

Effects of Stress on Eating Behavior

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BACKGROUND

There is growing evidence to suggest that stress affects health directly through autonomic, neuroendocrine, and biological processes and also indirectly through changes to behaviors that influence health (Jones & Bright, 2001; Oliver, Wardle, & Gibson, 2000). Stress-induced modifications of habitual health behaviors such as food choice and eating behavior may be particularly important in understanding physical disease risk (O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Steptoe, Lipsey, & Wardle, 1998). Research has suggested that high levels of stress can be associated with both increased (e.g., saturated fat consumption) and decreased (e.g., overall calories) food intake (Wardle, Steptoe, Oliver, & Lipsey, 2000). Other research has found stress to be associated with an increase in food consumed as snacks in adults and adolescents, which may or may not influence health (Cartwright et al., 2003; Conner, Fitter, & Fletcher, 1999; O'Connor & O'Connor, 2004).

Over recent years, there has been increasing evidence to suggest a link between various aspects of diet and life-threatening diseases such as cardiovascular disease (CVD; Van Horn & Kavey, 1997) and cancer (Wong & Lam, 1999). The relationship between such diseases and various aspects of diet is a complex one. Nevertheless, three aspects of diet have been particularly implicated in relation to health outcomes: total fat and saturated fat in the diet, dietary fiber, and fruit and vegetable consumption (see Kumanyika et al., 2000). Evidence that these aspects of diet have become incorporated into the general public's conceptions of what constitutes healthy eating has also been reported (Povey, Conner, Sparks, James, & Shepherd, 1998).

The evidence relating dietary fat to health is well established and has been incorporated into consensus recommendations (e.g., American Cancer Society, 1996; COMA, 1991; U.S. Department of Agriculture/U.S. Department of Health and Human Services [USDA/USDHHS], 1995) to consume no more than 35% of daily energy from fat (and less than 11% calories from saturated fat) to reduce the risk of CVD and cancer. Research has also indicated the health benefits of increased

dietary fiber consumption on lipid and glucose metabolism and prevention of colon cancer (Anderson, Smith, & Gustafson, 1994; Brown, Rosner, Willett, & Sacks, 1999; Wolk et al., 1999). Again, this has been translated into recommendations (e.g., American Cancer Society, 1996; Krauss et al., 1996), namely, to increase dietary fiber consumption (to 20–30 grams per day). Finally, there is epidemiological evidence to indicate that increased levels of fruit and vegetable consumption are protective against cancer and CVD (Appel et al., 1997; Deckelbaum et al., 1999; Giovannucci, Willett, & Stubbs, 1999; Ness & Powles, 1997). Recommendations (e.g., USDA/USDHHS, 1995) have focused on increasing the portions of fruit and vegetables consumed to at least five per day (e.g., the five-a-day campaign; Heimendinger, Van Ryn, Chapelsky, Forester, & Stables, 1996; U.K. Department of Health, 2007).

Taken together, these findings suggest that stress can contribute to both CVD and cancer risk to the extent that it produces deleterious changes in diet and/or helps maintain unhealthy eating behaviors, such as high fat intake or low fiber or fruit/vegetable intake. Over the last 25 years, a large volume of research has been concerned with understanding the precise nature of the relationship between stress and eating behavior. This work has been conducted using animal models of stress-induced eating as well as eating-disordered and noneating-disordered populations. However, the focus of this chapter is to provide an overview of research findings from noneating-disordered populations. Interested readers are also directed towards more comprehensive reviews of this area by Greeno and Wing (1994), Adam and Epel (2007), and Nieuwenhuizen and Rutters (2008). This chapter provides a summary of research that has explored

- (1) nature of changes in eating behavior in response to stress;
- (2) types of stress affecting eating behavior;
- (3) moderators of the stress–eating relationship;
- (4) influence of stress on cognitive processes relating to eating;
- (5) biological mechanisms associated with stress-related eating.

NATURE OF CHANGES IN EATING BEHAVIOR IN RESPONSE TO STRESS

In examining the impact of stress on eating, it is important to be specific not only about the type of the stress (as discussed later) but also about the nature of the expected changes in eating behavior. The major focus of early research on stress and eating was on whether stress increased, decreased, or produced no change in overall eating behavior. For example, early animal work, in particular, focused on how stress might lead to eating more food (i.e., hyperphagia) or eating less food (i.e., hypophagia). Such a focus was particularly apparent in early theoretical accounts of the stress–eating relationship and its impact on obesity provided by researchers such as Kaplan and Kaplan (1957) and Schachter, Goldman, and Gordon (1968). For example, Kaplan and Kaplan (1957) argued that certain (obese) individuals did not learn to distinguish between hunger and anxiety and thus responded to stress as if it were hunger (i.e., an increase in eating under stress). An alternative view, put forward by Schachter et al. (1968), was that some (obese) individuals had not learned to label various physiological cues (e.g., gastric contractions) as hunger. It was suggested that these cues are reduced under stress leading to a reduction in eating (i.e., a decrease in eating under stress) except among those who have failed to learn to label these cues appropriately (see later section on stress–eating moderators). More recent accounts have suggested that rather than having a general impact on overall eating, the effect of stress on eating might be specific to particular types of foods (with increases in the consumption of some foods and decreases in the consumption of others). This might include effects on more palatable or easily consumed foods (e.g., fast foods), foods with particular sensory or health characteristics (e.g., high-fat foods), or foods generally consumed between meals (e.g., snack foods) or at meals (cf., Gibson, 2006). The focus of this more recent work has been less about understanding the role of stress in obesity or weight control and more about how stress could have damaging effects on health through leading to the consumption of a less healthy diet. This section overviews the types of eating behaviors that have been considered in different research designs addressing the stress–eating relationship.

