RIGID AND FLEXIBLE STYLES OF SMOKING RESTRAINT

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Some smokers may compromise between continuing to smoke and quitting by limiting or *restraining* the amount that they smoke. While the effects of smoking restraint on behavior are unknown, eating restraint is well-investigated. The effects of eating restraint depend on eaters' approaches to the task of eating less: a rigid restraint style (dichotomous, "all or nothing" approach to self-imposed limits) is associated with unsuccessful eating regulation while a flexible restraint style (a plan to eat more on one day and less on the next) is associated with regulatory success. In the laboratory, when eaters are induced to overeat (i.e., preloaded with food), flexibly restrained eaters compensate by subsequently eating less while rigidly restrained eaters do not. In this study, we sought to determine if rigid and flexible restraint styles were similarly related to outcomes of attempts to limit smoking, both in and out of the lab. Methods: Participants were daily smokers (15-20 CPD) who wanted to limit their smoking. Participants underwent an experimental restraint style manipulation (rigid or flexible) and then limited their smoking for one week. N=95 participants then completed a smoking preload taste-test that challenged limits on consumption. Unlike studies of eating behavior, results did not support a relationship between restraint style and smoking outside of the laboratory. In the laboratory, findings were consistent with research on dietary restraint. A nearly-significant restraint style X preload interaction predicted total tasting $F(1,83)=3.72$, $p=0.06$: flexibly restrained smokers down-regulated their smoking after the preload while rigidly restrained smokers did not (27% vs. -7% compensation, respectively). Results were similar when participants' were grouped by their

reactions to the preload: Participants who perceived rules about "acceptable" consumption intact following the preload ("flexible" reaction) down-regulated their smoking while participants who perceived rules violated ("rigid" reaction) did not (24% vs. 1% compensation, respectively). Like eating, the effects of restraint on smoking depend on smokers' approaches to the challenge of smoking less – at least in the laboratory. The causal association between induced restraint style and smoking regulation in the lab suggests the importance of extending this effect to smoking in participants' natural environments.

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OVERVIEW

Cigarette smoking is the leading preventable cause of morbidity and mortality in the United States. Smoking is responsible for 20% of all deaths in the U.S., and 45% of smokers will die of a tobacco-induced disorder (Peto et al., 1992). Cigarette smoking causes cancer, chronic lung disease, cardiovascular disease, stroke, cataracts, and in women, damage to the reproductive system and fetus (NCI, 2005). Approximately 25% of Americans reported using tobacco within the last month (NIDA, 2005).

Most smokers (70%) want to quit smoking (Stratton et al., 2001), but quitting smoking is difficult. Despite widespread awareness of the negative health effects of smoking, only 42% of smokers quit smoking for at least 24 hours in the last year (Adams & Schoenborn, 2006), and fewer than 20% of smokers will ever quit outright (Jarvis, 2003). Tobacco cigarettes have a very high abuse liability (Henningfield, Cohen, & Slade, 1991) and current smokers are often discouraged from quitting by the difficulty of the task and the low likelihood of success (Leventhal & Cleary, 1980).

Consequently, smokers may be ambivalent about smoking, wanting both to stop (e.g., for health or cost) and to continue (e.g., to avoid withdrawal, for fear of failure, or for enjoyment). In order to manage their ambivalence, smokers may engage in compromises between continuing to smoke and quitting, for example, by smoking cigarettes that they believe are less harmful to their health (e.g., “light cigarettes”; Tindle et al., 2006; Shiffman et al., 2001) or by placing limits on

the amount that they smoke (Hickcox, 1995; Okeuyemi et al., 2002). While smoking "light" cigarettes is not an effective way to reduce the risks of smoking (Pankow et al., 2007), there is a strong dose-response relationship between smoking and health (Bartal, 2001). Thus, smokers who limit the number of cigarettes they smoke may reduce their risk of smoking-related disease (Benowitz et al., 1986; Bolliger et al., 2002).

Research suggests that many smokers impose limits on the number of cigarettes they smoke per day. Data from one survey suggest that half of all smokers employ this strategy each year (West et al., 2001). Among African Americans smokers, 62% of occasional and 19% of heavy smokers regularly limit their smoking by smoking less than half of each cigarette smoked (40% occasional, 17% heavy) or by setting a daily limit on how much they smoke (56% occasional, 37% heavy) (Okeuyemi et al., 2002). Even among smokers who are not interested in quitting, both occasional and heavy smokers report episodes of wanting to smoke but attempting to refrain because of self-imposed limits on smoking (Hickcox, 1995). How these attempts to *limit* (not quit) smoking might affect smoking behavior, and how robust they are, is unknown.

Qualitative differences between the challenges of quitting and limiting smoking suggest that they should be treated as separate tasks. For one, during a quit attempt, the goal of stopping a behavior is easily defined and quantified. Unlike smokers who aim to limit their smoking, prospective quitters do not need to monitor their smoking up to a preset limit; instead, all consumption is prohibited. In contrast, maintaining smoking within a prescribed limit includes the additional challenge of stopping smoking once it has started. Smoking behavior may contain some psychological momentum (such as priming, Shaham et al., 1997), which makes it harder to stop than preventing it in the first place. In short, factors that affect attempts to limit smoking warrant investigation in their own right.

Some smokers who attempt to limit their smoking may be successful; that is, limits on smoking may lead to smoking less than if there were no limits in place. Indeed, self-imposed limits on smoking are more common among occasional smokers than daily smokers (Perlick, 1977; Okuyemi et al., 2002), and occasional smokers are more likely than daily smokers to go without smoking at various times despite wanting to smoke (65% vs. 39%, occasional vs. daily, respectively) (Hickcox, 1995). Moreover, within groups of light smokers, those who report having self-imposed limits smoke fewer cigarettes per day than those with no such limits on their smoking (Perlick, 1977).

On the other hand, some attempts to limit smoking may fail. Only about 1-7% of daily smokers convert to non-daily smoking every year (Hughes & Carpenter, 2005).[1] Remarkably, even when smokers receive treatment or are paid to smoke less, only a fraction (<45%) achieve and sustain significant (40-50%) reductions in the amount that they smoke (Stead & Lancaster, 2007; Hatsukami et al., 2005).

One factor that may affect the success of smokers' attempts to smoke less is the approach that they take to the challenge of smoking less. For example, strict and unyielding limits on smoking may be more difficult to follow, more susceptible to violations, and may be more likely to be abandoned. On the other hand, an approach incorporating flexible standards to accommodate the occasional episode of heavier smoking may be easier to follow and more likely to be maintained. Unlike the factors that distinguish between successful and unsuccessful quit attempts (e.g., Fiore et al., 2000), those that distinguish between successful and unsuccessful attempts to limit smoking are not known.

One way for investigators to begin to study how smokers' behavior might change in the

[1] Conversions from daily smoking to non-daily smoking may be increasing (Hughes & Carpenter, 2005)

presence of limits on smoking is to draw from research on other appetitive behaviors (Garson & Engelhard, 2007). In particular, research on attempts to limit eating may be informative; unlike other appetitive behaviors (e.g., drug use, gambling, sex), the effects of attempts to limit eating are especially well investigated, likely because the alternative, *quitting* eating, is impossible.

Like smoking, overeating and overweight (a direct consequence of eating more calories than a person needs; e.g., National Task Force on the Prevention and Treatment of Obesity, 2000) have well-established negative effects on health. Overweight can contribute to diabetes, coronary heart disease, high blood cholesterol, stroke, hypertension, gallbladder disease, osteoarthritis, breathing problems, and some forms of cancer (Kopelman, 2007). People who successfully limit their eating, however, are more likely to have positive health outcomes (e.g., National Task Force on the Prevention and Treatment of Obesity, 2000). Nonetheless, the effects of limiting eating (i.e., dieting) on subsequent eating behaviors have been hotly debated (e.g., Lowe & Timko, 2004). Some data suggest that attempts to limit eating lead to disordered eating, weight cycling, and weight gain (e.g., Heatherton et al., 1988). On the other hand, it is nonsensical to assume that all attempts to diet are unsuccessful; many attempts to limit eating lead to weight loss in both the short and long-term (Wing & Phelan, 2005). Furthermore, limits on eating can also have positive effects on eating patterns. For example, low-calorie weight loss diets (vs. waitlist controls) result in significantly greater decreases in binge eating (Goodrick et al., 1998; Klem et al., 1997; Reeves et al., 2001).

Variability in eating and weight outcomes may be related to the approach that people take to the challenge of limiting their eating. Restrained eaters, for instance, rely on cognitively-defined limits of "enough food" instead of physiological signals of satiety to determine when eating should stop (Herman & Mack, 1975; Herman & Polivy, 1975). Originally, findings were

mixed about whether dietary restraint promoted or impeded successful controls over eating (Ruderman, 1986; Lowe, 1993; van Strien, 1999; Lowe & Timko, 2004). More recently, mixed findings have been attributed to heterogeneity among restrained eaters in the way restraint is applied. Specifically, data suggest that people who use predominantly rigid restraint strategies to adhere to cognitive limits on eating (e.g., strict rules combined with guilt after transgressions of the rules) are less likely to maintain a healthy weight, abide by their limits, and are more likely to report episodes of binge eating (Westenhoefer, 1991; Shearin et al., 1994; Smith et al., 1999). On the other hand, people who use predominantly flexible restraint strategies to limit their eating (e.g., those who afford themselves the freedom to eat more on one day and less on the next) are more likely to maintain lower body weights and are less likely to binge (Westenhoefer et al., 1994; Williamson et al., 1995).

Laboratory studies using the classic preload taste-test paradigm confirm these results. In a preload taste-test (the gold-standard test of dysfunctional restraint), restrained eaters are first forced to violate their limits by eating a high-calorie preload (e.g., a large milkshake) designed to induce a sense of ”overeating”. They then complete a “taste-test” where the quantity of consumption during the tasting is surreptitiously recorded (Herman & Mack, 1975). Data suggest that primarily flexibly restrained eaters regulate their eating after the preload by eating less during the tasting. Primarily rigidly restrained eaters, on the other hand, react to the preload, not by regulating, but by eating just as much as non-preloaded controls (Westenhoefer et al., 1994). No studies have investigated whether similarly restrained smokers show counterregulated smoking after a smoking preload.

The aim of this dissertation project is to investigate how smokers’ approaches to restraining smoking might be related to the outcomes of the attempts. At present, research on

limiting smoking (as opposed to quitting smoking) is in its infancy. In contrast, research on limiting eating (i.e., dieting) is extensive and could be used to inform research on limiting smoking. In particular, recent research has shown that the approach that people take to limiting eating is related to eating outcomes. Specifically, two conceptually opposing styles of restraint, rigid and flexible restraint, show promise for predicting both failed and successful attempts at eating and weight control. No attempts have been made to determine whether these opposing approaches are associated with similar outcomes in smokers.

In what follows, research on the validity of rigid and flexible restraint styles in eaters will be reviewed, including their definitions, history, measures, and behavioral correlates. Then, research suggesting how rigid and flexible restraint might be similarly related to outcomes in smokers is presented. To test these assumptions, finally, I experimentally manipulate rigid and flexible restraint in smokers, and then test how it might be related to smoking outcomes. Study methods for manipulating restraint style follow established procedures for manipulating approaches of behavior control in smokers and other groups (Dejonckheere et al., 2003; Joule, 1991b; Simmons et al., 2004). Tests of the relationship between restraint style and smoking behavior parallel the well-validated, preload taste-test paradigm that has been used to successfully challenge limits on eating. In particular, this study tests the specific hypothesis that, like primarily rigidly restrained eaters, primarily rigidly restrained smokers will react to a smoking preload by smoking more than if no preload had been consumed, while predominantly flexibly restrained smokers are expected to account for the forced preload by subsequently smoking less.

1.0 RESEARCH ON EATERS

1.1 DEFINITIONS OF DIETARY RESTRAINT, AND RIGID AND FLEXIBLE RESTRAINT STYLES

Dietary restraint, a tendency to restrict eating to cognitively-determined limits of "enough food" rather than to physiological signals of satiety (Herman & Mack, 1975; Herman & Polivy, 1975), has been a major construct of interest to researchers studying how attempts to limit eating (i.e., dieting) affect eating behavior. Restrained eaters are a heterogeneous group who vary in their approaches towards the task of limiting eating. While the literature on the assessment of restraint styles is complex and confusing, restraint styles can be placed along a continuum with two opposing poles: Rigid and Flexible Restraint. Conceptually, Rigid Restraint (RR) is a dichotomous, "all or nothing" approach to self-imposed limits on consumption. In eaters, a person who exhibits a predominantly RR style would try to avoid high-calorie foods, but if they ate any, would experience guilt over the transgression and would also be unlikely to compensate for that intake; according to theory, the amount that they eat would constitute counterregulation On the other hand, a person who uses a predominantly Flexible Restraint (FR) style would do the opposite and make allowances for guilt-free, episodes of increased consumption with plans to eat less at future meals (Westenhoefer, 1991). While a primarily RR eater has a strict, brittle, approach to limiting eating that includes a tendency to treat episodes of "overeating" as negative,

irreparable events, a primarily FR style can accommodate occasional episodes of overeating with planned periods of eating less.

Although RR and FR are conceptual opposites, restrained eaters are not expected to (nor do they) use either RR or FR approaches exclusively (Westenhoefer et al., 1994; Stewart et al., 2002). Analyses of paper-and-pencil measures of RR and FR produce separate factors, rather than poles of a single factor (see Section 1.6). Thus, the degree to which one style predominates likely determines the degree of protection or risk for various eating behaviors and outcomes.

1.2 HISTORY

The constructs of RR and FR came from research investigating the differences between individuals who maintained healthy weights and others who appeared to be diet-resistant, never losing weight, or cycling between weight losses and gains (Westenhoefer, 1991). One of the first promising mechanisms for explaining this difference was dietary restraint; a tendency to restrict eating to cognitively-determined limits of "enough food", as opposed to physiological signals of satiety (Herman & Mack, 1975; Herman & Polivy, 1975). Of particular interest was a paradoxical, behavioral phenomenon associated with restrained eating termed *counterregulatory eating*, in which restrained eaters ate very little (i.e., less than controls) under normal circumstances but overate (i.e., significantly more than controls) in situations that made cognitive control of eating more difficult, such as after forced violations of diet rules, negative affect inductions, or alcohol consumption (Cools et al., 1992; Heatherton et al., 1991b; Herman & Mack, 1975; Herman et al., 1987; Polivy et al., 1988, 1994; Polivy & Herman, 1976, 1999; Schotte et al., 1990). Counterregulation in the laboratory was considered to be an experimental

analogue of uncontrolled eating outside of the lab (Hadigan et al., 1992; Heatherton et al., 1988; Hetherington & Rolls, 1991; Polivy & Herman, 1985; Wardle & Beinart, 1981). Thus, researchers began to treat restrained eating as an important contributor to chronic overweight and disordered eating (reviewed in Lowe et al., 1996).

The effects of restraint on eating behavior, however, came into question when a series of studies showed that only restrained eaters identified by the Restraint Scale (Herman & Polivy, 1980), a measure known to be confounded with a tendency to overeat, showed evidence of counterregualtion (Ruderman, 1986; Gorman & Allison, 1995; van Strien, 1999). Moreover, when restraint was measured separately from a tendency to overeat, [i.e., with the Three Factor Eating Questionnaire (TFEQ), that has separate scales for Restraint (TFEQ-R) and Disinhibition (a tendency to overeat; TFEQ-D) (Stunkard & Messick, 1985)], neither counterregulation nor eating disorders were reliably associated with restraint (Ruderman, 1986; Gorman & Allison, 1995; van Strien, 1999). Specifically, depending on the study, TFEQ-R was either associated with a significantly increased *or* decreased risk of binge eating and weight gain (reviewed in Westenhoefer, 1991).

Confusion about the relationship between dietary restraint and eating outcomes prompted research into whether there might be two types (or *styles*) of restraint. Indeed, two styles of restraint, one associated with an increased risk of overeating and the other associated with a decreased risk, could obscure the expected relationships between TFEQ-R, disordered eating, and counterregulation (Westenhoefer, 1991). Data supported this hypothesis: TFEQ-R items measuring restraint strategies such as counting calories, avoiding some foods, frequent dieting, and consumption of low calorie foods were associated with high scores on the TFEQ-D, while others strategies measured by the scale, including cognitively-controlled stopping of eating,

taking small helpings, and eating slowly were associated with low TFEQ-D scores. Based on the content of each style, Westenhoefer (1991) labeled the styles RR and FR, respectively.

Subsequent studies have supported the utility of classifying restrained eaters as primarily RR or FR, particularly because the restraint style distinction provides clarity to a previously mixed set of findings. Indeed, studies once showing no predictable association between TFEQ-restraint and binge eating (reviewed in Howard & Porzelius, 1999) showed reliable, positive relationships between RR and bingeing, and negative relationships between FR and binge behavior (see also Section 1.4).

1.3 THEORY

When the constructs of RR and FR were first introduced, Westenhoefer (1991) described RR and FR as having "more descriptive than explanatory value" (p. 53) because they were identified as components of restraint post hoc. Nonetheless, RR and FR styles fit easily within existing theories about how consummatory behaviors are regulated.

In particular, the Boundary Model describes the shared cognitive structure of RR and FR eaters, and how both groups are hypothesized to rely on self-imposed "diet boundaries" to limit the amount that they eat (Herman & Polivy, 1984). Restrained eating is described as "an attempt to replace normal physiological controls with a cognitive agenda" for determining what, and how much to eat (pg. 146).[2] According to the model, boundaries are cognitively-defined, "acceptable" levels of consumption that lie below the amount needed to reach satiety.

[2] Restrained eating is used synonymously with dieting by Herman & Polivy (1984)

Consequently, counterregulation is hypothesized to result from dieters' perceptions that they have eaten beyond the boundary, abandoning attempts to limit their eating, and proceeding to eat (counter to the boundary) until they are satisfied.[3]

The authors of the Boundary Model suggest that counterregulation is caused by "logically fallacious" reasoning; Dieters conceptualize dieting as a behavior that occurs in definable (e.g., daily) units, and once the unit (daily) quota has been surpassed, there is no point in restraining for the rest of the unit (day) (Herman & Polivy, 1984). Accordingly, predominantly RR eaters would be more likely to engage in counterregulatory eating because their diet boundaries are more brittle and susceptible to violation, and therefore are also more likely to be abandoned. In contrast, predominantly FR eaters would be less likely to counterregulate because their boundary is more flexible, less likely to be transgressed, and therefore less likely to be abandoned.

The Limit Violation Effect (LVE; Collins & Lapp, 1991, 1992) adds to the Boundary Model by providing additional detail about how consuming more than one's limit (boundary) can lead to different outcomes for primarily RR and FR eaters. According to an LVE model, violations of self-imposed limits on consumption result in negative self-cognitions, decreased self-efficacy for limiting intake, and consequent, unwanted consumption to alleviate the negative emotions resulting from having taken responsibility for the failure. This theory is a modification of an earlier theory for an Abstinence Violation Effect (AVE), where violations of prohibitions on *abstinence* among drug users, for example, led to subsequent and compensatory increases in use. Importantly, the critical factor in both models for moving from a simple violation of an internal standard to a full-blown LVE or AVE is how the individual interprets the violation (Collins & Lapp, 1991; Marlatt, 1985; Marlatt & Gordon, 1985); if the limit is treated flexibly

[3] Satisfaction is due to a combination of physiological and psychological factors, and satisfaction after prolonged restraint seems to require *more* consumption than satisfaction under other circumstances.

(e.g., FR), allowances for increased consumption would be made, guilt-free, accompanied by plans to eat less at future meals, therefore circumventing the LVE. If the limit is treated rigidly (e.g., RR), however, increased consumption will likely be treated as a limit violation and as a critical and irreparable event. Thus, the violation will be more likely to initiate the processes of the LVE and result in counterregulatory eating. Although AVE and LVE models are situation-specific (i.e., state) and RR and FR styles describe trends in a person's response (i.e., traits) to episodes of overeating, the notion that individual differences in the interpretation of an eating event can affect future eating behavior is clearly compatible with both constructs.

A significant limitation of the existing research on restraint style is that eaters' restraint styles have only been characterized cross-sectionally and by self-report. As such, any relationship between restraint style and eating behaviors might result from self-selection. For example, dieters who feel that their eating is more out of control (e.g., because of more frequent or stronger impulses to consume) might be more likely to adopt more rigid rules and restrictions to control their eating (Hickcox, 1995). At present, neither experimental nor longitudinal data are available to test this hypothesis.

Nonetheless, whether RR and FR styles cause eating outcomes or vice versa, researchers and clinicians can benefit from quantifiable characteristics of dieters (and controllers of other consummatory behaviors) that are associated with outcomes of the attempt. Data showing the correlates of RR and FR in the eating and dieting literature are described below.

