwartz, *J. Pers. Soc. Psychol.* **18**, 157 (1971).
42. S. Breznits, Ed., *The Denial of Stress* (Free Press, New York, 1983).
43. R. S. Lazarus and A. DeLongis, *Am. Psychol.* **38**, 245 (1983); J. Rodin, L. Bohm, J. Wack, *Appl. Soc. Psychol. Annu.* **3**, 153 (1982).
44. A. Bandura, *Am. Psychol.* **37**, 122 (1982); *Social Foundations of Thought and Action: A Social Cognitive Theory* (Prentice-Hall, Englewood Cliffs, NJ, 1985); A. T. Beck, R. Laude, M. Bohnert, *Arch. Gen. Psychiatry* **31**, 319 (1974).
45. C. Eisdorfer and F. Wilkie, in *Handbook of the Psychology of Aging*, J. E. Birren and K. W. Schaie, Eds. (Van Nostrand Reinhold, New York, 1977), pp. 251–275.
46. S. W. Cornelius, J. Hannum, A. Caspi, paper presented at the meeting of Gerontological Society, San Antonio, TX, 18 November 1984.
47. P. Badia, J. Harsh, B. Abbott, *Psychol. Bull.* **86**, 1107 (1979); D. E. Berlyne, *Conflict, Arousal, and Curiosity* (McGraw-Hill, New York, 1960); M. E. P. Seligman, *J. Comp. Physiol. Psychol.* **66**, 402 (1968).
48. B. B. Abbott, L. S. Schoen, P. Badia, *Psychol. Bull.* **96**, 45 (1984).
49. H. D. Mechanic, *N. Engl. J. Med.* **286**, 1132 (1972); S. Schachter and J. Singer, *Psychol. Rev.* **69**, 379 (1962).
50. J. W. Pennebaker, *The Psychology of Physical Symptoms* (Springer-Verlag, New York, 1982).
51. K. Matthews, M. F. Scheier, B. I. Brunson, B. Carducci, *J. Pers. Soc. Psychol.* **38**, 525 (1980); J. W. Pennebaker, M. A. Burnam, M. A. Schaeffer, D. Harper, *ibid.* **35**, 167 (1977); G. Weidner and K. Matthews, *ibid.* **36**, 1213 (1978). These control manipulations may increase physical symptoms. For example, experiences of difficulty (with circumstances or health) beyond the subjects' control may influence cognitive strategies such that they try harder and pay more attention so that the "psychic cost" of increased attention is experienced physiologically. Second, subjects who are aroused and upset, as they would be in an uncontrollable situation, often attribute their distress to being ill and selectively search their bodies in greater detail for symptoms. Third, increased symptomatology may result