Much work on the stress–eating relationship in humans over the last 25 years has focused not only on overall amount eaten but also on changes to the types of food consumed. For example, a study by Bellisle et al. (1990) looked at men in hospital on days they were or were not due to undergo surgery and recorded both the amount and types of food eaten in the morning. Similarly, Michaud et al. (1990) examined both the overall calorie intake and calorie intake from fatty foods, such as snacks, in a sample of school children on days they were or were not due to take an examination. Although Bellisle et al. found no significant effects, Michaud et al. found that

stress was associated with increases in overall calorie and calorie from fat intake, at least among the girls in the sample. This latter finding was confirmed in a laboratory study by Grunberg and Straub (1992), where women were found to be more likely to select foods high in calories (and fat) when under stress. Relatedly, Steptoe et al. (1998) reported that “fast food” was eaten more frequently when respondents reported experiencing greater number of hassles. Comparable results were obtained by Oliver and Wardle (1999) in a study of the effects of perceived stress on food choice. Oliver et al. (2000) also reported increased consumption of sweet high-fat foods and more energy-dense foods in response to stress. Finally, O’Connor et al. (2008) reported increased consumption of both high fat and high-sugar snacks in response to stress as assessed by number of hassles. Stress being associated with an increased consumption of palatable foods that are higher in calories and/or fat appears to be one of the more consistent findings in this area and certainly more consistent than any effect on overall calories consumed. This is potentially important because of the established relationship between excessive fat consumption and CVD and cancer (e.g., Kumanyika et al., 2000; Van Horn & Kavey, 1997; Wong & Lam, 1999).

Another aspect of eating behavior that has been a focus of research on effects of stress has been examination of effects on between-meal food consumption as opposed to food consumed at meals. A justification for this focus has been that between-meal snacks may be more responsive to the effects of stress because they are more within the control of the individual than the typical meal (Conner et al., 1999). Indeed several studies do show that the number of snacks consumed is responsive to stress. For example, using a daily diary design, Conner et al. (1999) showed a linear relationship between the number of hassles experienced on a day and the number of snacks consumed the same day. Similar results were reported by O’Connor et al. (2008) using a similar design in relation to overall number of snacks, number of high-fat snacks, and number of high-sugar snacks (see also Oliver et al., 2000). Oliver and Wardle (1999) also reported a study of the perceived effects of stress on snacking. Snacking was generally perceived to increase under stress. In contrast, the consumption of foods usually eaten as meals was reported to decrease under stress (see also Weinstein, Shide, & Rolls, 1997). This contrasting effect of stress on main meals was also reported by O’Connor et al. (2008), who additionally reported hassles to be associated with a reduction in the amount of vegetables consumed. Together, this research suggests that stress may be associated with a disruption to normal eating patterns by increasing the amount of food consumed between meals (as snacks) but decreasing the amount of food consumed at meals. This disruption of normal eating patterns may have manifold effects on health. Not only might overall calories consumed increase, but, more importantly, the overall nutritional quality of the diet might decrease

(e.g., higher percentage of calories from fat; reduction of calories from fruit and vegetables).

As this brief review shows, research on stress and eating has gradually moved from a focus on overall amounts consumed to a focus on changes in eating patterns in response to stress. This partly reflects the growing understanding of the impact of diet on health and how not only does the overall number of calories matter but also the balance of macronutrients in the diet and, in particular, the percentage of calories derived from fat. As we noted, the consumption of high-fat foods appears to be influenced by stress and is one pathway by which stress may influence health outcomes. Between-meal snacks may represent one aspect of diet that is both sensitive to stress and can lead to increased fat consumption (because of the preponderance of high-fat snack foods). The extent to which it is the palatability or the calorie density of such foods that mediates such effects may be a key issue in relation to developing healthy alternative "stress-snack" foods (cf., Gibson, 2006). However, this finding should not lead us to ignore the impact that stress may have on unhealthy choices within meals. For example, Steptoe et al.'s (1998) finding that stress was associated with increased fast food consumption is important given that such foods also tend to be higher in fat and sugar. Again, the extent to which such effects are mediated by palatability, energy density, or some other factor (e.g., speed of consumption) is an important issue for future research in relation to understanding the effects of stress on eating. Finally, by increasing between-meal snacking, stress may have an impact on health simply through increasing the frequency of energy intake, which is beginning to be considered a risk factor for health (Mattson, 2005).

TYPES OF STRESS AFFECTING EATING BEHAVIOR

Less is known about the importance of the type of stress experienced and whether some stressors serve as key moderators of eating behavior, whereas others have little or no effect (Conner & Armitage, 2002). Several researchers have found stressors of an ego-threatening nature (e.g., where there is a fear of failure) to have distinct effects from those that elicit physical fear (e.g., fear of an electric shock). Heatherton, Herman, and Polivy (1991, 1992) suggested that situations involving potential negative evaluation or task failure (ego-threatening) will lead to disinhibition (overeating) in restrained eaters or current dieters, whereas physically threatening situations will not. In contrast, these authors found that fear of an electric shock led to a reduction in food intake in unrestrained participants. The impact of "interpersonal stress" has also been investigated (e.g., Oliver, Huon, Zadro, & Williams, 2001; Tanofsky-Kraff, Wilfley, & Spurrell, 2000). Tanofsky-Kraff et al. (2000) compared the effects of interpersonal stress (i.e., stress associated with feeling a sense of social

alienation and being interpersonally ill-equipped) with ego- and physically threatening stress and found that in the interpersonal stress group, individuals with high levels of restraint consumed the most food.