1.4 REVIEW OF EXISTING RESEARCH ON RR AND FR IN EATERS

Empirical research strongly supports the utility of distinguishing between RR and FR styles in eaters. At the time of this report, twelve published studies of approximately 60,000 participants included tests of the validity of RR and FR styles as measured with one of two versions of the subscales of the TFEQ-R (see Table 1 for the most recent version; Westenhoefer et al., 1999). Studies thus far have looked at the relationship between RR, FR, and eating outcomes such as bingeing, overeating, BMI, and a variety of weight loss strategies (e.g., exercising). Overall, data are consistent in showing that people who describe their eating as predominantly FR are more likely to maintain restrained eating while people whose style is predominantly RR are likely to experience gaps in eating restraint.

Five studies tested the association between RR, FR and binge eating or overeating. In all five studies, RR was positively correlated with binge eating and overeating, while FR was either uncorrelated (Shearin et al., 1994) or negatively correlated (Ricciardelli & Williams, 1997; Smith et al., 1999; Westenhoefer, 1991; Williamson et al., 1995) with those behaviors.

Of the 10 studies that tested the association between Body Mass Index (BMI, a measure of body fat based on height and weight) and restraint style, 7 showed that RR was positively correlated with BMI and that FR was negatively correlated with BMI (Ricciardelli & Williams, 1997; Shearin et al., 1994; Smith et al., 1999; Stewart et al., 2002; Westenhoefer, 1991; Westenhoefer et al., 1999; Williamson et al., 1995). While not supportive, none of the remaining three studies contradicted the majority findings (Bond et al., 2001; McGuire et al., 2001). Overall, data suggest that a primarily RR style is associated with high BMI while a primarily FR style is associated with low BMI.

Data from the two studies reporting links between weight-fluctuations, weight loss and restraint style are also consistent with the above findings. RR was positively correlated with prior weight fluctuations while FR was uncorrelated with previous changes in weight (Shearin et al., 1994). Similarly, while FR was positively correlated with unidirectional weight loss, weight loss was uncorrelated with RR status (Westenhoefer, 1991).

Six reports included tests of the association between restraint style and various weight control strategies. Overall, the association between RR and FR and "healthy" weight control strategies, such as self-reported dieting, limiting intake, and exercise, was mixed (Smith et al., 1999; Ricciardelli & Williams, 1997; McGuire et al., 2001; Westenhoefer, 1991). For example, exercise as a method for controlling weight was not reliably associated with either RR or FR (McGuire et al., 2001; Bond et al., 2001; Westenhoefer et al., 1999). This finding may be related to the fact that RR and FR (operationalized by paper-and-pencil measures) do not seem to represent opposite poles of a single factor (see Section 1.6). On the other hand, "unhealthy" weight-control strategies seemed to be specific to RR eaters. Specifically, the use of laxatives, appetite suppressants, and vomiting were positively associated with RR but either unassociated or negatively associated with FR (Westenhoefer et al., 1999). These findings, however, come from a single study and require replication. Nonetheless, results suggest that self-reported dieting, attempts to limit intake, and exercise occur among eaters who exhibit both RR and FR styles, but that the use of unhealthy, drastic weight control strategies may be specific to primarily RR eaters.

Finally, two studies tested an association between restraint style and eating disorder symptoms and diagnoses. Both studies showed that a diagnosis of bulimia nervosa (featuring both binge eating and compensatory purging; APA, 1994) and indicators of disordered eating in

general are positively associated with RR and unassociated with FR (Shearin et al., 1994; Stewart et al., 2002). A diagnosis of anorexia nervosa (eating characterized by extreme dietary restriction with few lapses, or gaps in restraint), on the other hand, was exclusively associated with FR (Stewart et al., 2002). While it might seem that anorexia nervosa should be positively associated with RR for its extreme dietary restriction, anorexics may ultimately use a combination of restraint strategies that on the surface, appear rigid (e.g., I will not eat anything) but also contain a significant "flexible" component (e.g., if I eat a small amount I will compensate for it by eating nothing later on). Moreover, due to the design of the RR and FR subscales, anorexia is expected to be positively associated with FR because its items were selected to be negatively associated with a tendency to overeat (TFEQ-D). Consistent with studies of other eating behaviors, RR is associated with eating disorders featuring lapses in restraint while FR is associated with symptoms and disorders featuring successfully limiting eating.

In sum, data from a variety of sources confirm that RR is associated with increased risk for lapses in dietary restraint while FR is associated with successful maintenance of restraint. Although most people do not report maintaining either a purely FR or RR style (Smith et al., 1999), primarily RR eaters are likely to suffer from disturbed eating patterns including frequent breakdowns of restraint, while predominantly FR eaters exhibit a "more or less" approach to eating and on-going, successful dietary restraint (Elfhag, 2005). Overall, data support the utility and validity of conceptualizing dietary restraint, not as a unitary construct, but as the combination of two opposing restraint styles.

1.5 COUNTERREGULATION

1.5.1 Operational Definition

Counterregulation was first described among restrained eaters as a combination of "under-eating" (or restraining) under normal circumstances and "overeating" (eating that is counter to restraint) in situations that make cognitive control of eating more difficult (Herman & Mack, 1975). More often, counterregulation refers to eating *after* a high-calorie preload (or other manipulation) that is above and beyond the regulatory response exhibited controls (Hibscher & Herman, 1977). Proponents of the Boundary Model similarly suggest that counterregulation is eating after a preload (or other diet-breaking event) that becomes governed by a satiety boundary that lies beyond the original diet boundary; instead of eating up to the diet boundary (which, in the case of a preload, has already been transgressed), during counterreulgation, eating will not stop until the person is satisfied (Herman & Polivy, 1984).

Nonetheless, different operational definitions of counterregulation have been used, especially when describing the amount of food consumed during a taste-test in a classic preload taste-test paradigm (see Section 1.5.2). Some authors have suggested that consuming the same amount of food after a preload (vs. no-preload) should be considered counterregulation because the total amount of consumption (preload + tasting) is greater than the typical, regulated response where the amount of consumption (tasting) after a preload would be less (see Figure 1) (e.g., Hibscher & Herman, 1977; Jansen et al., 1988; Ruderman & Christensen, 1983). For the purposes of this study, however, such a response will be termed *nonregulation* because although it involves greater total consumption than a regulated response, consumption may not be counter (against) regulation, either. Eaters who "taste" the same amount after a preload as after no

preload may simply be demonstrating that they can eat the preload and complete the tasting without exceeding their limits on consumption. Nonregulation is different from consumption during the tasting that is *greater* after a preload than after no preload (control condition); only this pattern of results will be referred to as *counterregulation*.

In short, counterregulatory eating will be defined here as eating that occurs in significantly greater quantities (marker "C" in Figure 1) than regulated (decreased) eating after a preload (marker "A") and no-preload (marker "B"). A number of studies with results meeting these criteria for counterregulation have been described (e.g., Herman & Mack, 1975; Herman et al., 1987; Polivy et al., 1988; Westenhoefer et al., 1994[4]).

1.5.2 Preload Taste-Test Laboratory Paradigm

In the first experiment to use a preload taste-test (PTT) to test the effects of restraint in eaters (Herman & Mack, 1975), participants were preloaded with zero, one, or two milkshakes and then asked to participate in an ice-cream "taste-test". During the taste-test, participants were told to taste as much ice-cream as they wanted in order to give accurate taste ratings, and that after all of the flavors had been rated, they could help themselves to anything that remained. The quantity of ice-cream consumed during the tasting was recorded. The rationale for the PTT procedure was that restrained eaters (per an early version of the Restraint Scale; Herman & Mack, 1975) who consumed the milkshakes in addition to their daily quota of calories would exceed their "permissible" limits and temporarily give up any attempt at restraint once they perceived themselves as having "overeaten". Among participants with no preload, normal restraint was

[4] Only when RR and FR are defined as an interaction of TFEQ-R and TFEQ-D (see section 1.5.3)

expected to remain intact. Results of the study were as expected: Restrained eaters ate more ice-cream following either milkshake preload than they did after no preload, while unrestrained eaters showed the opposite effect. In other words, counterregulation was observed only among restrained eaters. Importantly, these findings have been replicated in studies where the caloric content of the preload was manipulated. Both low- and high-calorie milkshakes induced counterregulation, demonstrating that what leads to counterregulation is the perception of a limit violation, rather than the amount of food consumed (Spencer & Fremouw, 1979).

The pre-load/taste-test paradigm is considered a laboratory tool for identifying people at risk for lapses, or gaps, in restraint (i.e., episodes of eating beyond one's limit) in their natural environments, and numerous studies demonstrate the validity of the task (Hadigan et al., 1992; Heatherton et al., 1988; Hetherington & Rolls, 1991; Polivy & Herman, 1985; Wardle & Beinart, 1981). For instance, Hadigan et al (1992) had women, with and without a tendency to binge eat, consume soup preloads of various sizes before eating a meal. Among controls, increases in the size of a soup preload were positively correlated with self-reported fullness and negatively correlated with subsequent eating. In contrast, among the women with a tendency to binge, increases in the size of the soup preload were unrelated to fullness and subsequent eating in the following meal; some women with a tendency to binge ate more after larger preloads than when the preload was very small. In other words, some women with a tendency to binge eat in the "real world" engaged in counterregulatory eating in the lab while the women with no history of bingeing did not (Hadigan et al., 1992).

Similarly, performance on a PTT paradigm has also been related to DSM-IIIR diagnoses of eating disorders (Hetherington & Rolls, 1991). For instance, regardless of the size of the preload, participants diagnosed with anorexia nervosa ate significantly less than all other subjects

(except normal weight dieters) when eating was ad lib. Moreover, all groups ate less after the high-calorie preload except participants diagnosed with bulimia nervosa – an eating disorder including symptoms of binge eating (APA, 1987). Taken together, data suggest that there is significant ecological validity to the PTT paradigm for identifying individuals at risk for violating self-imposed limits on eating outside of the laboratory. The question remains whether RR and FR are differentially related to counterregulation during this laboratory task.

1.5.3 RR, FR, and Counterregulation

Counterregulatory eating has been shown in taste-test experiments with Restraint Scale (Herman & Polvy, 1978)-defined restrained eaters, using high-calorie preloads, alcohol, and especially inductions of dysphoric mood (all of which are hypothesized to make cognitive control of eating more difficult) (Cools et al., 1992; Heatherton et al., 1991b; Herman & Mack, 1975; Herman et al., 1987; Polivy et al., 1988, 1994; Polivy & Herman, 1976, 1999; Schotte et al., 1990). Westenhoefer et al (1994) was first to investigate whether overeating in the lab could be predicted by restraint style.

Westenhoefer et al (1994) had normal-weight, young women from the general community (N=133) fill out the TFEQ and complete a PTT. Participants were assigned to one of four groups defined by scores either above or below population medians of the TFEQ-R and TFEQ-D. Groups were as follows: (1) low TFEQ-R/low TFEQ-D; (2) low TFEQ-R/high TFEQ-D; (3) high TFEQ-R/low TFEQ-D; and (4) high TFEQ-R/high TFEQ-D (the latter two groups represent FR and RR, respectively, as originally conceived by Westenhoefer, 1991). Participants also completed the RR and FR subscales of the TFEQ-R, and high RR/low FR eaters were compared against all other groups. Participants in the preload condition consumed a large

milkshake, and then tasted 3 flavors of ice-cream. Participants in the high TFEQ-R/high TFEQ-D group (conceptual equivalent of RR) showed a counterregulatory increase ice-cream consumption following the preload. Similarly, participants showing high RR/low FR ate significantly more following the preload than participants with high FR and low RR (nonregulation). In short, whether RR and FR were defined by their subscales, or conceptually as an interaction between TFEQ-R and TFEQ-D, primarily RR eaters showed evidence of overeating while all other groups did not.

Two published attempts to replicate Westenhoefer et al (1994) have neither confirmed nor refuted the original results. In both studies, young, female college students were randomized to preload (milkshake) or no-preload conditions and indicators of restraint style were used to predict post-preload eating (ice-cream or cookies) (van Strien et al., 2000; Ouwens et al., 2003). RR and FR were operationalized as interactions between TFEQ-R and TFEQ-D as in Westenhoefer et al (1994). Results of one study showed borderline (p's < 0.10) main effects of TFEQ-R *and* TFEQ-D on ice-cream consumption (TFEQ-R was associated with reduced eating and TFEQ-D was associated with increased eating), but no evidence of their expected interaction (van Strien et al., 2000). In the other, TFEQ-D was associated with increased eating, but neither TFEQ-R nor a TFEQ-R x TFEQ-D showed a relationship to the dependent variable, cookie consumption (Ouwens et al., 2003). In both studies, few relationships (expected or otherwise) between predictors and outcomes were observed.

While the possibility remains that the counterregulation exhibited by the conceptually RR eaters in Westenhoefer et al (1994) was anomalous, a more likely explanation is others failed to replicate their results because of *extreme* differences between the samples on key variables of interest. Specifically, while Westenhoefer et al's (1994) sample had TFEQ scores consistent with

population norms for the scales (TFEQ-R: M = 8.2, SD = 5.1 and TFEQ-D: M = 6.6, SD = 3.6), the two replication studies (exclusively college student samples) showed TFEQ-R and TFEQ-D scores well below population means (TFEQ-R: M = 1.74, SD = 0.33 and M = 1.68, SD = 0.36; and TFEQ-D: M = 1.48, SD = 0.27, and M = 1.44, SD = 0.23, respectively; van Strien et al., 2000; Ouwens et al., 2003). Indeed, in both studies, TFEQ-R was largely unassociated with eating in the no-preload condition. In short, findings suggest that counterregulation may only be observed in samples exhibiting a minimum degree of restraint and disinhibition. Replications of Westenhoefer et al (1994) using similar samples, however, are encouraged.

1.5.4 Summary of Research on Counterregulation

Tests of the ecological validity of the PTT paradigm suggest that it can be used to predict which eaters are susceptible to episodes of break-through eating in participants' natural environments. Overall, although data are extremely preliminary, the trend is for primarily RR eaters to be at risk for counterregulation, and primarily FR eaters to have no such risk when challenged in the lab. All-in-all, data from observational and experimental studies show that a predominantly RR style is a risk factor for episodes of break-through eating while a predominantly FR style has no additional risk for lapses in control.

1.6 MEASUREMENT

The only published measures of restraint style are the RR and FR subscales of the TFEQ-R, derived and revised by Westenhoefer and group (1991, 1999). Ideally, this (or any) instrument

would capture two opposing restraint styles that psychometrically, sit at opposite ends (or poles) of a single dimension. Indeed, RR and FR subscales are the result of research designed to identify two separate types of restrained eaters characterized by *either* a low or high propensity to splurge (TFEQ-D; Westenhoefer, 1991). At a superficial level, the names of the subscales imply opposing restraint styles (intuitively, no person can execute rigid and flexible restraint over the same behavior, at the same time); as indicated by empirical data, the scales show nearly opposite associations with eating behavior (see Section 1.4). Nonetheless, psychometric analyses of the RR and FR subscales suggest that they are not measuring opposite constructs. In fact, when compared to each other, RR and FR subscales appear to measure constructs that are similar.

Intercorrelations between RR and FR are consistently strong and positive for both the original (r's = +.54 to +.63) (Westenhoefer, 1991; Westenhoefer et al., 1994) and revised versions of the scales (r = +.71) (Stewart et al., 2002). Shared variance between RR and FR may be due to an overall assessment of the *magnitude* (rather than the style) of dietary restraint by both subscales (e.g., the use of cognitive limits to signal when eating should stop). Indeed, some statistical and conceptual overlap is expected between the subscales given that both of their items are drawn from a single, internally-consistent measure of dietary restraint (TFEQ-R; Stunkard & Messick, 1985). Shared variance may also reflect the fact that items chosen for the subscales post-hoc and consequently may not be ideal representations of either style. For example, FR items include questions about taking small helpings and eating slowly -- neither of which obviously reflect flexibility of restraint (Westenhoefer, 1999) (see Table 1 for scale items). One consequence of including subscales with low face validity is reflected in the low (RR = .55 and FR =.73) (Westenhoefer, 1991) and moderate (RR = .77 and FR = .79) (Westenhoefer et al.,

1999) internal consistencies of the original and revised versions of the scales, respectively. Regardless of its cause, a positive correlation between the subscales poses serious problems for describing how conceptually, RR and FR relate to behavior. In other words, the current subscales create conceptually contradictory groups of restrained eaters who appear both "rigidly" and "flexibly" restrained.

Nonetheless, RR and FR remain constructs with theoretical and practical value. Careful consideration of the meaning of the constructs, in conjunction with a psychometrically sound measurement scale, will likely suggest two styles of restraint that have implications for predicting the success of attempts to limit eating, and possibly other behaviors. As described above (Section 1.3), widely used and accepted theories of how appetitive behaviors are regulated place considerable weight on the importance of restraint strategy and style. Despite limitations of the existing subscales, empirical data clearly demonstrate that RR and FR shed light on the complex process of limiting appetitive behaviors and identifying individuals at risk for failure in this domain (Section 1.4). Whether the relationship between restraint style and success at limiting consumption is held for other appetitive behaviors is unknown.

1.7 SUMMARY

Research on dietary restraint has shown how attempts to restrict eating to cognitively-determined limits can affect eating and weight outcomes. In particular, research on RR and FR styles has helped to clarify the relationships between dietary restraint and a variety of eating outcomes. Laboratory experiments suggest how RR and FR subscales might predict who will overeat after a high-calorie preload, and performance on these experimental tasks can be used to identify eaters

with poorly controlled eating outside of the lab. Cross-sectional data show that primarily RR eaters are more likely to binge eat, be overweight, and use drastic methods for weight control, while primarily FR eaters do the opposite. Despite limitations in how the constructs are measured, RR and FR are useful for identifying eaters at risk for lapses in restraint, and RR and FR styles add to researchers' understanding of how attempts to limit eating affect eating behavior. Whether RR and FR are similarly associated with attempts to limit other consummatory behaviors is unknown.

2.0 RIGID AND FLEXIBLE RESTRAINT IN SMOKERS

Thus far, the constructs of restraint and restraint style have been described as they pertain to eating and dieting where they have received the most attention. In comparison, the effects of restraint and restraint style on smoking behavior are relatively unknown. The remainder of this proposal is devoted to describing how the constructs of RR and FR, as developed in research on eating, might also apply to smoking. The available (but limited) research on attempts to limit smoking show that cognitive limits on smoking are widely used, and that they also affect smoking behavior. A further review of existing data suggests that different restraint styles may be associated with different behaviors and outcomes in smokers. To directly address this hypothesis, however, this project includes an experimental manipulation of restraint style and a test of the relationship between restraint style and irregularities in smoking restraint. Specifically, the goal of this project is to investigate the risk of counterregulatory smoking in groups of primarily RR and FR smokers using a PTT design.

2.1 DEFINITIONS OF SMOKING RESTRAINT, AND RR AND FR STYLES IN SMOKERS

The construct of smoking restraint has been used elsewhere (Perlick, 1977; Hickcox, 1995; Kozlowski et al., 1981) and its operational definitions have ranged from summary scores of a

few questions about self-imposed limits on smoking (Perlick, 1977) to a complex interaction between intentions to limit smoking, impulses to smoke, and coping (Hickcox, 1995). One of the aims of this study is to examine the extent to which research on dietary restraint can inform studies of smoking restraint, thus smoking restraint is defined in parallel to its original definition in the eating literature: a tendency to restrict smoking to cognitively-determined limits of "enough smoking" rather than to physiological signals of satiety.

Rigid and Flexible styles of *smoking* restraint have not been used or defined in the extant literature. However, parallels to the definitions used in research on eating are easily drawn: Rigid Restraint (RR) of smoking is defined here as a dichotomous, "all-or-nothing" approach to self-imposed limits on smoking. A person exercising primarily RR over their smoking would try to avoid smoking above self-imposed limits, but if they did, they would experience guilt over the transgression and also be unlikely to compensate for that intake. On the other hand, a person who uses a primarily Flexible Restraint (FR) style would make allowances for guilt-free, episodes of increased consumption with plans to smoke less in the future.

2.2 THEORY

While very little is known about smokers' attempts to limit their smoking, the same theoretical models that suggest the importance of RR and FR styles in eaters suggest that the relationship between restraint and eating and restraint and smoking may be alike.

The Boundary Model has been used to explain how some smokers might limit their smoking during transitions from uninhibited smoking to quitting (Kozlowski & Herman, 1984). Like eaters, smokers may define "acceptable" levels (or boundaries) of consumption (e.g.,

perceived as "safe enough") within physiologically-plausible limits (i.e., between withdrawal and toxicity) to guide their consumption instead of smoking until they feel sated. When smokers have smoked beyond the "acceptable" boundary, like eaters, they may abandon further attempts to limit their smoking and proceed to smoke until they are satisfied (i.e., counterregulation). On the other hand, if the limit is somewhat flexible and can be adjusted to accommodate occasional episodes of increased consumption, perceived transgressions will be less frequent, and gaps in restraint should be less likely.