because failure to control the environment affects physiological activity in both the neuroendocrine and immune systems. Thus the individual may actually experience more symptoms as a function of physiological activation (*50*).
52. A. Bandura, L. Reese, N. E. Adams, *J. Pers. Soc. Psychol.* **43**, 5 (1982); J. Geer and E. Maisel, *ibid.* **23**, 314 (1972); D. C. Glass, B. Reim, J. E. Singer, *J. Exp. Soc. Psychol.* **7**, 244 (1971).
53. J. M. Weiss, *Psychosom. Med.* **32**, 397 (1970).
54. ———, *Sci. Am.* **226**, 104 (June 1972).
55. M. Frankenhaeuser, in *Emotions: Their Parameters and Measurement*, L. Levi, Ed. (Raven, New York, 1975), pp. 209–234; ———, J. Lundberg, L. Forsman, *Tech. Rep. 540*, University of Stockholm, Stockholm (1978).
56. U. Lundberg and M. Frankenhaeuser, *Biol. Psychol.* **6**, 51 (1978).
57. A. Bandura, C. B. Taylor, L. Williams, I. N. Meffort, J. D. Barchas, *J. Consult. Clin. Psychol.* **53**, 406 (1985).
58. D. S. Krantz, D. C. Glass, R. Contrada, N. E. Miller, in *The Five-Year Outlook on Science and Technology* (National Science Foundation, Government Printing Office, Washington, DC, 1981), pp. 186–225.
59. H. Davis *et al.*, *Physiol. Psychol.* **5**, 280 (1977); S. Levine and G. D. Cooper, *Physiol. Behav.* **17**, 35 (1976); Frankenhaeuser and colleagues (*55, 56*) have argued that how much a task can be controlled is a major determinant of the degree of distress experienced, whereas effort is related to how demanding the task is. In turn, effort is related to catecholamine secretion, whereas distress is related to cortisol secretion. Personal control appears to be the important modulating factor in these tasks, because it tends to reduce the negative and enhance the positive aspects of arousal, thereby changing the balance between sympathetic adrenal and pituitary adrenal activity.
60. L. S. Sklar and H. Anisman, *Science* **205**, 513 (1979); M. A. Visintainer, J. R. Volpicelli, M. E. P. Seligman, *ibid.* **216**, 437 (1982).
61. S. E. Keller, J. M. Weiss, S. J. Schleifer, N. E. Miller, M. Stein, *ibid.* **213**, 1397 (1981); R. W. Bartrop, L. Lazarus, E. Luckhurt, *Lancet* **1977-I**, 834 (1977).
62. J. Rodin, in *Aging, Control and Health* (presidential address), Eastern Psychological Association, Philadelphia, 13 April 1982.
63. M. Stein, S. Schleifer, S. Keller, in *Biological Mediators of Behavior and Disease*, S. Levy, Ed. (Elsevier/North-Holland, Amsterdam, 1982), p. 147.
64. Some health-related measures do not adequately separate the effects of illness severity from the effects of taking an active role in one's health enhancement; for example, an increased number of doctor visits may indicate that the individual has suffered an illness, or that he or she has decided to participate more actively in his or her own health care.
65. These include seeking information about hypertension or renal dialysis, remaining in programs for exercise, weight loss, and smoking cessation, and complying with recommended medical regimens involving life-style change. C. A. Chambliss and E. J. Murray, *Cognit. Theor. Res.* **3**, 349 (1979); M. M. Condiotte and E. Lichtenstein, *J. Consult. Clin. Psychol.* **49**, 648 (1981); R. K. Dishman, W. Ickes, W. P. Morgan, *J. Appl. Soc. Psychol.* **10**, 115 (1980); C. K. Ewart, C. B. Taylor, L. B. Reese, R. F. Debusk, *Am. J. Cardiol.* **51**, 1076 (1984); M. M. Manning and T. L. Wright, *J. Pers. Soc. Psychol.* **45**, 421 (1983); J. B. Toner and S. B. Manuck, *Soc. Sci. Med.* **13A**, 823 (1979); K. A. Wallston and B. S. Wallston, in *Social Psychology of Health and Illness*, G. S. Sanders, Ed. (Erlbuam, Hillsdale, NJ, 1982), pp. 65–95.
66. H. Lefcourt, *Locus of Control* (Erlbaum, Hillsdale, NJ, 1976), pp. 21–25; G. Gurin and P. Gurin, in *Economics Means for Human Needs*, B. Strumpel, Ed. (Institute for Social Research, Ann Arbor, MI, 1976), pp. 131–158.
67. D. L. Parron, F. Solomon, C. D. Jenkins, *Behavior, Health Risks, and Social Disadvantages* (National Academy Press, Washington, DC, 1982); S. L. Syme and L. F. Berkman, *Am. J. Epidemiol.* **104**, 1 (1976); A. Antonovsky, *Milbank Mem. Fund Q.* **45**, 31 (1967).
68. Supported by NIA grant AG02455. I am grateful to L. Berkman, N. Miller, and J. Rowe for their comments on an earlier draft.

Investigation of Ultrafast Phenomena in the Femtosecond Time Domain

CHARLES V. SHANK

Rapid progress has taken place in the generation and application of femtosecond optical pulses. The impact of these developments is being felt in a broad range of scientific fields, including physics, chemistry, biology, and engineering. These rapidly evolving techniques have been applied to such diverse problems as phase transitions in highly excited semiconductors, molecular photofragment spectroscopy, impulsive phonon generation in solids, and optical radar ranging through biological tissue.

PROGRESS IN THE GENERATION AND MEASUREMENT OF ultrashort optical pulses continues to be driven by innovations and enhanced capabilities. Recently optical pulses have been generated with a duration of less than 8 fsec (1 fsec = 10^{-15} second) (*1*), pressing the limits of current technology. Improvements in short-pulse dye laser design have offered new means for controlling pulse width and tunability. Femtosecond amplifiers have been developed that operate with a repetition rate of 10 kHz and yet provide sufficient intensity to generate a "white light continuum" source of femtosecond optical pulses covering the ultraviolet to near-infrared region of the spectrum (*2*). Such pulses are ideal for obtaining high-resolution time-resolved spectra.

The impact of measurements in the ultrashort time domain covers a broad range of scientific activity. Femtosecond-pulse techniques have contributed significantly to the study of the dynamical properties of molecules and solids. Optically induced phase transitions have been studied by using femtosecond pulses to monitor the dynamics of the evolution of crystal symmetry (*3*). A new technique has been developed to create images with femtosecond pulses that have been put together to make a slow-motion picture that slows the action by a factor of 10^{13} (*4*). In addition, a femtosecond optical radar has been devised that can "see" into biological tissue (*5*).

Femtosecond optical pulses have been used to create nonequilibrium, nonthermal population distributions in semiconductors (*2*). With optical pulses short enough to resolve an individual molecular vibration, it has been possible to resolve phonon dephasing by impulsive Raman scattering (*6*). The dynamics of the process of exciton ionization in a semiconductor takes place at room temperature in a few hundred femtoseconds (*2*). Femtosecond pulses have also found utility for probing high-speed electronic devices and circuits (*7, 8*). Femtosecond time-resolved measurements of molecular photofragmentation have provided the first direct measurement of the time of bond breakage in a molecule (*9*). This article will touch on some of these recent advances.

The author is the director of the Electronics Research Laboratory of AT&T Bell Laboratories, Crawfords Corner Road, Holmdel, NJ 07733.