More recently, Lattimore and Caswell (2004) and Wallis and Hetherington (2004), using laboratory methods, have also highlighted the importance of taking into account different types of stressors together with eating style variables (e.g., restraint and emotional eating). In particular, Wallis and Hetherington (2004) showed that cognitively demanding stressors (such as the incongruent Stroop task), as well as ego-threats, have the capacity to enhance food intake. The incongruent Stroop task was found to increase chocolate intake by 15% relative to control. Moreover, dietary restraint was associated with greater intake after the cognitively demanding stressor as well as an ego-threatening stressor compared with the control condition. In contrast, emotional eating was related to greater intake only after the ego threat, relative to control. These authors argued that their findings demonstrated differential effects of ego threat and cognitive demand on stress-related eating in restrained and emotional eaters. Lattimore and Caswell (2004) also demonstrated the importance of distinguishing between psychological (e.g., reaction time tasks and delivering a speech) and physical stressors (e.g., the cold pressor task) when considering stress-eating relations. They argued that reaction time-type tasks require active coping, whereas cold pressor-type tasks require passive coping. Within this framework, active coping involves a behavioral response whereby an individual is able to influence the outcome of a task. Passive coping involves passive sensory intake with no opportunity to influence the outcome of a task. In their study, Lattimore and Caswell (2004) found that restrained eaters consumed more than unrestrained eaters following the active coping stressor compared with the passive coping stressor and to a relaxation condition. Moreover, consistent with Wallis and Hetherington (2004), these results showed that stressors that are cognitively demanding, but do not have an ego-threatening or social evaluation element, still have the capacity to induce increases in food intake.

Other types of stressors, such as work-related stress, have received less attention. Relatively few studies have examined the impact of work-related stress as a distinct type of stressor or investigated whether ego-threatening or interpersonal-related work stressors have similar effects in the workplace as they do more generally. This is a significant oversight given that the psychosocial work environment is a major source of stress (Abraham, Conner, Jones, & O'Connor, 2008; Karasek & Theorell, 1990; O'Connor, O'Connor, White, & Bundred, 2000a, 2000b; Willis, O'Connor, & Smith, 2008). In addition, stressors that disrupt time (and work) schedules have received relatively less attention but may be important determinants of changes in eating behavior. A notable exception is a study by Wardle et al. (2000) of staff at a large department store. They found that periods of high

work stress were associated with greater caloric energy, saturated fat, and sugar intake compared with periods of low stress. More recently, Jones, O'Connor, Conner, McMillan, and Ferguson (2007), using hours worked as an index for work stress (as well as measures of the psychosocial work environment such as demands and control), found that long work hours were associated with greater consumption of high fat and sugar between-meal snacks in women only, whereas higher levels of negative mood were linked with snack intake in men. These differential findings for men and women are likely to be explained by the fact that women often have greater family responsibilities, which leaves less capacity for self-care on long work days. In addition, these results highlight the need for researchers to consider the fact that the impact of stress on eating behavior operates differently for men and women (an issue we return to later). Moreover, this study is also noteworthy in indicating that proximal, dynamic factors—daily variations in work hours and mood—were the main predictors of daily between-meal snack consumption, as opposed to the more distal and stable aspects of the psychosocial work environment as detailed by prominent models such as the job demands-control model (Karasek & Theorell, 1990).

A large amount of the previous research into the effects of stress on eating behavior has been overly reliant on laboratory-based, cross-sectional methodologies. As a result, it is difficult to discern the extent to which the influence of different types of stressors is generalizable to everyday stress-eating relationships. Much of the existing research has ignored the growing body of evidence showing that fluctuations in within-person stressful daily hassles are important in understanding stress-outcome processes (e.g., Affleck, Tennen, Urrows, & Higgins, 1994; Affleck, Zautra, Tennen, & Armeli, 1999; Dancy, Taghavi, & Fox, 1998; DeLongis, Folkman, & Lazarus, 1988; Fifield et al., 2004; O'Connor & Ferguson, 2008). The latter work has prompted investigators to consider alternative research designs. For example, the use of open-ended diaries allows respondents to record day-to-day minor life events or hassles that are part of everyday life and have the advantage of not constraining respondents to a limited number of events. A recent study using this approach found strong evidence for the moderating effects of different types of daily hassles on the stress-snacking relationship (O'Connor et al., 2008). Ego-threatening, interpersonal, and work-related hassles were found to elicit a hyperphagic response, whereas physical hassles were found to elicit a hypo-phagic response. The latter findings confirm the work by Heatherton et al. (1991) and demonstrate that the differential effects of stressors observed in the laboratory are generalizable to naturalistic settings. In addition, contrary to previous investigations, this research identified work-related hassles, and not ego-threatening or interpersonal, as the type of hassles that exerted the strongest effects on between-meal snacking (cf. Heatherton et al.,

1991, 1992; Oliver et al., 2001; Tanofsky-Kraff et al., 2000). It is also particularly noteworthy that these effects were not restricted to vulnerable individuals who were inhibiting their food intake per se (e.g., restrained eaters), as they have been in other studies (Heatherton et al., 1991; Wardle et al., 2000). Instead, these findings clearly demonstrate that daily hassles can directly influence snack food intake.