Similarly, although the Limit Violation Effect (LVE; Collins & Lapp, 1991, 1992) has not been explicitly applied to smoking behavior, the original Abstinence Violation model (Marlatt & Gordon, 1985) has been widely used to describe the processes underlying failed attempts to quit smoking (e.g., Chornock et al., 1992; Shiffman et al., 1996). According to the models, when self-imposed prohibitions (or limits) on smoking are violated, negative self-cognitions, decreased self-efficacy for limiting intake, and consequent smoking to alleviate the negative emotions associated with taking responsibility for the failure, occur. Empirical tests suggest that although most indicators of the AVE in smokers (self-efficacy, attributions and reactions to the transgression) generally fail to predict progression to relapse, participants who feel like giving up after a lapse (Shiffman, et al., 1996) or experience feelings of guilt (Chornock et al., 1992) progress more quickly to relapse. As postulated in both models, if the critical factor for moving from a simple limit violation to the full-blown "violation effect" is the meaning the person assigns to the violation (Collins & Lapp, 1991; Marlatt, 1985), primarily RR smokers, who attach greater failure-meaning to limit violations would be more likely to experience a "violation effect" and smoke further beyond their limits. Primarily FR smokers, on the other hand, would be expected to experience fewer consequential violations (e.g., episodes that

"ruined" success at limiting smoking requiring compensatory measures), be less susceptible to "violation effects", and therefore be at reduced risk for additional limit-violating smoking.

Notably, some researchers have suggested that models of eating and smoking should not be used interchangeably, particularly because people who limit eating might be different from those who limit smoking. Specifically, people who limit their eating may represent a more diverse population than smokers who limit their smoking, because unlike eaters, smokers also have the option of quitting completely. Smokers who attempt to limit their smoking (rather than quit) may be more dependent or perhaps less committed to change. On the other hand, people who chose to limit their smoking instead of quitting outright have been shown to resemble other smokers (Hughes, 2000). Few reliable reducer vs. quitter differences have been found (Hughes, 2000, 2007).

Similarly, Hickcox (1995) suggested that smokers may not engage in 'binge episodes' of smoking due to the acute aversion (nausea, dizziness, etc.) caused by 'over-smoking', and thus smokers might not be susceptible to counterregulation in the same way that eaters are. Perhaps surprisingly, therefore are data suggesting that binging in smokers does occur. Despite the risk of nicotine toxicity, some smokers periodically smoke multiple cigarettes in succession (i.e., "chain-smoke") (Gritz et al., 1983; Ohashi et al., 2003; Pulido-Duque et al., 2005), and in the laboratory, smokers tolerate experimental procedures that require chain-smoking, as well (Kolonen et al., 1992).

Overall, while there are a few reasons to suspect that restrained smokers might show some differences from restrained eaters when their restraint is challenged, data suggest that reduction-related patterns of behavior could also be alike. At present, very little is known about how attempts to limit smoking affect smoking behavior and researchers and clinicians can

benefit from quantifiable smoker traits that predict outcomes of attempts to cut-down. In short, data suggest that restraint style in smokers warrants investigation.

2.3 EVIDENCE OF SMOKING RESTRAINT

Evidence of smoking restraint comes from tests of the hypothesis that some smokers are light smokers because they make and abide by limits on how much they smoke. Despite between-study differences in how smoking restraint is operationalized (there are no published measures of smoking restraint), results are consistent across trials: Self-imposed limits on smoking are common among both light *and* heavy smokers, and smokers use of a variety of approaches to limit the amount that they smoke.

In one early study, "restrained" smokers were identified from a series of questions about strategies for limiting smoking (Perlick, 1977). Participants were asked: (1) Do you ever smoke your cigarettes half-way or limit your puffs in an effort to limit your intake? (2) In general, do you try to maintain your daily intake of cigarettes at or below a certain level? (3) Do you count up the number of cigarettes you smoke each day or otherwise keep a record of your intake? And (4) Are there times when you deliberately refrain from lighting a cigarette in order to cut down or keep down your smoking? (5-point scale). They were then divided into 3 groups by smoking rate and restraint status: Heavy Smokers (>21mg of nicotine/day), Light Smokers (<21mg of nicotine/day) who Restrained their smoking (total score ≥8), and Light Smokers who did not Restrain their smoking (total score <8). Overall, roughly 40% of participants could be classified as "restrained" smokers. Moreover, some attempts to restrain smoking were successful: Among the Light Restrained smokers, 70% reported having smoked more heavily in the past compared

to only 30% of the Heavy and 47% of the Light Unrestrained groups. There was also a clear division between Restrained and Unrestrained smokers; scores on the restraint index were twice as high among Light Restrained smokers as Light Unrestrained and Heavy smokers across all four questions on the index.

Perlick's (1977) study also included an experimental challenge designed to increase the saliency of nicotine withdrawal symptoms to investigate the relationship between withdrawal, nicotine deprivation, restraint, and subsequent smoking behavior. Participants were told that they were going to participate in a study on reactions to noise, and that they would be asked to rate how annoyed they became by listening to various sounds. Nicotine-deprived or non-deprived participants were allowed to smoke high-nicotine, low-nicotine, or no cigarettes during the session. Results showed that while all nicotine-deprived participants experienced withdrawal symptoms, only Light Restrained smokers reported withdrawal symptoms but also chose not to smoke. In short, results from Perlick (1977) suggest that some smokers consciously limit the amount that they smoke, and these limits are adhered to even when the desire to smoke is strong.

More recently, Hickcox (1995) reported on an investigation of restraint as a possible mechanism for low-rate smoking among chippers (smokers of 1-5 cigarettes per day (CPD), ≥ 4 days per week), as compared to heavy (≥15 CPD) smokers. Among other tasks, participants (n=97) completed semi-structured interviews about moments when the desire to limit smoking was challenged by an impulse to smoke ("restraint crises"). Results showed that both chippers and heavy smokers (≥95% in both groups) experienced restraint crisis situations, and that successful restraint (i.e., making the choice not to smoke during a restraint crisis) was evident some of the time in both groups (chippers, 65% and heavy smokers, 39%). Data from this study

suggest that both light and heavy smokers set cognitively-determined limits of "enough smoking", and that they use these limits to restrict their smoking despite wanting to smoke more.

Finally, based on findings that African Americans tend to smoke at lower rates than Caucasians and other groups (e.g., Hahn et al., 1990), Okuyemi et al (2002) investigated the use of various "reduction" strategies among African American smokers as possible contributors to their low smoking rates. Results showed that a significant proportion of smokers, from occasional (less than daily) to heavy smokers, reported that they often attempt to limit their smoking (e.g., 62% of occasional -- 19% of heavy smokers). Participants reported smoking less than half a cigarette per occasion (40% occasional -- 17% heavy) and setting a daily limit on their smoking (56% occasional, 37% heavy) as methods for keeping their consumption low (Okuyemi et al., 2002). While self-imposed limits on smoking were more common among lighter smokers, results suggest that smokers across a wide range of rates have cognitively-defined limits on their smoking, and that they have a repertoire of techniques to help them smoke within their limits.

Taken together, data from a number of studies show that both light and heavy smokers restrain their smoking; in other words, a wide-range of smokers set cognitively-defined limits on the amount that they permit themselves to smoke. Data suggest that what differentiates light and heavy smokers therefore, is not the presence or absence of restraint, but rather the resilience of the restraint when the desire to smoke is strong. Smokers' restraint styles may be related to the resilience of their restraint and their smoking behavior.

2.3.1 Evidence of RR and FR Styles in Smokers

Research on smoking restraint is in its infancy. As such, there are no published tests of restraint styles or their correlates in smokers. Nonetheless, data suggest that smokers use a variety of approaches to limit their smoking, and that these strategies are associated with different smoking patterns and outcomes. At present, the best available evidence to support this hypothesis comes from comparisons of the strategies used by heavy and light smokers to limit their smoking. While smoking rate is only an approximation of the success or failure of a restraint style (e.g., 20 CPD could represent success in a smoker who desires 30 CPD or failure for a smoker who aims to smoke 10), more direct tests (e.g., comparisons of the target vs. the actual quantity smoked) have not been reported. Thus, to suggest the possibility that different restraint styles are related to different outcomes in smokers, we compare and contrast data showing how light and heavy smokers restrain their smoking.

Data from three large trials compare light and heavy smokers' use of four strategies for limiting smoking (Perlick, 1977; Hickcox, 1995; Okeuyemi et al., 2002). Data from all three studies show that light smokers are more likely than heavy smokers to (1) have a daily or weekly limit for smoking, (2) try to limit the amount or frequency of smoking, (3) ration their cigarettes, and (4) deliberately refrain from smoking to minimize the amount that they smoke (Table 3).

Importantly, data from a variety of sources also suggest *qualitative* differences in restraint styles between smoker groups (not just quantitative differences, e.g., that light smokers are simply "more restrained"). For instance, within-group analyses of light smokers showed that light-unrestrained smokers more closely resembled heavy smokers than light-restrained smokers on the items described above (Perlick, 1977). Analyses of the contexts in which restraint strategies were used also differed between groups: Light smokers exerted more effort to limit

smoking during high craving, whereas heavy smokers exerted less effort when craving was high (Hickcox, 1995).

Perhaps the best available tests of RR and FR in smokers come from Hickcox (1995), who administered an extensive battery of questionnaires, including some questions that resemble items on the RR16 and FR12, to chippers and heavy smokers. Participants answered questions about coping in anticipation of restraint crises (anticipatory coping) and during restraint crises (immediate coping), whether their smoking was rule-bound (and if the rules were self- or other-imposed), a version of the Restraint Scale (Herman & Polivy, 1980) adapted for smokers, questions about intentions and controls to limiting smoking, an exploratory scale of self-control in other domains, and items from the Fagerstrom Tolerance Questionnaire (Fagerstom et al., 1978). They also completed items on craving. Items paralleling content assessed by RR and FR items are displayed in Table 4. The hypothesis of this exercise is that scores on items matched to RR will be higher among heavy smokers while scores on items matched to the FR will be higher among chippers[5]. Despite a few caveats (i.e., some components of FR and RR were not covered by the battery, some battery items did not obviously fit with either restraint style), results support the hypothesis that heavy smokers tend to score higher on RR-related items and lower on FR-related items, and that the converse is true for lighter smokers. For instance, chippers were more likely to skip opportunities to smoke and to limit puffing than heavy smokers. Heavy smokers had higher scores than chippers on questions about guilt and concern that smoking could get out of control. Taken together, results suggest that RR and FR styles may be useful for predicting the outcomes of attempts to limit smoking behavior.

[5] Data were largely insufficient for similar tests between converted and native chippers.

2.3.2 Summary: Evidence of Smoking Restraint

Data suggest that smokers restrain their smoking, and that different restraint strategies and styles are associated with smoking patterns and outcomes. Preliminary data from questions that resemble RR and FR subscale items in eaters suggest that smokers adopting similar styles might expect similar outcomes; that is, smokers who are primarily FR may have more success limiting their smoking behavior than smokers who are predominantly RR. Additional tests of this hypothesis, however, are needed. In particular, experimental tests of the validity of RR and FR in smokers would add credibility to conclusions based on self-report data. Experimental tests could also suggest the direction of causality between restraint style and smoking behavior. Indeed, it is unknown whether unsuccessful restrainers select mainly RR strategies, or whether using predominantly RR strategies lead to unsuccessful restraint.

2.4 COUNTERREGULATION

Counterregulation is the hallmark behavior of restrained eaters, and evidence of counterregulation in smokers would strengthen conclusions about parallels in restraint between smokers and eaters. Experimental results showing an increase in smoking following a preload (vs. no-preload condition) would constitute evidence of counterregulation because the quantity of smoking after the preload would be beyond that of a normal, regulatory response.

While no studies have used preloads and taste-tests to study the effects of restraint, or restraint style on smoking, available research suggests the feasibility of preloading smokers (Kozlowski et al., 1975; Gritz et al., 1983), that preloads generally cause smokers to down-

regulate their smoking (Kozlowski et al., 1975; Perkins et al., 1992; Pickworth et al., 2002), the feasibility of a taste-test cover story to assess ad lib consumption (Briddell et al., 1979; Pickworth et al., 2002), and the possibility of counterregulation following violations of limits on smoking (Briddell et al., 1979; Chait et al., 1985; Gritz et al., 1983; Kolonen et al., 1992; Benowitz & Peyton, 1990). Preload studies can also suggest the degree of change in smoking behavior that can be expected following various preloads. In other words, they can suggest norms against which counterregulatory smoking can be assessed.

2.4.1 Preloads

Research on smoking preloads (a.k.a. pretreatments) confirm that cigarette smokers typically adjust their smoking behavior (e.g., puff duration, inter-puff interval, puff volume, etc.) to regulate levels of nicotine in the body (Benowitz, 1988). Preloads have typically been in the range of 2-4 cigarettes or increases of an individual's smoking rate of 2-4 times. Preloads in this range are typically well-tolerated and are rarely associated with attrition from studies or adverse events (Chait et al., 1985; Henningfield et al., 1980; Herning et al., 1981; Kumar et al., 1977; Kolonen et al., 1992). Doses sufficient to induce nicotine toxicity, such as those in studies of rapid smoking (a method used to promote aversion to cigarettes and to facilitate quitting), range from 6 to 9 cigarettes per sitting (Houtsmiller & Stitzer, 1999; Tiffany et al., 1986).

Smoking pretreatment studies also suggest aspects of smoking behavior that are affected by preloads which may also be outcomes of interest in PTT studies. For instance, in a small (N = 5) study that tested the effects of increasing preloads (from 0, 2, 4, 8, to 12 standardized puffs) on ad lib smoking, participants showed a decrease in number of puffs per cigarette (from 6.9 to 4.9), an increase in inter-puff interval (from 31 to 84 sec), and a decrease in the total amount of

time spent puffing on each cigarette (from 9.7 to 7.0sec) with increasing preload size (SDs not reported; Chait et al., 1985). Similar results were found in a study of nicotine regulation, where participants (N = 56) were preloaded with low-nicotine, high-nicotine, or denicotinized cigarettes. Participants in the low-nicotine group had shorter latencies to smoke than the high-nicotine group (4.7 vs. 14.8 min, respectively; SDs not reported) during subsequent ad lib smoking (Kozlowski et al., 1975). Finally, in a study where participants (N = 8) were assigned to smoke 10 cigarettes (one at the beginning of each hour) or 20 cigarettes (2 in succession at the beginning of each hour) per day, volume per puff was lower on 20-cigarette days than on 10-cigarette days (605 ± 63ml vs. 642 ± 69ml, respectively) (Kolonen et al., 1992). Overall, data suggest that smoking preload size is inversely associated with quantity smoked.

Similar designs have shown that nicotine preloads administered through non-smoking modalities also reduce smoking. For example, intravenous nicotine (individually dosed to match consumption from ad lib smoking) compared to saline suppressed nicotine intake from ad lib smoking by 24.6% (Benowitz & Jacob, 1990). Similarly, others have shown less smoking following preloads of nicotine (compared to saline) nasal spray. High-dose nicotine (30 μg/kg) nasal spray significantly decreased number of cigarettes (-44%), number of puffs (-48%), breath carbon monoxide (-43%), and increased latency to smoke (+65%) compared to saline nasal spray (all p's < 0.05) (Perkins et al., 1992). When preloads are administered by transdermal nicotine patch (21, 42, or 63mg/day), results are the same: Compared to placebo, participants showed dose-dependent reductions in daily smoking of 3%, 10% and 40%, respectively (Benowitz et al., 1998). In sum, smokers who have been preloaded with nicotine through a variety of modalities compensate for the excess drug by subsequently smoking less.

An important caveat to this review is that the studies described above demonstrate regulation of smoking relative to the actual size (dose) of the preload, and not to the perceived size of the preload (note that smokers can sometimes differentiate between placebo and active treatments in "blinded" nicotine replacement treatment trials; Mooney et al., 2004). This suggests that compared to eating, smoking behavior may be guided more directly by physiological signals of the presence of nicotine and that subjective perceptions of "oversmoking" may be less important for predicting behavior.[6] On the other hand, the above studies were not of restrained smokers who, by definition, rely more heavily on cognitive assessments of consumption and attend less to physiological cues. Therefore, studies of restrained smokers might show decreased sensitivity to nicotine and greater sensitivity to visual and behavioral cues, such as lighting and smoking a cigarette. This interpretation is supported by data showing that smoking "lapses" with denicotinized and nicotine-containing cigarettes are equally likely to lead to resumptions of daily smoking after a period of prolonged abstinence (Juliano et al., 2006).

In sum, data suggest that smokers tend to show reductions in the number of puffs and total time spent puffing, and increases in inter-puff interval and latency to smoke following smoking preloads. In studies of other nicotine preloads, similar effects are observed. Therefore, greater amounts of smoking behavior (according to the above parameters) in preload (vs. no preload conditions) may be taken as evidence of counterregulated smoking because after a preload, smokers typically regulate their intake by smoking less.

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[6] Among restrained eaters, the perception of a limit violation when none has actually occurred (e.g., with a low-calorie milkshake preload) is sufficient to trigger counterregulation (Spencer & Fremouw, 1979).

2.4.2 Taste Tests

Compared to preloads, taste-tests have been used much less frequently in smoking research. Although taste-tests have been widely used to surreptitiously monitor consumption of eating (e.g., Herman & Mack, 1975; Westenhoefer et al., 1994) and alcohol drinking (e.g., Colby et al., 2004; Palfai, 2000), an extensive literature search led to only one explicit (Briddell et al., 1979) and one implicit (Pickworth et al., 2002) example of this type of design.

In the only explicit example of a smoking taste-test, Briddell et al (1979) describe how participants were invited to take part in "a study of discriminations in taste between various kinds of cigarettes". Participants were asked to taste five cigarettes by smoking as much or as little as necessary to rate each cigarette. Butts were weighed to evaluate the amount of each cigarette smoked. Participants then underwent a negative mood induction, and then repeated the entire taste-test design. Overall, this study says little about the validity of a PTT for studying smoking behavior because the independent variable (mood condition) is seldom related to smoking behavior in the lab (reviewed in Kassel et al., 2003). Nonetheless, it suggests procedures for how others might test the validity of the design with a manipulation (e.g., smoking preload) known to affect smoking behavior.

In contrast, in a study designed to compare objective and subjective reactions to two research cigarettes, participants (N = 36) smoked and then rated their liking of a commercial cigarette (not their usual brand) and two research (low- and high yield) cigarettes (Pickworth et al., 2002). Participants began the study session 45min nicotine-deprived and smoked each cigarette 45min apart. Experimenters unobtrusively monitored the total number of puffs and total time spent smoking each cigarette before participants recorded their ratings of cigarette taste. Data showed that participants used significantly fewer puffs to smoke the commercial cigarette

than either of the research cigarettes (8.4±1 commercial vs. 11.9±1.5 high-yield, 12.8±1 low-yield), and that they also smoked the commercial cigarettes considerably faster (284±20sec commercial vs. 426±30sec high-yield and 407±20sec low-yield). Although it remains unclear what aspect of the cigarette manipulation participants were responding to (e.g., chemical constitution, flavor, etc.) data suggest that under the guise of a smoking taste-test, smokers showed meaningful differences in the quantity and intensity of their smoking. In short, data suggest that a taste-test design can be sensitive to changes in smoking behavior.

2.4.3 Summary of Preload and Taste-Test Research in Smokers

Overall, data are available to suggest that smokers willingly participate in studies including preloads of various sizes and designs. Importantly, they also tend to regulate their behavior by smoking less after a preload than after a placebo or no preload control. Support for the sensitivity of a taste-test to study smoking behavior is preliminary. The two available taste-test studies with smoking behavior as the outcome have shown either no change in smoking following a mood manipulation or robust changes in smoking due to modifications to the study cigarettes. Additional data confirming the sensitivity of the smoking taste-test design would be useful for researchers interested in studying regulation of smoking in the lab.

2.4.4 Counterregulation in the Laboratory

Studies testing experimental models of relapse provide some evidence of counterregulation of smoking. In two similar studies, participants abstained from smoking for 3-4 days, smoked either a 4-5 cigarette preload or no preload, and then continued to try to remain abstinent for as long as

possible (Chornock et al., 1992; Juliano et al., 2006). Importantly, the cigarette preloads in Juliano et al (2006) were either nicotinized or denicotinized cigarettes, to control for any specific effects of nicotine re-exposure (e.g., priming; Shaham et al., 1997). In both studies, participants who had smoked a preload had shorter latencies to self-initiated smoking than those in the no-preload condition. Sixty percent (60%) of participants who received the preload had self-initiated smoking within 48h of the preload compared to 30% in the no-preload condition, regardless of cigarette type (Juliano et al., 2006). Findings support an AVE interpretation of counterregulation (Marlatt & Gordon, 1985) because feelings of guilt after the preload also predicted time to self-initiated smoking (Chornock et al., 1992). In short, forced violations of smoking prohibitions seem to instigate rule-breaking smoking among smokers –even among those who are being paid to abstain.

More direct evidence of restraint and counterregulation in smokers comes from a study of the effects of smoking at different rates on smoking regulation and topography (Gritz et al., 1983). Participants completed 3, 120-minute sessions of ad lib (first session), double rate, or quadruple rate smoking, respectively. In the double and quadruple rate conditions, participants were not required to smoke every cigarette, but they were required to light one at individualized, spaced intervals resulting in the opportunity to smoke at 2 or 4 times their baseline, ad lib smoking rate. All smoking was through a topography device. Results suggested individual differences in regulation of smoking: Some participants "overregulated" or restrained their smoking when the pace of opportunity was increased by 2 and 4 fold; that is, they smoked more (showed higher cumulative puff volume) during ad lib smoking than during times when heavy smoking was encouraged. Others showed appropriate regulation, such that their cumulative puff volume was consistent across conditions; i.e., they regulated their smoking such that they always

smoked about the same amount. Finally, others consumed considerably more than normal when opportunity was increased 2 and 4-fold, and did not regulate their smoking relative to what they smoked ad lib (Gritz et al., 1983). Assuming that the ad lib smoking condition represented regulated smoking (i.e., participants smoked until they "had enough"), smoking considerably more during the experimental manipulation (i.e., smoking *more* than enough) could be evidence of counterregulated smoking. Unfortunately, neither restraint status nor style was assessed in this study.

In sum, while no studies have explicitly used Herman and Polivy's (1975) PTT paradigm to attempt to induce counterreuglatory smoking, similar experimental procedures have been used to manipulate smoking behavior. Data suggest that smokers are amenable to consuming smoking preloads, and that PTT-like procedures can illustrate individual differences in smoking regulation. In order to strengthen the link between regulatory mechanisms of eating and smoking, studies that explicitly link restraint style with smoking behavior following challenges to restraint are need.

3.0 STATEMENT OF THE PROBLEM

Some smokers may place self-imposed limits on their smoking in order to regulate the amount that they smoke. Maintaining low levels of smoking may be important for reducing the risk of smoking-related illness among smokers with no immediate plans to quit. While self-imposed limits on smoking may be associated with lower rates of consumption, not all attempts to limit smoking are successful. How attempts to limit smoking might affect smoking behavior is largely unknown.

Research on eating and dieting has shown that particular approaches (or *styles*) to limiting eating are related to both eating behaviors and outcomes. Specifically, eaters who use a predominantly FR style are likely to lose weight and maintain healthy eating patterns, while those who limit their eating with a predominantly RR style are less likely to lose weight and are more likely to suffer from disordered patterns of eating. Importantly, primarily RR eaters are also likely to counterregulate (i.e., eat more than normal) when their limits on eating have been violated, both in and out of the lab.

Some theories about how consummatory behaviors are regulated suggest that there may be similarities between the mechanisms regulating eating and smoking behaviors. Empirical data show parallels between eating and smoking patterns, as well. Based on these similarities, data suggest that the general approach that smokers adopt to limit their smoking (i.e., their restraint style) may be associated with the success of that attempt, as well; this dissertation project tested

this hypothesis. Specifically, we investigated whether *smokers* who used a primarily RR style to regulate their smoking (as compared to a primarily FR style) were at increased risk for counterregulated smoking. In the first part of the study, smokers underwent an experimental manipulation of restraint style, aiming to produce clearly defined groups of RR and FR smokers. Then, RR and FR smokers participated in a widely-used laboratory paradigm for challenging limits on consumption; the preload taste-test design.

3.1 AIMS

1. Manipulate restraint style in smokers.
   A. Demonstrate the feasibility of manipulating restraint style in smokers.
   B. Validate the restraint style manipulation with a smoker-adapted version of Westenhoefer et al's (1999) Rigid and Flexible restraint scales.
2. Assess the effects of a restraint style manipulation on (short-term) ad lib smoking, in participants' natural environments during an attempt to smoke less.
3. Test the effects of rigid and flexible restraint styles on smoking behavior during a PTT.
   A. Adapt and validate Herman & Mack's (1975) preload taste-test paradigm to a sample of smokers.
   B. Test for group differences in smoking behavior between primarily rigidly and flexibly restrained smokers following a preload challenge.

Specifically, determine whether rigidly restrained smokers counterregulate their smoking after a preload.

4. Determine whether counterregulation of smoking in the lab is a marker for binge smoking in participants' natural environments.

4.0 METHODS

4.1 OVERVIEW

This study had a between-subjects, 2x2 design. In the first phase of the study, restraint style was experimentally manipulated. Smokers interested in reducing their smoking were randomly assigned to adopt either RR or FR styles, and were then asked to use the associated strategies to limit their smoking in their natural environments for a period of one week. In the second phase, participants returned to the lab at the end of the week and underwent a Preload Taste-Test (PTT) challenge. For the PTT, participants randomly received either a smoking preload (SP) or a control, water-drinking preload (WP), to determine if a primarily rigid restraint style was associated with counterregulation of smoking following a SP (Figure 2 contains a schematic of study procedures). The study was approved by the University of Pittsburgh IRB.

4.1.1 Participants

A convenience sample of one hundred and thirty (N=130) adult, daily smokers was recruited through print media sources in the greater Pittsburgh area. Participants were compensated $60 for completing the study.

4.1.1.1 Inclusion and Exclusion Criteria

Eligible participants were daily smokers who answered "yes" to the question, "Would you like to limit the amount that you smoke?" This inclusion criterion was intended to recruit smokers who were predisposed to restrained smoking. Eligible participants were also at least 21 years old, smokers of 15 - 20 cigarettes per day (see also Smoking Preload Condition, Section 4.3.1.1), and had been smoking for at least 3 years (to eliminate smokers who have just recently started smoking. Regular smoking patterns are usually established within 2 years of initiation; USDHHS, 1988). Participants could read and write English, consent to the study procedures, and have regular access to a telephone where they could receive voice messages.

Individuals who had immediate plans (i.e., within the next 30 days) to quit smoking were excluded from the study to reduce the risk of prospective quitters conceptualizing the restraint strategies as a means to stop smoking instead of smoking less. Smokers who were current (within the last month) users of another source of tobacco or nicotine were also excluded. Other sources of tobacco or nicotine could affect attempts to limit smoking through pharmacological mechanisms that operate independently of the cognitive and behavioral approaches of interest in this study.

Initial screening of participants was by phone. Participants who qualified for the study were screened again in person when they first arrived at the lab.

4.1.2 Measures

4.1.2.1 Primary Measures

The primary measures of interest in this study were indicators of participants' total smoking during the taste-test. We operationalized total smoking during the tasting in two ways: (1)

cumulative puff duration, and (2) total number of puffs. Puff duration is a frequently-used indicator of total smoking that can be reliably and unobtrusively obtained from video-recordings (Lee et al., 2003), and researchers have successfully operationalized a puff as the length of the observable glow at the end of participants' cigarettes during smoking (e.g., Shiffman et al., unpublished data; Lee et al., 2003; Blank et al., 2009), thus this method was also used here. Undergraduate students coded the videos of participants' smoking after being trained by the lead investigator. Initial ratings were made by a student who was aware of study conditions but who was unaware of study hypotheses. A second student who was completely blinded to study conditions recoded a random sample of 10% of the total videos. Inter-rater reliability was calculated with Pearson's correlation coefficient, and inter-rater agreement was high (r=.90), suggesting that values of cumulative puff time were reliable. Cumulative puff duration is sensitive to changes in smoking behavior in studies of smoking and nicotine regulation (Chait et al., 1985; Perkins et al., 1992), and data suggest that cumulative puff duration decreases linearly with increases in previous smoke exposure (Benowitz et al., 1986, Chait et al., 1985; but also see Gritz et al., 1983). For these reasons, cumulative puff duration was one of the primary outcomes of interest in this study.

Total number of puffs was also used to quantify total smoking on the taste-test. Number of puffs was similarly coded from video-recordings of participants' smoking. A single puff was operationlized as a discrete episode of cigarette glow. Like cumulative puff duration, total number of puffs is commonly used indicator of total smoking (Chait et al., 1985; Kolonen et al., 1992) that decrease linearly with increases in previous smoke exposure (e.g., Chait et al., 1985).

Of note, breath CO was *not* be used as a measure of smoke exposure during the taste-test because breath CO boost is not linearly related to intake (Jo & Oh, 2003).

4.1.2.2 Secondary Measures

Restraint Style

Restraint style was assessed with the *Rigid and Flexible Restraint Style Scales* (originally for eaters) (Table 1) (Westenhoefer et al., 1999), adapted for smokers (Appendix A). The adaptation of the scales for smokers included characterizing the structure of the scales (i.e., determining if the items represented two separate, rigid and flexible restraint style scales, or another structure) and establishing their validity as measures of smoking restraint style. Results of these analyses are described in Section 5.3.3. Practically, participants completed the RR and FR scales at baseline and at the beginning of the second study visit. Measures of restraint style taken at the first visit were used to characterize the sample and provide a baseline of participants' pre-existing restraint styles. Measures of restraint style taken at the second visit were used to assess changes in restraint style as a result of the restraint style manipulations.

Smoking Reduction

Smoking behavior before and after the study week was assessed with *breath carbon monoxide* (CO) (Bedfont Smokerlyzer, Bedfont Scientific, Ltd., Rochester, England). Breath CO is a non-invasive indicator of recent smoke exposure (Benowitz & Jacob, 1984), which was used to validate smoking status and to provide a rough estimate of changes in smoking from baseline to after the week-long style manipulation. Breath CO was assessed at the beginning of each laboratory visit.

Time Line Follow-Back assessments (TLFB; Sobel et al., 1979) were also used to characterize participants' smoking behavior. TLFB is a method for improving retrospective self-report by anchoring each episode of a behavior of interest (e.g. smoking a cigarette) to salient life

events (e.g., birthday parties, going to the dentist). TLFBs of *Cigarettes Per Day (CPD)* and smoking *Binges Per Day (BPD)* (i.e., smoking ≥2 cigarettes in succession) were collected for the 7 days preceding the first study visit (baseline) and throughout the study week (between visits 1 and 2). Baseline measures of smoking were taken to characterize the sample. Measures of smoking behavior taken at the second visit were used to assess the effects of the style manipulation on smoking behavior in participants' natural environments. Data on smoking BPD were also collected because eating binges are the naturalistic parallel of counterregulation in the laboratory for eaters (e.g., Wardle & Beinart, 1981), and it was of interest to determine whether dysregulated smoking in the lab was an indicator of gaps in smoking restraint outside of the lab.

Demographics and Personal Smoking Information

Common individual difference variables were examined at baseline to ensure that any variables that could confound the effects of the restraint or preload manipulations were equally distributed across groups. These variables included *personal smoking information* (e.g., cigarettes per day, preferred brand of cigarette, years smoked; Shiffman et al., 1994), *nicotine dependence* (Fagerström Test for Nicotine Dependence (FTND), Heatherton et al., 1991a; the Nicotine Dependence Syndrome Scale (NDSS), Shiffman et al., 2004), and *basic demographic information* (e.g., age, gender, education, income, ethnicity, and marital status). Participants also reported the daily limit they set on their smoking for the duration of the study week. Self-reported smoking limits were used to control for group differences in the proportion of total smoking reduction that participants planned to attempt. Group differences in the amount of total reduction that participants were attempting could confound the effects of restraint style on smoking behavior.

4.2 EXPERIMENTAL MANIPULATION OF RESTRAINT STYLE

4.2.1 Procedure

Upon first arriving at the study site participants were re-screened, and persons who were eligible for the study provided written informed consent. Participants then provided a breath sample for CO to verify smoking status and as a baseline level of smoke exposure. They then completed the questionnaire battery described above, and were randomized to one of two (RR or FR) restraint-style conditions. All participants were told that the purpose of the study was to help people reduce smoking.

4.2.1.1 Manipulation of Restraint Style

No published studies provide an explicit model for manipulating restraint style in smokers (or other groups). Studies that have manipulated other behavioral control strategies however, informed this portion of the design.

Participants were provided with a brief informational pamphlet describing how to reduce smoking, emphasizing either RR or FR strategies (Appendix B). Participants were asked to read the pamphlet carefully. The pamphlets included detailed descriptions of five, style-specific restraint strategies (e.g., Rigid: Put a firm limit on the number of cigarettes you smoke per day. Have an exact number in mind; Flexible: Put a flexible limit on the number of cigarettes you smoke per day. Have an approximate number in mind), and statements suggesting that the strategies in the pamphlet represent the only way to effectively maintain a low smoking rate. Pamphlets and messages were matched for length and subject matter.

After reading the informational pamphlet, participants were asked to write a few paragraphs about what they liked about the strategies that they learned. Similar procedures have been shown to help smokers and other groups learn new strategies to regulate behaviors, and to enhance commitment to change (Dejonckheere et al., 2003; Hall et al., 1984; Joule, 1991a; Simmons et al., 2004). Participants also wrote about how they could use the strategies themselves outside of the laboratory because the process of translating intentions into actions is enhanced by specifying how, when, and where an action is to be performed (Gollwitzer & Brandstatter, 1997). Indeed, written planning tasks have been shown to be effective for increasing smokers' use of coping techniques both in and outside of the lab (van Osch et al., 2007; Niaura et al., 1989). Finally, participants were asked to briefly (3 min) describe aloud what they would say to convince a friend to use the strategies to that they learned. This kind of "convincing-other" task has been widely used to help smokers and other groups feel less dissonant about a behavior and to increase the likelihood that they will engage in the behavior themselves (Dejonckheere et al., 2003; Joule, 1991b; Simmons et al., 2004).

Once the above tasks were completed, participants left the laboratory and were instructed to limit their smoking for a period of one week, using only the techniques described in the manipulation. A week-long restraining period was chosen based on studies showing that the first week after initiating a change in smoking behavior is a critical period for intervention (Zhu et al., 1996; Pomerleau et al., 2000).

During the week-long restraining period, participants were prompted by study staff via telephone on days 2, 4, and 6 to remind them to continue to restrain their smoking using only the study techniques. Reminders were in the form of standardized, style-specific voice messages (Appendix C). Telephone messages were also matched in length and content themes. Participants

were required to return any missed calls from the study within 8h. Remuneration was partly contingent ($5 per call) upon timely receipt of the standardized messages.

4.2.1.2 Manipulation Check

Participants attended the second study visit one week after the first. At the second visit, participants completed a number of paper-and-pencil questionnaires (RR and FR subscales, TLFBs interviews) to assess the efficacy of the restraint style manipulation. At the beginning of the second visit, participants also provided a sample of breath CO (for verification of smoking status and to assess any changes in smoking since baseline). At the end of the second study session, participants also answered closed- and open-ended questions about their compliance with the protocol and their experience in the study.

4.3 PRELOAD TASTE-TEST EXPERIMENT

The PTT took place during the second study session (i.e., 1 week after the initial restraint style manipulation procedures). The aim of the PTT experiment was to determine if participants who received the rigid manipulation were at increased risk of counterregulated smoking compared to participants in the flexible restraint group. During the PTT, participants received either a smoking preload (SP) or a water-drinking preload (WP), and were then asked to "taste" a total of 4 (but see Section 4.3.1.1) different cigarettes. Quantity of smoking was surreptitiously monitored during the tasting. It was expected that there would be an interaction between restraint style and preload condition such that smokers randomized to the rigid-SP group would smoke significantly more during the taste-test than all other groups.

4.3.1 Procedure

The second study session was held at roughly the same time of day as the first in order to control for any time-of-day effects on breath CO (Jo & Oh, 2003) or aspects of smoking. Approximately 1h after arriving at the study site, participants were taken to the experiment room; the 1h delay ensured that all participants started the PTT somewhat nicotine-deprived. The experiment room was equipped with a table and chair for the participant, positioned in full view of a video camera. The video camera allowed the experimenter to monitor the participant during the session. Video recordings were also used to quantify participants' smoking during the session. The room was equipped with an intercom system for communicating with the participant during the procedure and a fan and an air filter to prevent the room from filling with smoke.

4.3.1.1 Pilot Testing the PTT

This was the first attempt to use a PTT in smokers, thus it was necessary to pilot-test the procedures prior to use with the larger sample. A key component of pilot testing was identifying a preload dose that, 1) was large enough to challenge participants' cognitive limits on smoking, and 2) was small enough to be well-tolerated. Test doses ranged from 0.5 to 2.0 full cigarettes, in half-cigarette increments. Six (n=6) participants received each dose, and a total of N=24 participants completed the pilot procedures.

Data showed that total smoking on the taste-test (defined as cumulative puff duration) was negatively associated with preload size, except following the largest, 2-cigarette preload dose. Specifically, following the 2-cigarette preload, participants smoked more on the tasting than after any other (lower) dose (Appendix E). We interpreted this finding to mean that some participants were not regulating their smoking to the same extent after the 2-cigarette preload.

Indeed, this interpretation is consistent with early work suggesting that a 2-cigarette preload may induce counterregulation in some smokers (Gritz et al., 1983).

Existing literature suggested that a 2-cigarette preload should also be well-tolerated by participants (Houtsmiller & Stitzer, 1999; Tiffany et al., 1986) and that it should not saturate participants to the point at which they could not complete the taste-test. Indeed, while this was true for most pilot participants, one participant vomited before beginning the tasting. To reduce the risk of nicotine toxicity in other participants, the protocol was modified by raising the minimum eligible smoking rate from 10 to 15 CPD so that the sample was comprised of heavier smokers. We also reduced the number of cigarettes on the tray for tasting from 5 to 4, in order to reduce the total amount that participants were required to smoke.

Overall, n=2 pilot participants underwent experimental procedures that were the same as the final study design and their data was included in analyses of the PTT. Data from the remaining n=22 pilot participants was not used in analyses of the PTT, however, their questionnaire and ad lib smoking data (during the study week) were retained for analysis. Participant flow is detailed in Sections 5.3.1 and 7.3.1, and illustrated in Figure 4.

4.3.1.2 Smoking Preload (SP) Condition

The final preload procedure consisted of participants smoking two entire cigarettes of their usual brand in a 15min period. Once seated in the experiment room, participants in the SP condition were told the following:

"We are very interested in how this week of reducing your smoking might have affected your liking and tasting of various cigarettes. As such, we will ask you to taste or smoke a couple of different cigarettes and rate them for us. First, though, in this session we will have you smoke

some of your regular cigarettes in order to achieve standardized tasting conditions for all of the participants. In other words, we want to make sure that everyone starts the study in the same, exact way".

Participants were then provided with two cigarettes of their preferred brand, a lighter, and an ashtray. They were then given the following instructions:

"Please smoke both of these cigarettes completely. Smoke them as you would normally, but please be mindful of the time. I'll return to show you the next part of the study in about 15 minutes".

The experimenter returned after 15 minutes, removed all of the materials from the preload, and readied the participant for the taste-test.

4.3.1.3 Water Drinking Preload (WP) Control Condition

The control condition included a water-drinking procedure (WP) similar to the smoking procedure described above. Specifically, participants in the WP condition were told the following:

"We are very interested in how this week of reducing your smoking might have affected your liking and tasting of various cigarettes. As such, we will ask you to taste or smoke a couple of different cigarettes and rate them for us. First, though, we will have you drink some water to get rid of any tastes in your mouth to achieve standardized conditions for all of the participants. In other words, we want to make sure that everyone starts the study in the same, exact way".

Participants were then be provided with an 8oz glass of water, and given the following instructions:

"Please drink this glass of water completely. Drink it as you would normally, but be mindful of the time. I'll return to show you the next part of the study in about 15 minutes".

The experimenter returned after 15 minutes, removed all of the materials from the water preload, and readied the participant for the taste-test.

Taste Test

Procedures and instructions to participants in both conditions are the same from this point forward.

Participants provided a third breath sample for CO. This measure was used to determine change in CO after the preload and a baseline for the taste-test. At this point, the experimenter removed any materials from the preload from the room and placed a pre-prepared tray of the apparatus for the taste-test in front of the participant. The tray contained 4 ashtrays and 4 de-identified cigarettes, a lighter, a set of cigarette rating forms, and a pencil. Each ashtray was labeled with an index card bearing a number (1-4). Each de-identified cigarette was placed in its corresponding, labeled ashtray.[7]

Participants who regularly smoked non-mentholated cigarettes tasted non-mentholated brands, and participants who regularly smoked menthol cigarettes tasted mentholated brands. The brands selected for the taste test were of similar tar, nicotine content, and length. Participants were provided one rating form for each cigarette; each form consisted of 10 adjective pairs for the taste discriminations (Appendix D).