MODERATORS OF THE STRESS-EATING RELATIONSHIP

Previous research has examined either the "general effects hypothesis" that stress changes consumption of food generally or the "individual differences hypothesis" that stress leads to changes in eating in particular groups (e.g., the obese, restrained eaters, and women; Greeno & Wing, 1994; O'Connor et al., 2008). The individual differences model of stress-eating relationships (Greeno & Wing, 1994) suggests that differences in learning history, attitudes toward eating, or biology produce variations in vulnerability to the effects of stress. Those exhibiting vulnerability are assumed to respond to stress with an environmental or psychological change that has a secondary effect on eating behavior. In contrast, those with low vulnerability exhibit a different environmental or psychological change that does not promote changes in eating. Several vulnerable groups have been proposed, and the relevant research is reviewed in this section. The groups that have been compared are the obese and non-obese, restrained and unrestrained eaters, women and men, and emotional and nonemotional eaters.

OBESSE VERSUS NONOBESSE

Interest in the effect of stress on eating in humans began as an attempt to understand obesity. As noted earlier, it was suggested that overweight individuals were more likely to respond to stressful or emotional stimuli by eating (Stunkard, 1959). This view arose from psychosomatic views of obesity that suggested that obese individuals did not learn to distinguish between hunger and anxiety (Kaplan & Kaplan, 1957). Such individuals were assumed to respond to stress as if it was hunger (i.e., by eating) rather than anxiety. An alternative view was put forward by Schachter et al. (1968). These researchers suggested that unlike normal-weight individuals, obese individuals had not learned to label various physiological cues (e.g., gastric contractions) as hunger and that these cues are reduced under stress. Therefore, the prediction was that stress should produce a reduction in hunger and eating in normal-weight individuals but have no impact on the feelings of hunger and eating behavior in the obese. Thus, both the views predict differences in eating behavior of obese and nonobese in response to stress. However, the

direction of change is different across views. In Schachter et al.'s view, it was predicted that stress would decrease eating in normal-weight individuals and have no effect on obese individuals. From the psychosomatic view, stress would be expected to increase eating in obese individuals and have no effect on normal-weight individuals. The evidence in support of both these different predictions is disappointing.

Greeno and Wing (1994) reviewed 11 studies that addressed the effect of stress on eating in obese and non-obese groups. Schachter et al. (1968) produced the first laboratory test of this effect: Anticipating a painful compared with a mild shock (high vs low stress) produced a decrease in eating in normal-weight participants, but had no effect on obese participants. This finding is consistent with the Schachter et al. model outlined above. However, only one of the other 10 tests of this hypothesis reviewed by Greeno and Wing (1994) produced a similar decrease in consumption in normal-weight individuals, who in the other studies generally showed no change in consumption in response to stress. This represents very weak support for the Schachter et al. account of the impact of stress on eating in nonobese groups. Support for the psychosomatic account has also been mixed. Of the 11 studies reviewed by Greeno and Wing (1994), three demonstrated an increase in eating in obese individuals when stressed, three studies found that only some obese individuals eat more when stressed, and five studies failed to find any relationship between stress and eating in obese individuals. Taken together, this is the only relatively modest support for the psychosomatic account. In addition, those studies only finding partial support for the psychosomatic view suggest an alternative interpretation. For example, Baumcom and Aiken (1981) demonstrated that rather than obesity it was dieting that was the key predictor of stress-related eating in their study. For both obese and nonobese groups, stress only produced increases in eating in the dieting group. Given the fact that many obese individuals are dieting in an attempt to control their weight, the failure to control for dieting may explain the contradictory findings across studies in the impact of stress on eating in the obese. In effect, it may be the fact that dieting is more prevalent in the obese than the nonobese that explains why stress appears to lead to greater eating in the obese compared with the nonobese group. This perhaps accounts for the relatively limited attention that has been given in recent years to the possible role of obesity as a moderator of stress-eating relationships compared with that focusing on dieting status.

RESTRAINED VERSUS UNRESTRAINED

The concept of restrained eating developed from the "set point" theory of obesity (Herman & Polivy, 1975). Restrained eaters are assumed to restrict their food intake through self-control processes. When these self-control processes are undermined, disinhibition of

eating occurs, and excessive food intake takes place. For example, restrained eaters appear not to adjust their food intake for previous food intake (Herman & Mack, 1975). Unrestrained eaters adjust for consuming a "preload" of food by eating less in a subsequent eating test, whereas restrained eaters eat just as much as if they had not eaten the preload. It is believed that the preload disinhibits the restraint they normally show over eating. Stress is also expected to affect restrained eaters by disrupting the control normally exerted over eating. Thus, individuals with high restraint scores should be more likely to respond to stress by eating, whereas those low in restraint should show no change. Heatherton et al. (1991) and Schotte et al. (1990) both compared high and low restrained eaters and found that not only did restrained women eat more than unrestrained women, but restrained women who were stressed ate more than restrained women who were not stressed. Cools et al. (1992) used restraint as a continuous variable, rather than dividing subjects into high and low restraint groups, and showed that the stressed group consumed progressively more food as restraint scores increased. A number of other studies have also produced consistent results indicating that stress produces greater increases in eating in restrained compared with unrestrained eaters (see Greeno & Wing, 1994; see also Adam & Epel, 2007, for a useful recent review). Nevertheless, it must be conceded that the vast majority of studies to date have only demonstrated this effect in college-aged women. Future research needs to confirm these effects in other samples. In one study partly addressing these issues, Wardle et al. (2000) showed that work stress leads to increased eating in both restrained women and restrained men. However, in a recent review article, Lowe and Kral (2006) have argued that the moderating effect of restraint is not caused by restrained eating or by stress per se. These authors state that "restraint is primarily a result of, rather than a cause of, the behavioral patterns with which it has consistently been associated" (Lowe & Kral, 2006, p. 18). Instead, they contend that existing behavioral and physiological data indicate that restrained eating may be a proxy risk factor for vulnerability to weight gain.