Once the apparatus for the taste-test was positioned in front of the participant, the experimenter read the following instructions:

"We are very interested in how this week of reducing your smoking might have affected your liking and tasting of various cigarettes. As such, we will ask you to taste or smoke a couple

[7] Black marker was used to cover any identifiers on the cigarette indicating brand, flavor, etc.

of different cigarettes and rate them for us. The instructions for rating are very simple. You will first light cigarette #1. After the cigarette is lit, go ahead and taste it by smoking as much or as little as you feel is necessary to rate the cigarette on the forms in front of you. Circle the number that corresponds to the word best describing the taste of the cigarette. You have 10-15 minutes to complete the taste evaluations. We'll let you know when you have a minute or two left in the tasting period. If you finish the tasting before the allotted time, feel free to smoke any of the cigarettes here. As you can see, we have a video camera. We use this camera just to see that you have understood the instructions and are following through the tasting without any problems. Now you can begin with the tasting, and remember that you can smoke as much or as little as you feel like in order to make the ratings."

With two minutes remaining in the 15 minute tasting session, the participant was notified of the time over the intercom system. After the full 15 minutes, the experimenter returned to collect the materials from the taste-test and to collect the fourth and final sample of breath CO.

4.3.2 Debriefing

After the experimental procedures, participants answered a number of open-ended questions about their experiences in the study. Participants were given the opportunity to indicate whether they were generally compliant with the study procedures during the restraining period and how they felt the restraint manipulation affected their smoking. They also indicated how they felt during the preload procedures and whether they felt that the preload violated any rules or limits that they had implemented to reduce their smoking. Participants then reported what they thought was the true purpose of the study. Only one pilot participant saw through the deception. At the end of the debriefing, study staff described the deception and answered any remaining questions.

Participants who indicated a desire to reduce or quit smoking were referred to local tobacco treatment programs. All participants were thanked and paid for their participation.

In what follows, the analyses and results of each of the main components of the study are presented separately. Specifically, sections address (1) the adaptation and factor analysis of the restraint style scales for smokers, (2) validation of the restraint style manipulation, and the relationship between restraint style and ad lib smoking during a reduction attempt, and (3) the relationship between restraint style and preload on total smoking in a PTT design. These topics are discussed separately and in succession as the results each analysis informed the hypotheses and interpretation of the next.

The sample used in each part of the study is also discussed in detail within each section. Briefly, N=126 participants completed the restraint style questionnaires. N=120 attended two study visits and provided data about the restraint style manipulation and ad lib smoking, and a subset of participants (n=95) completed the final, PTT procedures. Participant flow is illustrated in Figure 4, and characteristics of each subsample are described in Table 5.

All statistical analyses were run with SAS v 9.2 for Windows.

5.0 ADAPTATION AND FACTOR ANALYSIS OF THE RESTRAINT STYLE SCALES FOR SMOKERS

5.1 HYPOTHESES

The experimental restraint style manipulation was the primary indicator of restraint style in this study, however, a paper and pencil measure of the constructs was included, partly to validate the style manipulation, itself. Westenhoefer et al (1999)'s Rigid and Flexible restraint style scales for smokers therefore, were adapted for this purpose. Given that the smoker adaptation of the scales was novel, its psychometric properties, and the properties of factor scales resulting from an analysis of its items, were examined to identify the optimal set of scales to validate the manipulations. A "useful" measure of smoking restraint style was expected to show adequate levels of internal consistency, as well as conceptual and concurrent validity in terms of, a) clearly representing separate, rigid and flexible constructs, and b) reliable associations with other, established correlates of restraint style (i.e., concurrent validity). To determine which set of scales best approximated these criteria, I tested the following hypotheses:

1. Indicators of rigid restraint will be positively associated with breath carbon monoxide (CO), cigarettes per day (CPD), binges per day (BPD), measures of nicotine dependence, and a consistent rate (per participants' self-report).

2. Indicators of flexible restraint will be negatively associated with breath CO, CPD, BPD, measures of nicotine dependence, and self-reported consistency smoking rate.

5.2 DATA ANALYSIS

5.2.1 Factor Analysis

Common factor analysis (SAS Proc Factor) was used to characterize the structure of the smoker-adapted Rigid and Flexible Restraint scales. Common factor analysis is a technique for analyzing interrelationships among a large number of variables and to explain their relationships in terms of common, underlying dimensions (i.e., factors) (Hatcher, 1994). The objective of this analysis was to determine whether the smoker-adapted scales would yield a 2-factor, rigid and flexible solution, or whether some other structure would emerge.

Exploratory factor analysis with squared multiple correlations was used to estimate the prior communalities. Factors were extracted with the principal components extraction method. Exploratory factor analysis was used instead of confirmatory factor analysis because it was unknown whether adapting the items to smoking-specific content would affect the underlying structure of the scales, and because the aim of the analysis was to ascertain the structure of the smoker scales rather than simply replicate the structure of the eater version. Factor analyses consisted of two iterations, each emphasizing the interpretability of the factors and simple factor loadings. Items with complex loadings or no loadings on interpretable factors were omitted from the second iteration analysis.

Potential factor solutions were subject to promax rotation to promote simple, oblique structure, which is useful for producing conceptually meaningful, interpretable factors (Hatcher, 1994; Gorsuch, 1990). In the scale development process however, I also examined orthogonal solutions and the results were similar. I ultimately proceeded with oblique solutions to maintain consistency with previous analyses of the restraint scales (e.g., Allison et al., 1992; Westenhoefer et al., 1999).

Among the many possible structural solutions, preference was given to 2-factor (rigid/flexible) solutions and others that addressed known problems with the eater-version of the scales (e.g., solutions that contained a "magnitude of restraint" factor were preferred because they could extract shared variance among the restraint style factors; Westenhoefer, 1991; Westenhoefer et al., 1999; Stewart et al., 2002).

Final scale scores from the factor analysis were computed as factor scores, formed from linear composites of the standardized regression coefficients. Factor scores were used because they provide a more reliable representation of the scale structure than other scoring techniques (e.g., averages of high-loading items; Hatcher, 1994).

5.2.2 Internal Consistency, Scale Structure, and Concurrent Validity

Cronbach's Alpha was used to assess the internal consistency of the original and factor scales. Cronbach's Alpha (α) assumes that items measuring the same construct will be highly correlated (Hatcher, 1994), and can thus be used to determine the degree to which all items on a scale measure a single construct.

Correlation analysis was used to assess the validity of the scales by examining the intercorrelation between the rigid and flexible scales, and restraint factor scales. Restraint style

scales that shared a strong, positive intercorrelation would not be useful for distinguishing between distinct, rigid and flexible restraint styles.

Correlation analysis was used to assess the concurrent validity of the scales against measures of smoking rate, patterns, and binges, as well as nicotine dependence.

5.2.3 Descriptive Statistics

Descriptive statistics such as range, frequency, and measures of central tendency were used to characterize the sample on demographic, psychological, and smoking variables at baseline.

5.3 RESULTS

5.3.1 Participants

Participant flow is illustrated in Figure 4. Ultimately, N=130 participants enrolled in the study. Four (n=4) participants were excluded before completing the first session because they were deemed ineligible during the rescreening interview. One hundred and twenty-six (n=126) participants completed the first study session, and data from this sample was used to characterize and validate the questionnaires.

Participant characteristics are detailed in Table 5. Participants who provided questionnaire data were approximately half male, in their late thirties, and half non-Hispanic Caucasian. One third of the sample had completed a college degree. Participants were daily smokers who smoked on average, just under a pack of cigarettes per day, had been smoking for

almost 20 years, and were moderately nicotine dependent (e.g., FTND *M* = 4.02, *SD* = 1.79). Baseline assessments of rigidity, based on the Smoker-adapted Rigid Restraint scale (SRR) (*M* = 6.81, *SD* = 2.22) and the Smoker-adapted Flexible Restraint scale (SFR) (*M* = 4.09, *SD* = 2.28) were within the moderate range compared to normative values for American eaters (RR = 3-7, FR = 3-6; Timko, 2007).

5.3.2 Factor Analysis

All 28 items comprising the Smoker Rigid Restraint (SRR) and Smoker Flexible Restraint (SFR) scales were entered into the first common factor analysis. In the first iteration, four (4) factors were retained based on the following criteria (adapted from Hatcher, 1994): (1) the number of factors corresponded to a large break in the scree plot, (2) each factor accounted for at least 10% of the total variance, (3) factors were interpretable (i.e., they included at least 3 items with loadings of .35 or greater that shared conceptual meaning), and (4) the rotated factor pattern had simple structure (i.e., each item loaded highly on only one factor). Factors had Eigenvalues of 3.42, 1.77, 1.21, and 1.01, respectively, and the solution accounted for 70.59% of the total variance in the reduced correlation matrix. Questionnaire items and corresponding factor loadings for this analysis are in Appendix F.

Based on the results of the first analysis, several items were dropped to promote the creation of purer factors in the second analysis. Specifically, eight items that did not load on any of the original four factors and two items that had complex loadings (i.e., loaded on more than 1 factor) were excluded. As a consequence of removing items with complex loadings, factor 4 retained too few items to be interpreted reliably (n=2 items; Hatcher, 1994), thus the remaining items that loaded on factor 4 were omitted. Ultimately, the four items that loaded on factor 3

were also dropped because the item content did not clearly reflect smoking restraint or restraint style.[8] What remained were 11 items that had simple loadings on factors 1 and 2. These factors reflected general restraint concepts and restraint style, respectively. These 11items were entered into the second factor analysis.

Results of the second analysis produced a two (2) factor solution. Factors 1 and 2 had Eigenvalues of 2.22 and 1.12, respectively. Factor 1 accounted for 68.75% and factor 2 accounted for 34.55% of the total variance in the reduced correlation matrix.[9]

The two factor solution was subjected to a promax rotation, and questionnaire items and corresponding factor loadings are in Table 6. The two derived factors were labeled Balanced Consumption and Basic Restraint. Factor scores were computed for each scale and scoring coefficients are detailed in Appendix G.

Basic Restraint (factor 2) reflects participants' attention to, and concern about the amount that they smoke (e.g., "How conscious are you of how much you are smoking?"). This factor does not appear to represent restraint style per se, but rather a predominantly style-neutral concern about smoking, and attention to amount smoked.

In contrast, Balanced Consumption reflects an individual's belief that he or she compensates for episodes of heavy smoking with subsequent lighter smoking. This pattern of compensatory down-regulation is a hallmark of a flexible restraint style. Conversely, low scores on Balanced Consumption reflect the absence of compensatory restriction following episodes of heavier consumption, which is a behavioral characteristic of rigidly restrained consumers

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[8] Factor 3 items reflected concerns about health as a reason for restraining smoking, rather than if or how smoking is restrained. Further, this factor may have been an artifact of how its items were translated from eaters to smokers, in which the word "health" was substituted for "weight" (see Appendix F); this factor was also not expected to be replicated in subsequent analyses of dietary restraint data.

[9] Total variance accounted for is >100% because the communality estimates were not perfectly accurate (see Hatcher, 1994, pg. 85).

(Westenhoefer et al, 1994, pg. 28). This suggests that aspects of rigid restraint may be represented by low scores on the Balanced Consumption scale.

Rigid smoking restraint, however, is also characterized by invariance in smoking rate across days due to strict adherence to limits on smoking, and consistent, rule-bound smoking is not explicitly captured by any items on the Balanced Consumption scale. Also noticeably absent are items describing the cognitive components of either restraint style. For example, neither the feelings of guilt following rule violations characteristic of rigid restraint nor the relaxed approach to rule adherence characteristic of flexible restraint are not objectively assessed by the scale. Nonetheless, Balanced Consumption may reflect at least some of the behavioral components of both restraint styles, with higher scores on the scale reflecting aspects of flexible restraint and lower scores reflecting aspects of rigid restraint. Specifically, high scores on the scale reflect compensation for episodes of heavy smoking with subsequent periods of lighter smoking, which is a flexible restraint style behavior. Conversely, low scores on the scale reflect no compensation for episodes of heavy smoking, which is a rigid restraint style behavior (Westenhoefer et al., 1994, pg 28).

5.3.3 Psychometrics of the Original and Factor-Analyzed Restraint Scales for Use in Smokers

Since the factor analysis of the original Smoker Rigid Restraint (SRR) and Smoker Flexible Restraint (SFR) items did not replicate the rigid and flexible factor solution seen in the eater version of the questionnaire, the psychometrics of the SRR and SFR scales with the factor scales to were compared to determine which set of scales could best characterize the effects of the restraint style manipulations.

5.3.3.1 Internal Consistency

George and Mallery's (2003) criterion were used to characterize the internal consistency of the original and factor scales (i.e., α >.9 = "excellent", >.8 = "good", >.7 = "acceptable", >.6 = "questionable", >.5= "poor", and <.5 = "unacceptable").

Data showed that the internal consistency of the SRR scale was unacceptably low (α = .44) thus attempts were made to improve the scale by removing single items; single item removal did not categorically improve the structure of the scale (highest α = .49). In contrast, internal consistency for SFR was slightly higher, reaching a "questionable" level (α = 0.67), however removal of single items resulted in no categorical improvement. In contrast, internal consistency of Basic Restraint reached a "questionable" (α = 0.60) level, while internal consistency of Balanced Consumption was "acceptable" (α = 0.78). Single item removal did not categorically improve the internal consistency of either factor scale.

5.3.3.2 Structural Analysis of the Original and Factor Scales

The relationships between the original scales and the factor scales were examined in order to determine how the scales were interrelated. Measures of rigid and flexible restraint that are consistent with Westenhoefer's (1991, et al., 1999) restraint style theory would represent rigid and flexible restraint as two separate and opposing constructs as indicated by either, a) separate rigid and flexible restraint scales that are strongly, negatively correlated, or b) a single, bipolar measure of restraint style with opposite poles reflecting rigid and flexible restraint, respectively.

Like the eater versions of the scales (see Section 1.6), the original scales (SRR and SFR) scales were strongly, positively correlated $r(112)=.54$, $p<.0001$ (baseline values). This finding suggests that the scales did not clearly differentiate between rigid and flexible restraint because smokers could be classified as simultaneously rigidly and flexibly restrained. The structure of the

original, smoker-adapted restraint style scales therefore could not provide a meaningful representation of either style, thus it could not be used to validate either restraint style manipulation.

In contrast, restraint style was represented by only one of the factor scales. Thus, validation of the single restraint style measure (Balanced Consumption) consisted of establishing its bipolarity. The bipolarity of the scale was determined based on the degree to which rigid and flexible restraint were adequately represented at the opposite poles of the scale, respectively. A moderate (e.g., Cohen, 1988), positive correlation between Basic Restraint and Balanced Consumption $r(118)=.29$, $p=0.002$ suggested that Balanced Consumption was not bipolar, because the restraint styles were expected to be equally associated with general features of restraint such as attention to, and concern about total smoking. Similarly, although a strong positive correlation between Balanced Consumption and SFR $r(116)=.67$, $p<0.0001$ suggests its utility for measuring flexible restraint, a moderate, *positive* correlation with SRR $r(113)=.39$, $p<0.0001$ casts further doubt on the bipolarity of the Balanced Consumption scale. On the other hand, Basic Restraint is also a product the oblique factor analysis that yielded Balanced Consumption, so some association between the scales was expected. Given the strength of association with SRR and Basic restraint, and the content of the Balanced Consumption scale items however, it is likely that high scores on the Balanced Consumption scale represent flexible restraint more completely than low scores represent rigid restraint.

In sum, although neither the original scales nor the factor scales provided a completely satisfactory measure of smoker restraint style, based on the above tests of their reliability and validity, I selected the factor scales to validate the restraint style manipulations. Specifically,

although the original scales were the closest analog to the eater version, the original scales also shared a scale structure that limited their utility for illustrating the unique effects of *either* restraint style on smoking behavior. In contrast, the single factor measure of smoking restraint style showed adequate reliability, good face validity for measuring behavioral aspects of flexibility and some limited behavioral aspects of rigidity, and less conceptual overlap between restraint styles -- even with the constructs unequally represented at the opposite ends of the scale. Indeed, insofar as decreases in flexibility necessitate increases in rigidity, lower scores on the Balanced Consumption scale may be somewhat useful for characterizing some of the effects of the rigid manipulation.

In what follows, the relationships between the factor scales and measures of smoking behavior hypothesized to be related to smoking restraint style are characterized. These analyses were intended to establish the concurrent validity of the scales. Specifically, statistical relationships between established measures of smoking behavior and nicotine dependence were used to show that Balanced Consumption shared variance with instruments measuring conceptually-related constructs.

5.3.3.3 Concurrent Validity

The concurrent validity of Balanced Consumption, the factor scale measure of restraint style, was tested against measures of self-reported smoking patterns, bingeing, and nicotine dependence. Specifically, it was expected that Balanced Consumption would be positively related to self-report measures of variability in smoking between days, and inversely related to measures of total smoking (breath CO, CPD, BPD), and smoking regulation (i.e., nicotine dependence). Results of this analysis are in Table 8.

Balanced Consumption showed none of the expected associations with measures of smoking behavior. This finding suggests that unlike restraint style in eaters, smoking restraint style may not be associated with smoking rate or smoking binges. On the other hand, smoking rate in this sample was highly constrained (limited to 15-20 CPD, see Section 4.3.1.1) and there may not have been sufficient variability in consumption to detect an association between the constructs. Tests of the association between restraint style and smoking behavior should be replicated in a more varied sample.

On the other hand, Balanced Consumption was associated, as expected, with a few measure of nicotine dependence. Specifically, Balanced Consumption was significantly, inversely related to consistency of smoking rate (NDSS Continuity, $r(114)=-0.22$, $p=.02$). Indeed, the hallmark of flexibly restrained smoking is a mix of periods of heavy smoking followed by periods of lighter smoking; thus this finding suggests that Balanced Consumption captures a key characteristic of flexibly restrained smokers' behavior. Furthermore, this aspect of flexible restraint was also heavily emphasized in the flexible restraint style manipulation, suggesting that the fit between the scale and the manipulation is good. In contrast, consistency in smoking rate is a key characteristic of rigidly restrained smokers' behavior because rigidly restrained smokers are expected to adhere to the same smoking limits from day to day, and although the inverse relationship between Balanced Consumption and NDSS Continuity suggests that Balanced Consumption has some utility for capturing aspects of rigid restraint style, an inverse relationship to items explicitly suggesting continuity of smoking would provide better support for this effect.

Finally, Balanced Consumption was also positively associated with a measure of smokers' preference for smoking over other reinforcers (NDSS Priority, $r(112)=.23$, $p=0.01$). As

with flexibly restrained eaters, this association could suggest that flexibly restrained smokers might smoke for different reasons than rigidly restrained smokers. Specifically, flexibly restrained smokers reported smoking because they enjoy smoking instead of feeling compelled to smoke. This interpretation is further supported by the null association between Balanced Consumption and a measure of dependence-driven drive to smoke (NDSS Drive, $r(117)=0.00$, $p=.99$).

Unlike Balanced Consumption however, few a priori hypotheses about Basic Restraint and smoking and dependence were made, as Westenhoefer's theory does not make predictions about the effects of restraint on behavior independently of restraint style. However, I ventured that Basic Restraint would be associated with lower daily smoking rate and lower levels of breath CO, as participants who were trying harder to restrain might also smoke less. In fact, Basic Restraint was not significantly associated with any measure of smoking behavior or dependence. This finding could be due to the fact that the scale is unreliable due to its poor internal consistency. Alternatively, it could suggest that generalized restraint has few associations with smoking behavior, independent of other influences, such as restraint style.

5.4 DISCUSSION

It was important to have a paper-and-pencil measure of smoking restraint style in order to validate the restraint style manipulations used in the next phase of this study. To do this Westenhoefer et al's (1999) Rigid and Flexible restraint scales were adapted for use with smokers, and then used exploratory factor analysis was ued to determine if the smoker-adapted items produced a factor solution that represented rigid and flexible smoking restraint styles.

Results showed that the two-factor, rigid and flexible restraint style solution characteristic of the eater version of the scale was not replicated. Instead, factor analysis produced a two factor solution consisting of Balanced Consumption (a measure of smokers' perception that they compensate for episodes of heavy smoking with subsequent periods of lighter smoking), and Basic Restraint (a measure of attention to, and concern about smoking and its effects). Although tests of the reliability and validity of both sets of scales suggested that neither was a completely satisfactory measure of smoking restraint, I concluded that the factor scales had greater utility for representing rigid and flexible smoking restraint.

The original scales had several undesirable characteristics. Specifically, the rigid scale had unacceptably low internal consistency and no associations with any measure of smoking behavior or nicotine dependence. The strong, positive, intercorrelation between the original rigid and flexible scales was also particularly problematic because smokers could be classified as simultaneously rigidly and flexibly restrained. A combined rigid and flexible restraint style is inconsistent with theory and impractical for identifying the specific effects of each restraint style manipulations (i.e., the priority of the analysis). For these reasons, I decided to use the factor scales to validate the style manipulations.

Characteristics of the factor scales that suggested their greater utility included a relative improvement in the factor scale that measures restraint style (Balanced Consumption), and its predicted association with an established measure of self-reported variability in smoking rate. The face validity of Balanced Consumption was also good; items such as "If I smoke at little bit more on one occasion I make up for it at the next occasion" comprised the scale representing regulation of total smoking through a balance between periods of heavier and lighter smoking. A further strength of the factor scales is that items representing other constructs intermixed with the

original scales were either relocated to the Basic Restraint factor or were excluded prior to the secondary analysis, creating a purer measure of restraint style. Most importantly, rigid and flexible restraint styles were generally represented by either high *or* low scores on a single factor scale. Unlike the original scales, the factor scales offered more distinct markers of rigid and flexible restraint that could be use to better reflect the specific effects of each restraint style manipulation.

Several limitations of the factor scales however, are worthy of mention. For instance, a limitation of using Balanced Consumption as the single measure of restraint style is that it appears to only capture flexible restraint *behaviors* without clearly addressing the cognitions that also comprise the style. Specifically, flexibly restrained smokers are expected to have periods of heavy smoking without guilt due to planned periods of subsequent, lower-rate smoking. A drawback of assessing behaviors alone is that smokers exhibiting the same behaviors without the cognitions could be misclassified as flexibly restrained when their Balanced Consumption score reflects a very different approach to consumption. For instance, extreme variability in intake characteristic of flexibly restrained smokers is reminiscent of the binge-purge cycle of bulimic eaters, where periods of heavy consumption are paired with periods of lighter consumption but bulimics' periods of heavy consumption are also associated with guilty feelings after the binge (Powell & Thelen, 1996). In short, the Balanced Consumption scale reflects a pattern of smoking behavior that is characteristic of flexibly restrained consumers without entirely reflecting a flexible restraint style because it does not assess the cognitions characteristic of flexibly restrained consumers. Researchers should be careful not to infer complete flexible restraint style from high scores on the Balanced Consumption scale.

A further limitation of Balanced Consumption is that there are no (negatively loaded) items reflecting rigidly restrained smokers' unbending adherence to smoking limits. Instead, rigid restraint was only represented by the absence of flexible restraint, which is limited to the theoretically rigid behavior of not compensating for "forbidden" consumption when it occurs (Westenhoefer et al., 1994, p.28). Similarly, as with flexible restraint, Balanced Consumption does not reflect rigid restraint cognitions; rigidly restrained smokers are hypothesized to prioritize strict adherence to cognitive rules for smoking, and to experience guilt and shame when these rules are transgressed. Moreover, guilt and shame are hypothesized to precipitate counterregulatory consumption. Thus, a scale that does not assess them is expected to have limited utility assessing predictors of counterregulated smoking. Consequently, proceeding with Balanced Consumption as the sole measure of restraint style implies proceeding with a measure of rigid restraint that is likely conceptually incomplete.

Despite the shortcomings of the factor scales, the content of the scales is somewhat consistent with the material included in the restraint style manipulations, suggesting that the scales may have some utility for their validation. In the case of flexible restraint specifically, fit between the content of the scale and the manipulation was good. Participants who received the flexible manipulation were instructed to set an approximate limit for their smoking, and then to balance periods of heavier smoking with lighter smoking in order to stay within their limits (see Appendices B and C). Although participants were also instructed to practice flexible restraint-consistent cognitions not reflected by the scale (e.g., "Remember that smoking more than your limit on one day does not mean that you have broken your promise to cut down. Just plan and do smoke less later on"), these messages are also not inconsistent with the constructs measured by the scale.

The fit between the rigid measure and the content of the manipulation was less complete. For the rigid style manipulation, participants were instructed to set firm limits on their smoking and to adhere to these limits each day (see Appendices B and C). Participants did not receive any specific behavioral coaching about how to handle limit transgressions (i.e., if they should or should not compensate for episodes of heavy smoking) – only that the consequences of violating smoking limits should be perceived as disappointments to themselves and to the study (e.g., Appendix C). Neither of these components addressed in the restraint style manipulation were objectively captured by the scale. Associations between reductions in Balanced Restraint and the rigid manipulation therefore are not necessarily expected and additional methods, such as participants' self-set limits on smoking behavior and perceived limit violations from the preload (see Section 6.3.3) will also inform the validity of the scale.

In short, a restraint style scale that represents flexible and rigid restraint with high and low scores on the same scale, respectively, has several conceptual and statistical benefits. Balanced Consumption demonstrates this structure to some extent. On the other hand, its representation of both restraint styles is also incomplete. Representations of flexible restraint appear face valid for flexible-like behaviors. Items do not, however, assess cognitions characteristic of a flexible restraint style. Representations of rigid restraint are largely inferred from the absence of flexible behaviors; this inference is consistent with restraint style theory (i.e., that the restraint styles are opposites), however the content of the scale items does not include characteristically rigid behaviors such as strictly adhering to limits on smoking. Further, Balanced Consumption does include items addressing rigid restraint-specific cognitions. Taken together, data indicate that interpretations of the restraint style constructs from Balanced

Consumption should be limited to what is objectively measured by the scale; in other words, the scale should not be interpreted as a comprehensive measure of either restraint style – rather just a broad indicator of style-specific behaviors.

On the other hand, the fit between the content of the flexible restraint style manipulation and the behaviors measured by Balanced Consumption was good, suggesting that Balanced Consumption can be reasonably expected to validate some of the expected effects of the flexible style manipulation. The fit between the content of the rigid manipulation and Balanced Consumption was less therefore, failure of the manipulation to affect Balanced Consumption should not be considered definitive evidence that the manipulation itself had failed. Other markers of the success of the manipulation, such as self-set limits on smoking behavior and the perception that the smoking preload violated smoking limits, must also be considered.

Little mention has been made about Basic Restraint until this point because it does not reflect restraint style per se. Rather, Basic Restraint items assess awareness and attention to total smoking and its effects on health, which combined reflect a cognitive component of restraint that is conceptually independent of style. Statistically, Basic Restraint showed a moderate, positive correlation with Balanced Consumption, questioning its independence from restraint style. On the other hand, Basic Restraint also had low internal consistency, and showed no meaningful associations with measures of smoking behavior or nicotine dependence. While the lack of association between Basic Restraint and other constructs could reflect the unreliability of the scale, other studies have shown that generalized restraint is not consistently associated with regulation of behavior in the absence of an additional factor, such as restraint style (reviewed in Howard and Porzelius, 1999; see also Section 1.2). Nonetheless, Basic Restraint may have potential for improving prediction of smoking behavior during a reduction attempt because the

degree of restraint could be important for determining the extent of the restraint style behaviors that occur. For example, a flexibly restrained smoker who is also high on Basic Restraint might show more reliable or more complete compensation for episodes of heavy smoking than a smoker who is less concerned about over-smoking, while a rigidly restrained smoker who is high on Basic Restraint might adhere to their daily smoking limits on more days than others. Therefore, we retained the Basic Restraint factor scale for use as a control in analyses of restraint style in subsequent portions of the study. Any reported associations between Basic Restraint and smoking however, should be interpreted with extreme caution because the scale may be structurally unsound.

5.4.1 Limitations and Future Research

The methods used to develop a paper-and-pencil measure of restraint style for smokers were limited in several ways. Procedures deviated significantly from standard scale development procedures, such as developing items from focus groups, or testing the items in multiple samples and across time. Similarly, no new smoking-specific items were developed for the study, and the pool of items used was limited to smoker-adaptations of questions from scales with considerable psychometric problems (see Section 1.6). The final factor scales were also the result of an analysis of very few items, and the factor scales themselves were even smaller. Additional limitations were that validation of the scales occurred in a sample of smokers whose smoking behaviors (i.e., rate) were largely homogeneous, which limited the number of conclusions that can be drawn about the relationship between the restraint style scales and smoking behavior, in general. Perhaps most importantly, the final factor scales did not provide an adequate measure of rigid restraint. On the other hand, examination of items dropped prior to the secondary analysis

did not include face-valid indicators of rigid restraint style (see Table 6), suggesting that even the original scales did not offer a comprehensive representation of the construct.

Future research on restraint style would benefit immensely from a carefully developed instrument for measuring restraint style, as well as other aspects of smoking restraint. Specifically, a novel scale including face-valid, theory-based items, particularly for the explicit measurement of restraint style-related cognitions, and rigid restraint behaviors, would improve the reliability and validity of the current factor scales. Similarly, standard procedures for scale development (as in DeVellis, 2003, for example), including tests of the measure in larger, more varied samples of smokers, would give needed credence to a novel scale of this complex construct.

In the next section, the factor scales are used to test (within the abovementioned bounds) the validity of the restraint style manipulations. Analyses of the effects of the restraint style manipulations on ad lib smoking behavior in participants' natural environments are then presented and reviewed.

6.0 RESTRAINT STYLE MANIPULATION AND AD LIB SMOKING

6.1 HYPOTHESES

This section of the study had two aims: 1) to assess the validity of the restraint style manipulations, and 2) to examine the relationships between rigid and flexible restraint styles and ad lib smoking behavior in participants' natural environment. In order to validate the restraint style manipulations, it was necessary to demonstrate that participants were actively attempting to reduce their smoking. The following hypotheses were tested:

1. Participants will show evidence of attempting to reduce their smoking during the study week by reporting increases in Basic Restraint from baseline to visit 2.
2. Participants will reduce their smoking during the study week by demonstrating reductions in average CPD, BPD, and breath CO from baseline to visit 2.
3. The flexible restraint style manipulation will be associated with increases in Balanced Consumption from baseline to visit 2.
4. The rigid restraint style manipulation will be associated with decreases in Balanced Consumption from baseline to visit 2.

5. The rigid manipulation will be associated with more stringent, self-set limits on smoking behavior for the study week compared to the flexible manipulation.
6. More participants in the rigid manipulation will report experiencing that the 2-cigarette preload as a violation of their limits for daily smoking than participants in the flexible group.
7. Participants who received the flexible restraint style manipulation will show greater reductions in self-reported (CPD, BPD) and actual smoking behavior (breath CO) compared to participants in the rigid restraint group during the study week.

6.2 DATA ANALYSIS

6.2.1 Smoking Reduction

All participants were interested in reducing their smoking and were asked to reduce their smoking as part of the study. Thus, we assessed their attempts at smoking reduction according to increases in Basic Restraint, and reductions in breath CO, CPD, and BPD. Although the ideal design to test these hypotheses would have included a control group of participants who did not take part in the study (e.g., wait-list controls) to ensure that any changes in restraint and smoking were due to study participation and not some third variable, practical and financial constraints prevented me from undertaking this more complete design. Instead, an overall trend of reduced smoking behavior and increases in Basic Restraint across assessments were considered as

evidence of attempts at smoking reduction. Hypotheses about changes in smoking behavior and general restraint from baseline to visit 2 were examined using separate Repeated Measures Analysis of Variance (ANOVA). RM ANOVA tests the equality of means when all members of a random sample are measured under multiple conditions, such as before and after an experimental manipulation (Littell, Stroup, & Freund, 2007).

Hypotheses about changes in restraint style following the restraint style manipulations were tested with Repeated Measures Analysis of Covariance (RM ANCOVA). RM ANCOVA tests the equality of means for members of a random sample measured under multiple conditions (e.g., before and after an intervention), while also accounting for inter-group variation attributable to variables other than the primary independent variable (Littell et al., 2007). In particular, RM ANCOVA was used to assess the effects of the restraint style manipulations on self-reported restraint style (Balanced Consumption), so that concurrent changes in Basic Restraint could be held constrant; indeed, basic restraint has been shown to be (modestly) positively correlated with the self-report measure of restraint style used in this study (see Section 5.3.3.2).

6.2.2 Validating the Restraint Style Manipulations

This is the first study to attempt a manipulation of restraint style in smokers (or other groups), thus it was important to demonstrate that the manipulations affected restraint style as intended. To do this, the Rigid and Flexible restraint manipulations were validated against low and high scores on Balanced Consumption, respectively. Specifically, the hypothesis that the Flexible manipulation would increase self-reported Balanced Consumption from baseline to visit 2, and that the rigid manipulation would reduce self-reported Balanced Consumption scores from

baseline to visit 2 were tested. Hypotheses about the effects of the restraint style manipulations on self-reported restraint style were tested with RM ANCOVA, controlling for baseline levels of Basic Restraint. The validity of the restraint style manipulations was also tested against a behavioral marker and a cognitive marker. The behavioral marker was the daily limit participants set for their smoking during the week-long study. Participants who received the Rigid manipulation were expected to set more stringent limits on their smoking than participants who received the Flexible manipulation. This simple comparison between means was tested with 1-way ANCOVA, controlling for baseline self-reported daily smoking rate. The cognitive marker was participants' perceptions that the 2-cigarette preload violated their limits for daily smoking. Limit violations were defined as answering "yes" to the question, "Did you feel as though you were breaking your limits on smoking when you smoked the first two study cigarettes?", which was asked during the debriefing interview at the end of the second study visit (i.e., immediately after the PTT). Pearson's chi-square test (χ^2) was used to compare the number of participants in the rigid and flexible manipulation groups who reported that the preload violated their limits on smoking. A chi-square test determines whether the frequency distribution of an outcome (i.e., perception if limit violations) across groups (i.e., rigid and flexible restraint style manipulations) is different from the expected distribution (George & Mallery, 2003).

6.2.3 Restraint Style Manipulation and Ad Lib Smoking

Tests of hypotheses about the relationship between restraint style and ad lib smoking behavior were done with RM ANCOVA. RM ANCOVA was chosen above RM ANOVA so that we could assess the effects of the style manipulation on smoking while controlling for baseline levels of self-reported restraint (Basic Restraint) and restraint style (Balanced Consumption).

6.2.4 Additional Analytic Procedures

Prior to the ANOVA and ANCOVA analyses, the assumption of normal distribution for dependent variables was met by excluding two participants whose baseline smoking rate and breath CO were > 3 SDs above the mean. The two excluded participants were in the rigid and flexible conditions, respectively, suggesting that their removal did not unilaterally affect the results. BPD was also normalized by subjecting the data to a square-root transformation.

6.3 RESULTS

6.3.1 Participants

The sample used for this part of the study is very similar to the sample used in the Factor Analysis (described above; see Table 5). However, n=6 participants were omitted from the analyses because they did not attend the second study visit (i.e., they did not provide any data indicating change in smoking or restraint throughout the study). Briefly, participants who completed the baseline session only were either lost to follow-up (n=2, Rigid condition), or who discontinued their participation in the study before the second visit (n=3 Rigid, n=2 Flexible).

6.3.2 Smoking Reduction

All participants were asked to reduce their smoking over the course of the study. Thus, we examined markers of total smoking reduction to determine if participants attempted to reduce

smoking and actually smoked less. Separate RM ANOVAs showed that participants reduced their smoking, as seen in breath CO $F(1,112)=17.91$, $p<.0001$, mean change=3.81ppm (SD=9.81), CPD $F(1,111)=99.09$, $p<.0001$, mean change=4.22 CPD (SD=4.87), and BPD $F(1,110)=33.21$, $p<.0001$, mean change=0.41 BPD (SD=0.75) from baseline to visit 2 (Figure 6). Overall, participants reported smoking 25% fewer cigarettes at the end of the study compared to baseline and an 18% reduction in breath CO substantiated participants' self-reports. Perceived attention to, and concern for total smoking (i.e., Basic Restraint) was also used as a marker of attempted smoking reduction. RM ANOVA showed that participants reported higher levels of Basic Restraint at the end of the week-long study $F(1,108)=53.63$, $p<0.0001$, mean change = 0.25 (SD=0..32), with 72.48% of participants reporting increases on the scale.

In short, participants reported increasing their concern and attention for total smoking, as well as decreasing their smoking during the course of the study. Self-reported reductions in smoking behavior were also verified with breath CO. Participants' attempts at smoking reduction suggest that they were attentive and adherent to the study protocol, and that they were actively restraining their smoking.

6.3.3 Validity of the Restraint Style Manipulations

This was the first attempt to experimentally manipulate restraint style in smoker or eaters, thus it was necessary to demonstrate that the manipulations affected restraint style as intended. Results supported the hypothesis that the Flexible manipulation increased self-reported flexibility (i.e., Balanced Consumption), controlling for baseline values of Basic Restraint. Specifically, there was a main effect of time (i.e., study visit) showing that scores on Balanced Consumption increased from baseline to visit 2 $F(1, 105) = 9.21$, $p=.003$. However, there was also a time-by-

manipulation interaction $F(1,105)=4.74$, $p=.03$) such that participants who received the Flexible manipulation reported greater increases in Balanced Consumption than those who received the Rigid manipulation (92% vs. 29% increases, respectively; see Figure 5). In lieu of a more direct measure of rigid restraint, the hypothesis that the Rigid manipulation would be associated with decreases in Balanced Consumption was also examined. Results did not support this hypothesis. As indicated above, participants in the Rigid condition showed no substantial change in Balanced Consumption from before to after the manipulation; in fact, data suggested a slight (non-significant) *increase* in Balanced Consumption following the rigid manipulation. In other words, the rigid manipulation did not affect the self-reported measure of flexible restraint as intended.

The validity of the restraint style manipulations was also tested against the daily limits participants set for their smoking during the week-long study. Specifically, it was expected that participants who received the Rigid manipulation would set more stringent limits on their daily smoking than participants in the Flexible group. 1-way ANCOVA, controlling for baseline smoking rate, did not support this hypothesis: no differences in smoking limits between the two restraint style manipulation groups were observed $F(1,78)=0.08$, $p=.78$, difference between adjusted means=0.09 cigarettes, 95% CI = -1.46 – 1.63.

The final test of the validity of the restraint style manipulations was to assess group differences in participants' perceptions that their daily smoking limits had been violated by the 2-cigarette preload. Just under half (43.75%) of participants who received the CP reported that it broke their limits for smoking. Contrary to hypothesis however, although the numeric trend was for more participants in the rigid condition to report feeling as though their limits were broken (57.14% rigid vs. 42.86% flexible), restraint style manipulation was not significantly associated with perceptions of broken smoking limits χ^2 (1, $N=64$) = 0.62, $p=.43$.

In sum, data tentatively supported the validity of the Flexible manipulation because it was associated with increases in participants' self-reported use of behaviors characteristic of flexible restraint. Data did not, however, support the validity of the Rigid manipulation: the Rigid manipulation did not yield decreases in self-reported flexibility, more stringent limits set on participants' daily smoking, nor did it result in more participants perceiving that their daily smoking limits had been violated. While Balanced Consumption may not have been a complete measure of rigid restraint style, taken together, these findings suggest that the rigid manipulation may not have increased participants' rigid restraint in a meaningful way. In other words, further comparisons of the restraint style groups could be conceptualized as tests of flexible restraint vs. a potentially null manipulation however, with notable separation, at least in self-reported restraint behaviors between the groups.

6.3.4 Effects of Restraint Style Manipulation on Ad Lib Smoking

Rigid and flexible restraint styles are strongly and uniquely associated with ad lib eating among restrained eaters, thus it was expected that the restraint style manipulations would be differentially associated with ad lib smoking behavior during the study week. Specifically, the flexible manipulation was expected to be associated with greater reductions in breath CO, CPD, and frequency of smoking binges than the rigid manipulation. RM ANCOVA, controlling for baseline Balanced Consumption and Basic Restraint was used to test these hypotheses. Overall, data did not support an association between restraint style manipulation and smoking behavior. Restraint style manipulation was unrelated to change in breath CO $F(1,100)=0.10$, $p=.75$, difference between adjusted means = -0.94 ppm, 95% CI = -5.19 – 3.31), self-reported average

daily smoking rate $F(1,100)=0.01$, $p=.91$, difference between adjusted means = -0.36 cigarettes, 95%CI = -2.08 – 1.36, or self-reported binges per day from baseline to visit 2 $F(1,99)=0.19$, $p=.66$, difference between adjusted means =0.30 binges, 95% CI= -0.03 – 0.64. Simply put, data did not support any association between restraint style and ad lib smoking.

6.4 DISCUSSION

6.4.1 Smoking Reduction

Participants' attempts at smoking reduction were assessed in two ways: 1) through reductions in smoking behavior from baseline to the second study visit, and 2) through self-reported changes in attention to, and concern about smoking (i.e., Basic Restraint). Overall, data showed that participants attempted to reduce their smoking, and that these attempts were largely successful. A measure of self-reported, general restraint showed that participants were also reporting increased attention to, and greater concerns about their smoking at the second study visit. This suggests that regardless of whether participants successfully reduced their intake, they were likely expending cognitive energy trying to smoke less. These data suggest that participants may also have been amenable to the specific smoking reduction strategies promoted in each restraint style manipulation.

A major limitation of this assessment of smoking reduction was the absence of a control condition that did not undergo the style manipulations. Consequently, there is no way to verify that reductions in smoking were a consequence of the specific study procedures or a consequence of participating in smoking research, in general. On the other hand, given that the evidence of

smoking reduction includes self-reported behaviors, cognitions, and biochemical indices of smoke exposure, and that the amount of smoking reduction reported was non-trivial, participants' reductions in smoking are likely attributable to features of this smoking reduction study.