Some other recent research has suggested that disinhibition rather than restraint may be a better predictor of food consumption under stress (see Ouwens, van Strien, & van der Staak, 2003). Disinhibition is one of the three subscales measured by the three-factor eating questionnaire (Stunkard & Messick, 1985) that assesses the tendency to overeat. O'Connor et al. (2008) have reported that both restraint and disinhibition moderated the stress-eating relationship, although there was a stronger effect for disinhibition. In both cases, the daily relationship between number of hassles and number of snacks consumed was stronger for higher levels of restraint or disinhibition. The effects of restraint in men, the impact of disinhibition in general, and the exploration of the precise mediating mechanisms are issues particularly worthy of further study in this area.

WOMEN VERSUS MEN

Several studies have looked at differences between female and male eating in response to stress. For example, Grunberg and Straub (1992) sought to determine whether there are differences between women and men in vulnerability to stress-induced eating. Sweet, salty, and bland foods were provided for participants while they were watching a video, and for half the subjects the video was unpleasant (i.e., stress-inducing). Results showed that unstressed men consumed significantly more food than any other group. However, stressed women did consume twice as much sweet food as unstressed women, suggesting the importance of food type, at least in women. Although stress generally reduced eating in men, this effect was not significant. Pine (1985) compared obese and nonobese men and women and found that stress-induced eating was more pronounced among women than men. Stone and Brownell (1994) examined the relationship between stress and eating for married couples who completed daily records of stress and eating. Results showed both men and women were likely to eat less than usual in response to stress, and the tendency to eat less with an increasing severity of stress was particularly pronounced in women. It is not clear why increased levels of stress were associated with decreased rather than increased eating in this sample. Using a similar design, O'Connor et al. (2008) reported that stress was more strongly associated with between-meal snacking in women compared with men. Interestingly, stress was associated with a reduction in consumption of food at meals in this study, suggesting that the nature of the eating behavior examined may be key in determining whether stress decreases, increases, or has no effect on amount eaten. As outlined earlier, Jones et al. (2007) also found that the impact of work stress (indexed by work hours) on eating behavior was statistically significant only in women.

Thus, the evidence for gender differences in stress-induced eating is somewhat contradictory. The effects appear to be generally greater in women than men, but in some studies stress appears to increase eating, in others it appears to decrease eating, and in still others it has no effect on eating. Some of the effects also appear to be specific to particular types of food (e.g., sweet foods). Interpretation of these findings is further complicated by the fact that gender is found to be correlated with restrained eating (i.e., women generally show higher levels of restraint). In addition, comparatively few studies have examined the effect of restraint on stress-eating relationships in men.

EMOTIONAL VERSUS NONEMOTIONAL EATERS

Emotional eating refers to a tendency for some individuals to eat more when anxious or emotionally aroused compared with nonemotional eaters who do not show such reactivity to emotion in their eating habits. Emotional

eating is found to be generally higher in women than men (Van Strien, Frijters, Bergers, & Defares, 1986). Stress is assumed to lead to increased eating in emotional eaters because they fail to distinguish between anxiety and hunger (i.e., they respond to stress as if it were hunger), whereas it does not affect those low in emotional eating. The origins in psychosomatic approaches to understanding stress-eating relationships discussed earlier in relation to understanding obesity should be clear. Psychometric measures of emotional eating have been developed (e.g., Van Strien et al., 1986). Van Strien et al. (1986) found that stressful life events predicted weight gain in men over a period of 18 months, but only amongst those who were emotional eaters. In women, stress led to weight gain irrespective of their level of emotional eating. Other studies have reported a limited (Schlundt et al., 1991) or lack of impact (e.g., Conner et al., 1999) of emotional eating on stress-eating relationships. More recently O'Connor et al. (2008) reported a strong impact of emotional eating on stress-eating behavior relationships. However, given the limited number of published studies of emotional eating, its impact on stress-eating relationships remains an issue for further study.

OTHER MODERATORS

A number of other factors have received more limited attention as moderators of the stress-eating relationship. These include external eating and personality traits. The concept of external eating derives from "externality theory" (Schachter et al., 1968). It suggests that external eaters eat in response to food-related stimuli, regardless of the internal state of hunger and satiety, whereas internal eaters are more responsive to internal cues such as hunger in deciding to eat. Van Strien et al. (1986) have developed a measure of external eating that uses items such as "If food tastes good to you, do you eat more than usual?" Only a few studies have examined external eating as a moderator of stress-eating relationships. In one that was conducted in a student sample, Conner et al. (1999) found that hassles were more strongly related to number of between-meal snacks consumed in individuals high in external eating than they were in those low in external eating. Although O'Connor et al. (2008) reported the same effect using a similar design in a sample of working adults, further studies are required to confirm the generality of these findings.

In addition to the aforementioned eating-specific moderators, some recent studies have begun to examine personality traits as moderators of the stress-eating relationship. Two personality traits in particular have drawn attention: conscientiousness and perfectionism. Conscientiousness is one of the Big Five personality traits (Costa, McCrae, & Dye, 1991). It refers to the ability to control one's behavior and to complete tasks. Those with high conscientiousness scores are seen to be more organized, careful, dependable, self-disciplined, and

achievement-oriented than those low in conscientiousness. Conscientiousness has been found to be related to longevity (Friedman et al., 1993), and some of this effect is attributable to health behaviors such as eating (Hampson, Goldberg, Vogt, & Dubanoski, 2007). The possibility that conscientiousness might moderate the stress-eating relationship was explored by O'Connor, Conner, Jones, McMillan, & Ferguson (2009). They found that stress significantly reduced the consumption of vegetables only among individuals with lower levels of facets of conscientiousness. Those with higher levels of conscientiousness were able to maintain their levels of vegetable consumption on both low- and high-stress days. O'Connor and O'Connor (2004) also reported that a manipulation of stress was associated with an increase in between-meal snacking in low-conscientiousness individuals, but only for those who were dieting.