6.4.2 Validation of the Restraint Style Manipulations

Attempts to validate the restraint style manipulation were made by assessing changes in self-reported smoking restraint style from before to after the study week. Attempts to validate the manipulations however, were complicated because although we had a reasonably face-valid measure of flexible restraint (high scores on Balanced Consumption), the scale only reflected a single behavioral component of a rigid restraint style that was not well represented in the manipulation itself (see Section 5.4). While it was expected that the absence of flexible restraint could hint at the presence of rigid restraint (rigid and flexible restraint are conceptual opposites, according to restraint theory), analyses of the eating restraint scales has never produced a single measure of restraint style, thus it was unknown whether such a scale could reliably indicate both flexibility and rigidity, in practice.

Nonetheless, based on the available measures of restraint style in smokers, data somewhat supported the validity of the flexible manipulation. Specifically, participants reported significantly greater increases in flexibility following the flexible manipulation than following the rigid manipulation. At a minimum this finding suggests that participants were aware of how they were expected to regulate their smoking during the study because they reported doing so at the follow-up assessment. At best, it suggests that participants who received the Flexible manipulation adopted a flexible approach to limiting their smoking, becoming more likely to

compensate for episodes of heavier smoking with episodes of lighter smoking. While results of this study cannot be used to discern the degree to which participants' behavior objectively changed in this regard, changes in self-reported flexibility were in the expected direction, thus providing provisional support for the validity of the flexible style manipulation.

Tests of the Rigid manipulation however, were unable to support its validity. Participants in the rigid group showed no decrease in Balanced Consumption after the manipulation and if anything, there was a modest trend for scores on Balanced Consumption to go up. Whether the rigid manipulation did not affect Balanced Consumption as intended because the manipulation was ineffective or because the scale was insensitive to its effects, is unknown. The two other criteria used to assess the rigid manipulation were similarly unclear. Specifically, there were no restraint style-related differences in participants' self-set limits for their smoking: whether the absence of a restraint style effect on self-set limits is due to limitations of either restraint style manipulation, no actual difference in the limits set by rigidly and flexibly restrained smokers, or because the flexible group relaxed their limits but the rigid group made no similar change (hence creating a detectable difference) is unclear. Similarly, while there were no significant, group differences in the proportion of participants who perceived a limit violation, there was a numeric difference in the expected direction that might not have been detected due to power limitations in the sample design. Nonetheless, the possibility remains that the rigid manipulation did not affect participants' restraint style as intended. More targeted tests of participants' self-reported rigid restraint, as well as tests with larger, more powerful designs, should be used in any replications of this research.

Indeed, it is worthwhile to consider some possible reasons why the rigid manipulation might not have affected participants' restraint as intended. For instance, although the procedural administrations of the rigid and flexible manipulations were the same, participants may have been less engaged with the rigid restraint style material. Indeed, there was an intentional, negative undertone associated with the rigid materials designed to reflect the guilt and shame that are hypothesized to co-occur rule transgressions among rigid smokers (Westenhoefer et al., 1994, pg 28). More specifically, participants may have disliked the rigid manipulation and therefore not used the strategies as often or as well. Another possibility is that participants entering the study were already significantly, rigidly restrained. The rigid manipulation message of setting a firm limit on smoking and sticking to it might be a strategy that many restrained smokers were already using on their own. Thus, there could have been a ceiling for how much more rigidly restrained smokers could have become. Finally, because the experimenters were aware of the study hypotheses and not blinded to conditions (the main experimenter was the principal investigator of the study), there could have been experimenter effects related to the efficacy of the rigid manipulation.

Overall, our assessments failed to demonstrate the expected effects of the rigid manipulation on participants' smoking behavior. Thus, in the absence of evidence supporting its effects, a conservative approach is to consider comparisons of the style manipulations as comparisons of a flexible manipulation and a null (or perhaps weak) rigid manipulation.

Future studies of restraint style should establish valid measures of flexible *and* rigid smoking restraint before working to develop improved restraint style manipulations. Subsequent to the establishment of such measures, researchers should return to the question of whether rigidity of smoking restraint is malleable; indeed, this was the first study to attempt to manipulate

restraint style in either eaters or smokers, and whether a rigid restraint style can be induced is unknown. Additional procedures that might be more effective for altering participants' restraint style (e.g., motivation-enhancing techniques; Hettema, Steele, & Miller, 2005) should also be examined. With these caveats in mind, the relationship between the restraint manipulations and ad lib smoking behavior are discussed.

6.4.3 Restraint Style Manipulation and Ad Lib Smoking

Studies of restraint style in eaters have reliably shown that flexible restraint is associated with weight loss and low BMI, and that rigid restraint is associated with eating binges and high BMI (e.g., Westenhoefer, 1991; Shearin et al., 2002), thus it was similarly expected that participants who received the flexible style manipulation would smoke at a lower rate and have fewer smoking binges than participants who received the rigid manipulation. Results did not support these hypotheses. Overall, neither restraint style manipulation was associated with any measure of self-reported smoking behavior, or biochemical indicator of recent smoke exposure (breath CO). In what follows, several possible reasons behind the lack of a restraint style - ad lib smoking behavior association are discussed.

One possible reason that an association between flexible restraint style and ad lib smoking behavior was not detected is that flexible smoking restraint may not have the same effects on smoking behavior as flexible dietary restraint does on eating. For example, a consequence of inducing flexible restraint in otherwise rigidly restrained smokers could have been that some participants may have misinterpreted the message to balance periods of heavier smoking with lighter smoking as "permission" to smoke more heavily, more often. Thus, if

compensation for heavy smoking periods was incomplete, it follows that the flexible group would not show reductions in daily smoking that were greater than those in the rigid group.

Alternatively, between-group differences in smoking behaviors may have gone undetected because the rigid manipulation was ineffective. Specifically, although participants in the flexible group appeared to have reduced their smoking as expected, if participants in the rigid group (contrary to expectations) also reduced their total smoking, there may not have been sufficient between-group variability for restraint style effects on ad lib smoking to emerge.

Another reason that the restraint style manipulations might not have shown associations with ad lib smoking behavior is that the restraint style manipulations could have created unexpected differences in participants' reporting of their smoking behavior. For instance, participants who received the rigid manipulation might have felt greater pressure to report reductions in their smoking than the flexible group without actually doing so, resulting in findings suggesting that the rigidly restrained participants smoked just as little (if not less) than the flexibly restrained group. Inconsistencies in participants' reporting of their smoking are consistent with the finding that there was a non-significant trend for the flexible group to show greater reductions in breath CO, suggesting that it was indeed the flexible group who tended to smoke less (at least shortly before each study session). Findings related to total smoking during the study based on breath CO however, are unreliable because breath CO only reflects participants' smoke exposure within the few hours prior to the test (SRNT Subcomittee on Biochemical Verification, 2002). Indeed, if participants in the flexible group refrained from smoking prior to the second lab visit in anticipation of the breath test, breath CO would indicate reduced smoking even if total smoking between study visits was unchanged. Similarly, if participants in either style condition prepared differently for the second study visit (e.g., if the

flexible group refrained from smoking on the day of the study in anticipation of the PTT) then group differences in CO could also have emerged. In short, measures of participants' total smoking could have been confounded by inaccuracies in their reporting of their behaviors, or by their behaviors immediately prior to the study session rather than prolonged, objective changes in how they behaved.

A related issue is that participants may not have been able to accurately quantify changes in smoking behavior co-occurring with changes in their restraint style. Specifically, smokers were asked to quantify their smoking in terms of whole cigarettes (e.g., via CPD or BPD), yet attempts to reduce total smoking can also include smoking half-cigarettes or taking smaller or fewer puffs (Hickcox, 1995; Okeuyemi et al., 2002; Perlick, 1977). Indeed, others have shown that a change in daily number of cigarettes is not a common mechanism of compensation (Scherer, 1999). Therefore, smokers may not have been able to reliably quantify total smoking when total smoking reduction was occurring through reductions *within* each cigarette smoked. Indeed, results from the laboratory component of this study (below, Sections 7.3.2 – 7.3.3) suggest that regulation of smoking behavior occurs within cigarettes, at the level of total number of puffs and per seconds of total puffing. More specifically, group differences in regulation of smoking were between 5 and 7 seconds of cumulative puffing, which approximates 1/4 – 1/3 of the amount of puffing needed to smoke a whole cigarette (Brauer et al., 1996). Thus, if restraint style effects on ad lib smoking were of a similar magnitude, it is unlikely that such differences would be reliably reported in daily totals of cigarettes smoked. More sensitive measures of total smoking therefore, are needed in order to quantify the effects of restrain style on smoking behavior.

6.5 SUMMARY

In conclusion, participants underwent a restraint style manipulation in this study that was likely effective for promoting flexibility, but potentially ineffective for promoting rigid restraint. Although participants appeared to be actively reducing their smoking during the study, no effects of the restraint style manipulations on smoking behavior were detected. Self-report measures of total smoking however, have the potential to be influenced by social desirability bias, bias in participants' perceptions of their total smoking, or because changes in participants' total smoking occur in ways that are difficult to detect and quantify with the naked eye. Thus, the measure of smoking behavior use here was likely inadequate for definitively testing the relationship between smoking restraint style and ad lib smoking. Conclusions about their association therefore, are deferred to future studies that include more robust manipulations of rigid restraint style and more sensitive measures of ad lib smoking.

7.0 PRELOAD TASTE-TEST (PTT)

7.1 HYPOTHESES

This section of the study consisted of three related parts. In the first section, attempts were made to demonstrate that the smoker-adapted PTT could be used to illustrate regulation of smoking following a cigarette preload. Next, and most central to the study as a whole, an attempt was made to characterize the relationship between restraint style, challenges to restraint, and total smoking on the PTT. Finally, tests were undertaken to determine if participants' consumption on the PTT was related to smoking binges in participants' natural environment. The following hypotheses were tested:

1. Participants will smoke less following a 2-cigarette preload (CP) than following a control, water preload (WP) when total smoking is defined as cumulative puff duration and total number of puffs (regulation).
2. Total smoking on the taste-test will be predicted by a restraint style X preload interaction, such that:
    A. Flexibly restrained participants who receive the CP will smoke less on the tasting than flexibly restrained controls (WP), whether total smoking is defined as cumulative puff duration or total number of puffs.

B. Rigidly restrained participants who receive the CP will smoke more on the tasting than rigidly restrained controls (WP), whether total smoking is defined as cumulative puff duration or total number of puffs.

3. Among participants who receive the CP, total smoking on the taste-test will be positively associated with smoking binges in participants' natural environments.

7.2 DATA ANALYSIS

7.2.1 Validating the PTT for Use in Smokers

One-way ANCOVA was used to test the hypothesis that participants would down-regulate their smoking by smoking less following a 2-cigarette preload (CP) than following a control, water preload (WP). 1-way ANCOVA compares means between groups defined by an independent variable (in this case, preload condition) while simultaneously accounting for variation due to other effects (Littell et al., 2007). In this analysis, the effects of preload condition on total consumption on the taste-test while controlling for preexisting group differences in smoking restraint were tested. It was particularly important to control for preexisting differences in restraint and restraint style in this analysis because restraint was strongly suspected to be related to reactivity to the preload (see Table 5, particularly Balanced Consumption); thus, differences on this measure could significantly obscure a regulatory effect. Outcomes for these analyses are cumulative puff duration and total number of puffs.

7.2.2 Dysregulation of Smoking on the Taste-Test

The primary laboratory hypothesis of this study was that participants who received the Rigid manipulation and the CP would counterregulate their smoking (cumulative puff duration and number of puffs) on the taste-test. This hypothesis was tested with a 2-way ANCOVA. 2-way ANCOVA is similar to a 1-way ANCOVA except that it allows for tests of the interaction between two independent variables (here, restraint style manipulation and preload condition) while controlling for any specified, potential differences between the groups. Data would suggest *counterregulation* if participants who received the rigid manipulation and the CP smoked significantly more than participants who received the rigid manipulation and the WP and participants who received the flexible manipulation and the CP. Data would suggest *nonregulation* if participants who received the rigid manipulation and the CP smoked significantly more than participants who received the flexible manipulation and the CP. Each of these effects is illustrated in Appendix H.

Given that there were questions regarding the efficacy of the rigid restraint style manipulation, we also sought to determine if a key aspect of rigid restraint that might occur separately from the style manipulation – reactance to smoking limit violations – would also result in dysregulated smoking on the taste-test. Limit violations were defined as answering "yes" to the question, "Did you feel as though you were breaking your limits on smoking when you smoked the first two study cigarettes?", which was asked during the debriefing interview at the end of the second study visit (i.e., immediately after the PTT). To test the effects of limit violations, we used 1-way ANOVA to compare total smoking on the taste-test among three groups: 1) Participants (regardless of restraint style condition) who received the WP, 2) participants who received the CP and who reported broken smoking limits following the preload,

and 3) participants who received the CP and who reported smoking limits intact after the preload. Data would suggest counterregulation if participants who received the CP and reported broken smoking limits smoked significantly more than participants who received the WP. Data would suggest *nonregulation* if participants who received the CP and reported broken smoking limits smoked significantly more than those who received the CP but with limits intact. Analyses were repeated with 1-way ANCOVA, controlling for restraint style condition.

7.2.3 Relationship between PTT Consumption and Smoking Binges in Participant's Natural Environments

PTT consumption is considered to be a laboratory analog of binge behavior in eaters (e.g. Hetherington & Rolls, 1991), thus it was of interest to determine whether the same was true for smokers. To do this, the hypothesis that among participants who received the CP, consumption during the tasting (cumulative puff duration, total number of puffs) would be associated with frequency of binges during the study week was tested. In particular, it was expected that participants who exhibited dysregulated smoking on the PTT would report more frequent binges during ad lib smoking. Specifically, the association between PTT consumption and frequency of binges using Pearson's correlation analysis was examined. The R^2 statistic was used to test this hypothesis. R^2 can be interpreted as the proportion of variability of the dependent variable that is predictable, given one's knowledge of the independent variable (Littell et al., 2007). Of note, the sample for this analysis was restricted to participants who received the CP (n=46) because water-preloaded participants did not undergo procedures to elicit "binge" behavior in the lab.

7.2.4 Additional Statistical Procedures

Covariate selection for the ANCOVA models was guided by criteria proposed by Littell, Stroup, & Freund (2002). Attempts were made to make parsimonious ANCOVA models, such that the number of covariates was less than (0.10*n) – (k-1) where n= the total sample size, and k= number of experimental groups (Littell et al., 2002). The specific covariates included in each model are described with the Results.

7.3 RESULTS

7.3.1 Participant Characteristics

Participant flow is illustrated in Figure 4. N=120 participants started the PTT procedures and n=117 completed the PTT; n=3 participants could not complete the PTT due to symptoms of nicotine toxicity (vomiting). Data from n=22 pilot participants (see Methods, Section 4.3.1.1) was excluded because participants received either a different dose of preload or had a different number of cigarettes on the tray for tasting. The subsample who completed the PTT therefore consisted of n=95 participants.

Participant characteristics of the whole sample and of this subsample are detailed in Table 5. Of the n=95 participants who provided useable data from the PTT, participants were approximately half male, in their late thirties, and approximately half were non-Hispanic Caucasian. One third of the sample had completed a college degree. Participants were daily smokers who smoked just under a pack of cigarettes per day, had been smoking for almost 20

years, and were moderately nicotine dependent (e.g., FTND *M* = 4.00, *SD* = 1.71). Baseline assessments of rigidity using the SRR (*M* = 6.71, *SD* = 2.13) and the SFR scale (*M* = 3.90, *SD* = 1.92) were within the moderate range compared to normative values for American eaters (RR = 3-7, FR = 3-6; Timko, 2007).

Randomization was largely successful. However, between experimental-group differences were observed for NDSS Tolerance (higher scores in cigarette preload group; Shiffman et al., 2004) and Basic Restraint (higher scores in water preload groups). Pilot participants and drop-outs (combined) who did not complete the PTT were similar to the final PTT sample with one exception: pilot participants and drop-outs had higher scores on Balanced Consumption.

7.3.2 Validating the PTT for Use in Smokers

Given that this was the first attempt to use a taste-test paradigm in smokers, it was important to demonstrate that the PTT could be used to illustrate regulation of smoking following a cigarette preload, regardless of restraint style. Using 1-way ANCOVA controlling for smoking restraint and restraint style (i.e., Basic Restraint, Balanced Consumption; see Section 5.0), data supported the hypothesis that participants would smoke less following the CP than the WP. Specifically, whether consumption was operationalized as cumulative puff duration $F(1,84) = 4.10$, $p = .05$, difference between adjusted means=4.20 sec, 95% CI = 0.08 – 8.33, or number of puffs $F(1,84) = 2.84$, $p = .10$, difference between adjusted means = 2.89 puffs, 95% CI=-0.52 – 6.31, participants who received the CP reliably smoked less (see Figure 8). In particular, participants smoked between 17% (number of puffs) and 19% (cumulative puff duration) less following the

CP, depending on how smoking was operationalized. Lower-level smoking following a CP than a WP demonstrates that the PTT is useful for illustrating regulation of consumption in smokers.[10]

An important component of validating the PTT for use in smokers was also verifying that the procedures were safe and well-tolerated. Data only partly supported this hypothesis. Specifically, n=3 participants vomited after completing the 2-cigarette preload. An additional n=5 participants were instructed to "take a break" from smoking the preload or tasting because they reported feeling dizzy or nauseated. In total, 23% of the participants who provided useable data for the PTT reported some form of expected, adverse event. [11] Overall, the utility of the smoker-adapted PTT should be carefully considered alongside the strong likelihood of participant discomfort and/or illness. Evidence of regulated and dysregulated consumption on the tasting should also be balanced against how mild participant illness or discomfort (i.e., not sever enough to stop the procedures) could have affected their intake during the tasting. This issue is discussed in greater detail, below.

7.3.3 Regulation and Dysregulation of Smoking on the Taste-Test

The primary laboratory hypothesis of this study was that participants who received the rigid manipulation and the CP would counterregulate their smoking on the taste-test. We used 2-way ANCOVAs, controlling for baseline restraint scale factor scores (Balanced Consumption, Basic Restraint), and two dimensions of nicotine dependence (both related to restraint style and with marginal differences between groups despite randomization, NDSS Priority and Continuity,

[10] I also replicated these analyses without controlling for baseline restraint and restraint style and the results were similar, although they fell short of statistical significance; all *p*'s <.24.

[11] Expected adverse events are those included in the informed consent form as a possible consequence of participating in the study.

Shiffman et al., 2004; see Section 5.3.3.3) to test this hypothesis. Specifically, a restraint style X preload interaction was expected to predict total consumption on the taste-test, whether consumption was defined as cumulative puff duration or total number of puffs. Tukey's Honestly Significant Difference (HSD) post-hoc tests were used to make prespecified group comparisons to determine whether non-regulation or counterregulation had occurred. Tukey's HSD compares means between two groups like a t-test, but is more stringent because the total number of possible comparisons in the analysis is accounted for (Littell et al., 2002).

When consumption was defined as cumulative puff duration, there were no main effects of preload or restraint style, however a nearly-significant restraint style X preload interaction predicted total smoking on the taste-test $F(1,83)=3.72$, $p=0.06$. Specifically, within the flexible group there was a trend towards down-regulation of smoking on the taste test (CP vs. WP, difference between means = 6.64 sec, 95% CI = -0.84 – 13.72, Tukey, $p=.10$; total compensation = 27%). No similar effect of preload was observed however, in the rigid group (difference between means = -1.45 sec, 95% CI = -9.62 – 6.72, Tukey, $p=.97$; total compensation = -7%). Of note, the absolute amount of total smoking was numerically greater for the rigidly restrained, CP smokers than the rigidly restrained controls (Figure 9). Given that a significantly greater amount of smoking by the rigid, CP group compared with the rigid controls would indicate counterregulation, the size of this effect and the power of this study for detecting it were assessed.

Briefly, the difference between the rigidly restrained, CP participants and the rigid controls was small (Cohen's $d=.15$; Cohen, 1988) and would only be detected in a sample of this size about 10% of the time. While the possibility remains that similar studies using much larger samples might evidence counterregulation, this effect was not observed here.

In contrast, when consumption was defined as number of puffs, neither the main effects of restraint style $F(1,83)=0.42$, $p=.52$, difference between adjusted means= -1.13 puffs, 95% CI = -4.58 – .32, preload $F(1,83)=1.01$, $p=.32$, difference between adjusted means= 1.82 sec, 95% CI=1.78 to 5.42, nor their interaction $F(1,83)=0.19$, $p=.66$ were statistically significant. More specifically, while there were trends for both the flexible and rigid groups to smoke fewer puffs following cigarette preload than the water preload (flexible difference between adjusted means=2.58 puffs, 95% CI = -3.64 – 8.80, total compensation = 11%; rigid difference between adjusted means 1.05 puffs, 95% CI=-5.93 – 8.03, total compensation = 5%), neither amount of down-regulation reached statistical significance; there were also no significant differences in the amount of down-regulation between restraint style groups. Results were however, consistent with analyses of cumulative puffing such that total down-regulation in the flexible group was more than 2x that of the rigid group.