Perfectionism is another personality trait that has been explored in relation to the stress-eating relationship. Perfectionism refers to the tendency to experience distress when events and situations are perceived to be imperfect. Ruggiero et al. (2003) have reported that stress promotes behaviors related to eating disorders in individuals high on perfectionism. O'Connor and O'Connor (2004) reported that exam stress was associated with an increase in consumption of between-meal snacks among those high in one facet of perfectionism, although this difference was only significant among those low in conscientiousness. These are interesting findings that await further confirmation from future studies.

MULTIPLE MODERATORS

As this review makes clear, the individual differences approach to studying stress-eating relationships while answering some questions has raised many others. A key issue is the integration of the effects of the different moderators. This is particularly important given their known interrelationships. For example, restrained eaters are reported to be more likely also to be emotional eaters (Weissenberger, Rush, Giles, & Stunkard, 1986) and external eaters (Heatherton & Baumeister 1991), and we have noted the relationship of gender to emotional and restrained eating and of obesity to restraint. Research examining such moderators simultaneously would appear to be an obvious avenue for research but is one that has been little explored. Two studies have particularly focused on testing a number of the above moderators simultaneously.

Conner et al. (1999) used a daily diary study to compare eating behavior on high- and low-stress days in a sample of 60 students over 7 consecutive days. Stress was assessed in terms of number of hassles reported, and the eating behavior was assessed in terms of the number of between-meal snacks consumed. The moderator variables examined were external eating, emotional eating, restrained eating, gender, and severity of stress.

Number of snacks was significantly positively correlated with number of hassles. Thus, on days that respondents reported greater numbers of hassles, they also reported consuming more snacks, compared with days on which they reported fewer hassles. When considered independently, external eating and gender were significant moderators of the stress-eating relationship, whereas severity of hassles, restraint, and emotional eating were not. More importantly, when these moderators were considered simultaneously, only external eating emerged as a significant moderator. O'Connor et al. (2008) used a similar design to consider the simultaneous effects of various moderators in a sample of 422 workers over 28 consecutive days. In addition to a larger sample size, O'Connor et al. also used more sophisticated statistical techniques (multilevel modeling) to control for multiple responses from each individual and considered a greater range of moderators. In their data, consistent with previous findings, restraint, emotional eating, external eating, disinhibition, gender, and obesity all individually moderated the relationship between daily hassles and number of between-meal snacks in a direction consistent with previous research. However, when considered simultaneously, only emotional eating emerged as a significant moderator of the stress-eating relationship. These findings suggest the need for further studies to examine the simultaneous effects of multiple moderators on the stress-eating relationship using more sophisticated research designs.

INFLUENCE OF STRESS ON COGNITIVE PROCESSES RELATING TO EATING

A number of studies have employed more cognitive approaches to explore the mechanisms that may transmit the effects of stress on eating behavior in relation to the various moderating variables. Much of this work has been influenced by Heatherton and Baumeister (1991), who have argued that stress causes increased awareness of the immediate environment and decreased awareness of the self. More specifically, it is hypothesized that for particular individuals, stress narrows the level of attention to the current and immediate stimulus environment (i.e., accessible food such as snacks), thereby shifting attention away from negative self-appraisals and/or from feeling distressed. It is argued that such low levels of attention reduce self-awareness to a point where meaningful thought, evaluations of self, and the implications of one's activities are avoided. In the context of stress-induced eating, vulnerable individuals may experience greater distress and negative self-appraisals when they encounter daily hassles and therefore shift their attention toward high-fat/sugar, energy-dense snack foods to escape from this negative emotional state. Moreover, this shift toward snack-type foods may also be driven by the learned outcomes from dietary-induced changes in

neurohormonal mechanisms. Future research ought to investigate further the effects of high-fat and high-sugar snack foods on the stress response within the context of the escape from self theory.

EXTERNAL EATING

One possible explanation for stress-induced eating in external eaters is a change in attention toward environmental cues during stress. Since external eaters are driven to eat by environmental cues, an attentional shift toward the immediate environment might be expected to increase food intake in these individuals. To date, only two studies have investigated attentional biases for food stimuli in external eaters (Johansson, Ghaderi, & Andersson, 2004; Newman, O'Connor, & Conner, 2008). Interestingly, Johansson et al. (2004) showed that external eaters showed a bias away from, rather than toward, food words presented in a dot probe task. However, this study did not manipulate or measure participants' stress levels. Since external eaters have been found to increase snack intake during periods of stress (Conner et al., 1999), an attentional bias toward food stimuli may emerge when stressed rather than under normal conditions. Newman et al. (2008), using an emotional Stroop task, found partial support for this notion when they observed a significant interaction between external eating and stress for snack food words. Further exploration of the interaction showed two marginal effects: High external eaters tended to have a greater bias in the stress condition than did low external eaters, and low external eaters tended to have a greater bias in the control condition than in the stress condition. That a difference between high and low external eaters only emerged in the stress condition may indicate a difference in processing of snack-related information between high and low external eaters only under conditions of stress. This is consistent with the finding that high external eaters increase snack food intake when stressed (Conner et al., 1999). The construct of external eating and its relationship to stress-induced eating has not as yet been well validated or greatly researched. It might be speculated that the greatest bias scores for snack foods would appear only in high external eaters who are also high-emotional eaters and may be especially prone to stress-induced eating, a possibility that future studies could test.

DIETARY RESTRAINT AND EMOTIONAL EATING

Food-related processing biases have been frequently observed in restrained eaters, emotional eaters, and obese individuals (e.g., Long, Hinton, & Gillespie, 1994; Overduin, Jansen, & Louwerse, 2006; Stewart & Samoluk, 1997; Tapper, Pothos, Fadardi, & Ziori, 2008). In a recent crosscultural study, Tapper et al. (2008) showed that high restraint was associated with a processing bias toward

food words using an adapted version of the emotional Stroop. This is consistent with cognitive theories of emotional disorders (e.g., Williams, Mathews, & MacLeod, 1996) that contend that attentional processes, such as schema elaboration, may promote selective bias toward negative stimuli. For example, Waller, Watkins, Shuck, and McManus (1996) showed that bulimic attitudes were associated with an attentional bias toward ego threats that were self-directed. These authors suggested that this finding was accounted for by schema elaboration for those particular forms of threat. Nevertheless, because relatively little research has examined attentional processes in restrained or emotional eaters in response to stress, it is difficult to discern the importance of this line of inquiry. Researchers ought to endeavor to utilize more cognitive techniques, such as the emotional Stroop and the dot probe task, to fully understand the role played by attentional processing biases in stress-induced eating.

BIOLOGICAL MECHANISMS ASSOCIATED WITH STRESS-RELATED EATING

Several plausible psychological and biological mechanisms have been proposed to explain why stress promotes increased food intake in vulnerable individuals. Psychosomatic theory (outlined earlier) contends that the normal response to stress/arousal is loss of appetite (Bruch, 1973; Kaplan & Kaplan, 1957). However, some individuals have an inability to differentiate between hunger and other unpleasant sensations/feelings and as a result react to stress by overeating, a response that is thought to originate in early learning experiences.

Neurohormonal factors have also been investigated. Markus et al. (1998) found that carbohydrate-rich, protein-poor food intake can prevent stress-related deterioration of mood and cortisol elevations in stress-prone individuals via serotonergic mechanisms. These authors argued that carbohydrate-rich, protein-poor diets allow greater uptake in the brain of the precursor amino-acid tryptophan, thus facilitating reduced negative mood and better coping. Moreover, as suggested by Oliver et al. (2000), vulnerable individuals may learn to "self-medicate" by shifting their preferences to low-protein foods such as sweet and high-fat snacks to experience reduced general dysphoria. These findings suggest that important neurohormonal pathways are likely associated with stress-related eating, although further confirmatory studies are required.

Another potential mechanism for stress-induced eating involves the activity of the hypothalamic-pituitary-adrenal (HPA) axis during stress, particularly the release of glucocorticoids from the adrenal cortex. Sapolsky (1998) proposed that corticotropin releasing hormone (CRH) and glucocorticoids (GCs) have opposing effects on appetite such that food intake is inhibited by CRH

and promoted by GC production. Direct manipulations of GC levels support the association of GCs with appetite and food intake. Adrenalectomized rats unable to secrete GC have been shown to consume smaller amounts of carbohydrate relative to other macronutrients (Laugero, 2001), and GC appears to protect against the hypophagic effects of leptin (Zakrzewska, Cusin, Sainsbury, Rohner-Jeanrenaud, & Jeanrenaud, 1997). In humans, the administration of glucocorticoids has been shown to increase energy consumption, especially from carbohydrates and proteins (Tataranni et al., 1996).

Surprisingly, less work has explored the link between cortisol, stress, and eating. However, two recent studies have investigated the role of changes in cortisol levels (i.e., cortisol reactivity) in understanding individual differences in stress-related eating behavior. The first, a laboratory study by Epel, Lapidus, McEwen, and Brownell (2001), found that participants who exhibited a high cortisol response to stress consumed more calories afterwards compared with those who exhibited a low cortisol response. The second, using a naturalistic diary research design (Newman, O'Connor, & Conner, 2007), found a significant positive relationship between daily hassles and between-meal snacking in a sample of high cortisol reactors but not in a sample of low cortisol reactors. The latter study also found that the relationships between the eating style variables (including emotional eating, restraint, external eating, and disinhibition) and snack intake were significantly stronger in the high cortisol reactivity group compared with the low reactivity group. These findings provide strong evidence that the stress-induced release of cortisol may underpin the effects of stress on eating behavior. More alarmingly, the release of GC also appears to promote the release of insulin (Dallman et al., 1994). This combination of insulin release and food consumption increases the likelihood that consumed energy will be stored as fat, particularly around the abdominal region where GC receptors are abundant (Laugero, 2001; Strack, Sebastian, Schwartz, & Dallman, 1995). Therefore, the appetite-stimulating effects of GC may have adverse consequences for obesity and health. Broadly speaking, these findings are consistent with a recently proposed theoretical model of reward-based stress eating, which highlights the role of cortisol and brain reward circuitry in motivating calorically dense food intake (Adam & Epel, 2007; see also Nieuwenhuizen & Rutters, 2008). Adam and Epel (2007) argue that stress, as well as palatable food, can stimulate the release of endogenous opioids and that the latter may protect individuals from the deleterious effects of stress by reducing the activity of the HPA axis. These authors go on to suggest that "repeated stimulation of the reward pathways through either stress induced HPA stimulation, intake of highly palatable food, or both, may lead to neurobiological adaptations that promote compulsive overeating. Cortisol may influence the reward value of food via neuroendocrine/peptide mediators such as leptin, insulin, and neuropeptide Y" (Adam & Epel, 2007, p. 449). Further

studies are required to explore the robustness of this new theoretical model.

In addition to the links with obesity, it has also been suggested that the effects of stress on food intake may contribute to increased risk of metabolic syndrome (Brooks, McCabe, & Schneiderman, chapter 29; Epel et al., 2004). The characteristics of metabolic syndrome include obesity, insulin resistance (or type II diabetes), high blood pressure, high blood triglyceride levels, and low *high-density lipoprotein* cholesterol levels. Recently, Epel et al. (2004) examined the effects of self-reported stress-eating tendencies (more eaters vs. less eaters) in a longitudinal study. They assessed changes in cortisol, insulin, adiposity, lipid levels, and food intake from baseline to exam-stress periods in a sample of medical students. These authors found that increases in weight, cortisol, insulin, and lipid profile in response to stress were only observed in those who respond to stress by eating more and not in those who respond to stress by eating less. Taken together, these findings indicate that stress-related changes in food intake, if maintained overtime, may be a risk factor for the development of metabolic syndrome as well as obesity, CVD, and cancer. Larger and more comprehensive longitudinal investigations are required to determine more precisely the causal pathways.

CONCLUSION AND FUTURE DIRECTIONS

This review of research on the effects of stress on eating behavior indicates both the range of knowledge we have acquired and the important remaining gaps for future research to address. Considerable evidence now indicates that the impact of stress on eating behavior is an important pathway through which stress influences health outcomes. Stress can be associated with overall increases or decreases to the amount eaten as well as changes in the patterns of eating. However, the nature of the eating behavior, as well as the type of stressor, is key in determining what the effect of stress will be. Much recent research has shown how stress is associated with increases in the consumption of high-fat and high-sugar foods, particularly when consumed as fast food or between-meal snacks (e.g., O'Connor et al., 2008; Steptoe et al., 1998). Future research could fruitfully explore the effects of stress on a broader range of eating behaviors (e.g., meals and snacks) and use more precise measurements of food intake (e.g., 24-hour recall). In relation to the stressor, ego-threatening, work, and interpersonal stressors appear to be particularly likely to show associations with increased eating (e.g., Wallis & Hetherington, 2004), whereas physically threatening stressors are generally associated with decreased eating (e.g., O'Connor et al., 2008). More detailed research is required to further elucidate the exact impacts of different types of stressors on eating and how these might interact. Understanding of the stress-eating behavior relationship is further

complicated by the presence of various important moderating effects. Here, evidence specifically suggests that stress-eating relationships are strongest among individuals high in restraint, disinhibition, external eating, or emotional eating, with one study having identified emotional eating as the preeminent moderating variable (O'Connor et al., 2008). Future research could usefully follow the suggestion from some authors (e.g., Conner et al., 1999) to simultaneously assess the effects of various moderators.

In addition to pursuing carefully designed studies in the laboratory, future research should also consider using innovative multilevel, daily diary methods in naturalistic settings. Daily diaries allow researchers to identify more closely "real-time" occurrences or moments of change in study variables, reduce recall bias, decrease potential confounding by using participants as their own controls, and provide stronger tests of causality in naturalistic settings (Affleck et al., 1999). Previous research has given insufficient attention to evidence indicating that assessment of fluctuations in within-person daily events is important (cf., Affleck et al., 1999; O'Connor & Ferguson, 2008). Using daily diary techniques, interval-contingent (i.e., assessments completed at the end of each day), event-contingent (i.e., assessments completed in response to an event), or signal-contingent methods (i.e., assessments completed in response to random alarms or beeps from a palmtop computer) can be employed. In such designs, participants complete diaries each night at a fixed time period, during each day triggered by stressful encounters, or in response to random signals. This methodology facilitates the use of the powerful multilevel random coefficient modeling techniques. This approach provides accurate analyses of multilevel data structures and allows the modeling of day-to-day within-person effects together with the impact of between-person factors such as potential vulnerability variables (emotional eating, restraint, etc.; see O'Connor et al., 2008, for an example in the stress-eating area).

A further important area for development is in relation to exploration of the psychological and biological mechanisms underlying the stress-eating relationship. As our review makes clear, these mechanisms are likely to be complex if they are to account for the complexity of findings reported. Interesting research has focused on various attentional biases that might explain some of these effects (e.g., Tapper et al., 2008), although further research using more sophisticated techniques (e.g., dot probe task) is required to clarify the consistency of these effects. Advances are also being made in relation to understanding biological mechanisms. For example, differences in cortisol reactivity appear to offer one explanation of some moderating effects on the stress-eating relationship (Newman et al., 2008). However, further careful assessment of daily fluctuations in cortisol levels in relation to changing stress levels is required to clarify the importance of this pathway. Moreover, several of the studies reviewed here also point to diathesis-stress

mechanisms that suggest that psychological vulnerabilities, when activated by stress, may result in negative outcomes. For example, coping styles (the behavioral and cognitive responses individuals consistently use when they encounter stress), in particular, have been shown to have well-established moderating effects on an individual's response to a stressful encounter (cf., O'Connor & O'Connor, 2003). It would therefore be beneficial for future research to assess the psychological factors (e.g., coping) associated with the cortisol response to stress and to test whether this differs according to stressor type (e.g., ego-threatening, interpersonal, work-related).

In addition, work on Adam and Epel's (2007) brain reward system notion offers the promise of a fuller explanation of the impacts of stress on eating. Studies that include detailed exploration of stressors and eating behavior and measurement of relevant biological markers may be a useful model for studies hoping to significantly contribute to this area.

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