Finally, although the results of earlier sections of this manuscript suggest that we were unable to measure (Section 5.4) or manipulate (Section 6.4.2) restraint style as desired, we were interested in whether a key distinguishing feature of rigid and flexible restraint styles -- reactance to rule violations -- would be related to regulation of smoking on the taste-test. To test this hypothesis, we used 1-way ANOVA to compare total smoking among three groups: 1) participants who received the WP, 2) participants who received the CP and reported that it broke their limits on smoking, and 3) participants who received the CP and reported that it left their limits on smoking intact. Specifically, it was expected that perceived limit violations would be associated with counterregulated smoking on the taste-test. Results of these analyses are in Figure 10.

Among participants who completed the PTT procedures and received the CP, fifty percent (50%) reported that it broke their limits for smoking. Although there was a numeric, non-significant trend for more participants in the rigid condition to report feeling as though their limits were broken (58.33% rigid vs. 41.67% flexible) χ^2 (1, N=46) = 1.39, p=.24, we used participants' reactions to the preload as a separate definition of participants' restraint style and effects on behavior on the taste-test. Results showed that when total smoking was defined as number of puffs, there was a significant main effect of group F(2,77)=4.38, p=0.02. Post hoc comparisons supported the hypothesis that participants in the CP – intact limit group smoked significantly fewer puffs than the WP group (difference between means = -5.45, 95% CI = -10.18 - -0.72; total compensation = 24%); this suggests that the CP - intact limit group significantly down-regulated their smoking on the taste-test. Post hoc tests did not however, support the hypothesis that the CP - broken limit group would smoke significantly more than the WP group (difference between means = -0.14, 95% CI = -4.94 – 4.65; total compensation < 1%). In other words, the CP – broken limit group did not evidence counterregulated smoking on the taste-test. The hypothesis that the CP – broken limit group would evidence non-regulated smoking by smoking significantly more on the taste-test than the CP – intact limit group, was also tested. Data supported this hypothesis (difference between means = -5.30, 95% CI = -10.56 - -0.05, p<0.05). In short, the perception of intact smoking limits following a cigarette preload was associated with successful regulation of smoking on the taste-test, and broken smoking limits were associated with nonregulation of smoking during the tasting.

When total smoking was defined as cumulative puff duration however, group membership was not related to total smoking F(2,77)=1.53, p=.22. Nonetheless, data suggested similar, non-significant trends for smokers with smoking limits intact following the CP to have

smoked less than controls (CP – unbroken limits vs. WP: difference between means = -3.95 sec, 95% CI = -9.41 – 1.51; total compensation = 19%), and for smokers with limits intact to smoke less than those with broken limits (CP – broken limits vs. CP –limits intact: difference between means = -2.92 sec, 95% CI = -8.99 – -3.14; total compensation = 14%).

Analyses of cumulative puffing and number of puffs were repeated using a 1-way ANCOVA controlling for restraint style manipulation condition. Results from the ANCOVA produced very similar results, suggesting that regardless of restraint style condition, participants who (retrospectively) reported not breaking their limits successfully down-regulated their smoking, while those who reported broken limits evidenced non-regulation on the tasting.

7.3.4 Consumption on the PTT and Smoking Binges in Participant's Natural Environments

PTT consumption is considered to be a laboratory analog of binge behavior in eaters (Hetherington & Rolls, 1991), thus the hypothesis that PTT smoking would be similarly associated with binge behavior during ad lib smoking in participants' natural environments was tested. Specifically, linear regression analysis was used to test the hypothesis that high levels of smoking on the PTT following a smoking preload would be associated with frequency of binges during ad lib smoking among the n=46 participants in this sample who received the SP prior to the taste-test. The data did not support the hypothesis that total tasting following a SP was associated with binges per day, whether consumption was operationalized as cumulative puff duration (b=-0.01, p=.24, R^2=0.03) or total number of puffs (b=-0.59, p=.55, R^2=0.004). Further, results were not qualitatively different when restraint style was also accounted for in the model.

In short, data did not support the hypothesis that PTT consumption is a laboratory analog of binge smoking in participants' natural environment.

7.4 DISCUSSION

The main objective of this part of the study was to test the hypothesis that that rigidly restrained smokers would show counterregulated smoking following a cigarette preload in a PTT paradigm. In order to properly test this hypothesis, it first had to be determined whether the PTT could be used to illustrate smoking regulation in the lab. Performance on the PTT was of interest because it was expected to be associated with dysregulated smoking in participants' natural environments; the relationship between PTT smoking and ad lib smoking was tested, as well.

Briefly, data showed that the PTT was useful for illustrating smoking regulation in the lab: after controlling for baseline levels of self-reported restraint style, data showed that participants who received the cigarette preload smoked less than controls (water preload) on the tasting. Participants expected to show counterregulation on the PTT, however did not exhibit the expected effect. Instead, when group differences in total smoking were observed, they were driven by substantial down-regulation of smoking either by the flexible restraint style group, or by participants whose cognitive limits remained intact following the cigarette preload (a characteristically "flexible" reaction). On the other hand, in comparison to the group whose smoking limits remained intact, the group reporting limit violations from the preload (i.e., characteristically "rigid" participants) showed substantially greater smoking on the tasting thus suggesting non-regulation.

Group differences in total smoking on the tasting however, showed no meaningful association with self-reported smoking binges outside of the lab. Unlike research on eaters therefore, dysregulated smoking on the PTT may not be a reliable indicator of dysregulated smoking in participants' natural environments. Each of these findings is discussed in detail, below.

7.4.1 Preload Taste-Test Adapted for Smokers

Taste-test paradigms have been used successfully to assess regulation of a variety of consummatory behaviors, such as eating and alcohol drinking (e.g., Herman & Mack, 1975; Palfai, 2000). Yet, there are no published studies of smoking taste-tests used for this purpose. Thus, we assessed the feasibility and utility of using a PTT paradigm to illustrate regulation of smoking behavior.

7.4.1.1 Preload

A nontrivial challenge in adapting the PTT for smokers was establishing an appropriate preload dose that would challenge participants' cognitive limits on smoking without saturating them to the point where they would become unwilling or unable to participate in the taste-test. As described in Section 4.3.1.1, several different preload doses during piloting, ranging from 0.5 to 2.0 full cigarettes in half-cigarette increments, were tested.

Evidence from a number of sources suggested that the 2-cigarette preload was largely sufficient to challenge smoker's limits for their smoking. Anecdotally, before beginning the PTT several participants reported concern about the PTT procedures because they perceived smoking two cigarettes in a 15min period was "a lot" of smoking. Any amount of smoking described by

participants as “a lot” was thus reasonably expected to threaten cognitive limits on consumption. Results of the pilot testing also showed that the 2-cigarette preload was associated with more cumulative puffing than other lower-dose preloads (Appendix E). According to restraint theory, a preload large enough to challenge cognitive limits for smoking should cause some participants to abandon restraint and counterregulate. Thus, this sudden jump in taste test consumption was interpreted as evidence that more participants were experiencing rule violations and consequent disruptions in restraint following the 2-cigarette preload than after other, lower doses. Finally, and most explicitly, half of participants who consumed the 2-cigarette preload reported retrospectively that it “broke their limits” on smoking. This suggests that the preload was large enough to violate many participants’ limits for daily smoking, and likely challenge (but not violate) the limits of others. Indeed, a preload that was so large that it violated all participants’ limits would be undesirable because it would eliminate any expected variation between restraint style groups. Indeed, flexibly restrained smokers should be able to accommodate even very large preloads in their regulatory schema. Taken together, data suggest that the 2-cigarette preload satisfied the criteria of being sufficiently large to violate participants’ limits on smoking.

On the other hand, some smoker’s consumption on the tasting may have been constrained because they hit a physiological ceiling for what they could tolerate during the preload. Indeed, the 2-cigarette preload was the highest dose tested because some participants were unable to tolerate the two cigarettes, irrespective of any additional smoking on the tasting. Approximately a third of participants who attempted the CP reported nausea, dizziness, or they became physically ill (i.e., vomited). While the majority of cigarette-preloaded participants completed the procedures without incident, researchers interested in using a similar PTT design in a similar population of smokers should determine a priori if the ~30% adverse event rate is acceptable for

their design. Certainly, adverse events at this rate impact the feasibility of the PTT for use in smokers through selective attrition and the effects of nicotine toxicity symptoms limiting smoking behavior during the tasting.

In sum, data suggest that the 2-cigarette preload functioned as intended for some of the smokers in this sample. For instance, the 2-cigarette preload reportedly violated some participants' limits on smoking while leaving others' intact. For some participants, the 2-cigarette preload was also well-tolerated thus allowing for variability in smoking on the taste-test. For others however, the 2-cigarette preload was saturating and the total amount of smoking on the taste test was likely driven by physiological symptoms rather than cognitive reactions to the preload.

7.4.1.2 Down-Regulation of Smoking

After establishing the relative feasibility of a PTT for use in smokers, attempts were made to demonstrate its utility for illustrating regulation of smoking following a cigarette preload. Generally, results showed that smokers smoked less following the 2-cigarette preload than the control (water) preload, suggesting that indeed, the paradigm could be used to illustrate down-regulation of smoking. Evidence of smoking regulation following a cigarette preload is consistent with research testing the nicotine regulation hypothesis, indicating that smokers adjust their smoking to maintain steady-state levels of nicotine in the body (Benowitz, 1988). The current study adds to research on smoking regulation by replicating earlier findings of down-regulation following a pretreatment in a larger sample (previous n's <56) and with a paradigm in which consumption was monitored surreptitiously.

On the other hand, statistical tests for down-regulation of smoking were only marginally significant, and tests were non-significant when analyses did not control for baseline levels of

smoking restraint. These modest effects raise questions about the relative magnitude of down-regulation observed here compared to other reports. Specifically, participants' smoking on the taste-test in this study was between 17 and 19% less among preloaded smokers compared to controls, depending on how total smoking was defined (see Section 7.3.2). Assessing the relative magnitude of regulation was difficult however, because there was variability within our outcomes, and other studies used very different sizes and types of preloads. For example, Gritz et al (1983) showed comparatively greater reductions in cumulative puff duration following "pretreatments" consisting of decreases in the amount of time between opportunities to smoke. Specifically, when the time between opportunities to smoke was halved, consumption was reduced by 50%. On the other hand, total reductions for larger "pretreatments" were non-linear: when time between sessions was reduced to a quarter (i.e., 25%) of baseline, total compensation was only 65% (Gritz et al., 1983), suggesting that for larger preloads, regulation may not be complete. In another study, participants were preloaded with between 1 and 12 standardized puffs, and subsequent puffing during an ad lib smoking period was decreased by a maximum of 28% (12 puff preload vs. control) (Chait et al., 1985). In a study in which participants were preloaded with enough intravenous nicotine to approximate each participant's ad lib smoking, suppression of nicotine intake from cigarette smoking however, was roughly 25% (Benowitz et al., 1990), which is more consistent with the effects observed here. In comparison to regulation of consumption by eaters on a PTT, amount of total food reduced following an active preload was either similar (e.g., ~16%; Lowe et al., 2001) or less (e.g., ~8%; Westenhoefer et al., 1994). Taken together, a ~20% reduction in smoking on the taste-test is consistent with some studies of smoking regulation using different designs, and similar or greater to regulation of eating on a

PTT. Thus while effects may be somewhat modest, data suggest that the taste-test can be used to illustrate regulation of smoking behavior of a similar magnitude to other designs.

7.4.2 Restraint Style and Regulation of Smoking on the Taste-Test

The primary hypothesis of this study was to test Westenhoefer's prediction that rigidly restrained consumers (here, smokers) subject to a boundary-challenging preload would show counterregulated consumption on a taste-test. Data did not support this hypothesis. Instead, when total smoking was defined as cumulative puff duration, there was a nearly-significant preload X restraint style interaction attributable to down regulation of smoking in the flexible restraint group, and no apparent down-regulation among rigidly restrained, preloaded participants. Indeed, participants in the rigid group neither regulated nor counterregulated their smoking, suggesting that non-regulation occurred. Findings were similar when restraint style was defined with participants' cognitive reactions to the cigarette preload: participants who reported that their cognitive limits on smoking remained intact following the cigarette preload (i.e., proxy for flexible restraint style) down-regulated their smoking compared to controls; smokers who reported that their limits were transgressed (i.e., proxy for rigid restraint style), however, smoked significantly more than smokers whose limits remained intact. Thus, using two very different definitions of restraint style, data consistently showed that flexible restraint is associated with regulation of smoking on the taste-test and that rigid restraint is not.

The finding that dysregulated smoking in this study occurred in the form of non-regulation -- *not* counterregulation – is not consistent with hypotheses. Indeed, the fact counterregulation was not observed is disappointing given that restraint theory suggests that rigid restraint is associated with counterregulation, and that some samples of eaters do occasionally

show true counterregulation on a PTT (e.g., Herman & Mack, 1975; Westenhoefer et al., 1994, through disinhibition scale scores). On the other hand, there are several possible reasons why counterregulation might not have been observed.

First, tests of the rigid manipulation suggested that its effects on participants' restraint style could have been too weak to be detected, thus participants might not have been sufficiently rigidly restrained to feel inclined to truly abandon smoking limits after a limit violation and smoke very large amounts on the tasting. On the other hand, when rigid restraint was defined as smokers' perception that their limits on smoking were "broken" by the preload (suggesting self-reported rigid restraint), counterregulation was still not observed. Thus, insufficient rigidity within the sample is not likely responsible for the absence of a counterregulatory effect.

Alternatively, participants may have been unable to tolerate enough smoking following the preload to surpass the amount smoked by controls on the tasting; this is a very real possibility given the high rate of adverse events reported from the preload alone. Researchers might consider substituting reduced nicotine or denicotinized cigarettes for regular cigarettes during the preload in future studies as they may reduce saturation, and provide a better test of participants' cognitively-driven reactions (unconfounded by nicotine toxicity) to the preload on the tasting. On the other hand, smokers rarely smoke denicotinized cigarettes outside of a laboratory setting, and their reactions to a denicotinized cigarette preload could have limited ecological validity.

On the other hand, our findings are entirely consistent with the results of Westenhoefer et al (1994) who examined the effects of restraint style on smoking behavior on a PTT. Specifically, although Westenhoefer predicted that the predominantly rigidly restrained group of eaters would evidence counterregulation on the tasting, rigidly restrained participants' consumption only reached non-regulation. Our results are also consistent with Westenhoefer's

study because the predominantly flexibly restrained eaters in their study down-regulated their intake after the preload. Results of these two studies suggest that rigid and flexible restraint appear to have similar effects on smokers' and eaters' total consumption in the lab.

Our replication of Westenhoefer et al's (1994) findings has implications for restraint style theory – at least in terms of behaviors observed in the lab. As predicted, data support restraint style theory's claim that flexible restraint (i.e., self-reported tendency to balance periods of heavy smoking with lighter smoking, characteristic of smokers completing the flexible restraint style manipulation) is associated with compensatory down-regulation of consumption in the lab. This claim was also supported by data showing that smokers' perception that their limits were intact following the cigarette preload is associated with successful regulation on the tasting. A notable limitation of this measure however, is that participants who reported having their limits broken may be responding to the perception that they smoked a large amount on the taste test, rather than the experience of the preload violating their limits. Perceptions of rule violations were assessed ~15 minutes post hoc.

On the other hand, restraint style theory's claim that rigid restraint is associated with counterregulation of smoking following a rule-challenging preload does not appear to hold. Instead, rigid restraint appears to be associated with non-regulation of consumption, where non-regulation is defined as total consumption that is, a) greater than regulated consumption, and b) that is equivalent to (i.e., statistically non-divergent from) consumption by non-preloaded controls. In other words, rigidly restrained smokers and eaters can still be expected to consume more than their flexibly restrained counterparts because they are unlikely to compensate for episodes of heavier consumption, but the nature of their dysregulated behavior appears qualitatively different from that proposed in theory. Specifically, the behavior of rigidly

restrained consumers whose boundaries have been violated does not appear to reflect eating or smoking with total abandon. Rather, consumption following a rule-breaking event seems to remain within bounds that are appropriate for a specific situation -- without accounting for any preceding consumption. While the possibility remains that rigidly restrained smokers might counterregulate on a PTT were they not saturated by the preload, as was demonstrated by Westenhoefer et al (1994), evidence from eaters does not support this hypothesis. Indeed, it is only when eaters are divided along other dimensions of behavioral regulation (see Section 1.5.3), do true, counterregulatory effects to emerge. Future studies should consider whether instruments containing specific questions about binge-like consumption (e.g., disinhibition -- a self-reported the tendency to over-consume under a variety of circumstances; Stunkard & Messick, 1985) might be more reliably associated with counterregulation in smokers. Indeed, a core issue for the application of this model to smokers is whether they engage in binge-like behavior at all. Data indicating counterregulation in some samples of smokers (e.g., beyond Chait et al., 1985), but not among rigidly restrained smokers, would provide additional evidence to support this suggested revision to restraint style theory.

A conceptual limitation of the analyses suggesting non-regulation of smoking is that its definition depends on rigidly restrained smokers smoking "the same" amount as rigidly restrained controls, which is functionally equivalent to attempting to prove the null hypothesis. Specifically, when non-regulation was observed among the rigid restraint style group this characterization was derived exclusively from "what wasn't" -- i.e., the absence of a statistically significant difference between the total smoking of rigidly restrained, cigarette-preloaded smokers and controls. Data suggesting non-regulation using participants' perceived rule violations from the preload however, were more robust (i.e., as indicated by the significant

difference between total smoking among the limits broken vs. limits intact groups). Nonetheless, researchers interested in further establishing the effects of restraint style on laboratory behavior should consider improving how non-regulation is defined. For the purposes of this study therefore, results of smokers' performance on the PTT suggest that a flexible restraint style is associated with successful regulation of smoking in the lab while a rigid restraint style is not. We address the external validity of this finding in the subsequent section.

7.4.3 Dysregulation on the PTT as a Marker of Bingeing in Participants' Natural Environments

The final aim of this portion of the study was to determine whether dysregulated consumption on the PTT is a marker of smoking binges in participants' natural environment. Overall, there was no association between participants' smoking on the PTT following a cigarette preload (whether defined as cumulative puff duration or number of puffs) and self-reported smoking binges during ad lib smoking. This finding is inconsistent with research on eaters, in which total consumption on the taste-test has been linked to eating disorder diagnoses (e.g., Hetherington & Rolls, 1991; Hadigan et al., 1992). On the one hand, some differences in how constructs were operationalized between studies could account for differences in overall effects. On the other, binges in this study were assessed quantitatively and continuously instead of with categorical diagnoses as in studies of eaters (Shearin et al., 1994; Stewart et al., 2002), thus the quantitative outcomes provide a statistically more robust test of the relationship between PTT smoking and bingeing. In other words, the absence of this hypothesized association suggests that there is likely no meaningful relationship between our measures of PTT consumption and smoking binges used in this study.

One possibility is that the absence of an association between PTT smoking and ad lib smoking binges is due to how smoking binges were operationalized. As described above (Section 4.1.2.2) smoking binges were defined as self-reported episodes of smoking ≥2 consecutive cigarettes. Evidence of regulated consumption in this study however, was only detected at the level of cumulative seconds of puffing or number of puffs. Therefore, although smokers who did not regulate their smoking on the PTT might also have evidenced non-regulation (or counterregulation) in their natural environment, it might have been reflected in their puff topography instead of in the total number of cigarettes smoked. This is consistent with research showing that compensatory changes in smoking behavior do not typically occur at the level of whole cigarettes (Scherer, 1999).

Further, the size of the preload may have limited variability in consumption during the tasting. Specifically, few participants smoked very large amounts during the tasting (as evidenced by the modest non-regulation effect), possibly due to the negative physical effects of smoking beyond the cigarette preload. Limits on the variability of consumption during the tasting therefore, could have decreased the likelihood that an association between PTT consumption and ad lib smoking binges would be observed. Similarly, because the sample of smokers included in the study was restricted to smokers of 15-20 CPD (see Section 4.3.1.1), participants with clinically significant binge patterns, perhaps more common among heavier smokers, may have been excluded from the sample. Future research should consider examining the relationship between PTT consumption and binge behavior in samples of heavier smokers where significant dysregulation may be more common.

Of course, the possibility remains that the PTT may not be an appropriate analog for smoking "binges" outside of the lab. Specifically, smokers may not engage in total disinhibition

of consumption with the same frequency or relative quantity that eaters do because of the aversive effects of smoking too much (e.g., Hickcox, 1995). Instead, when smokers feel the urge to "binge", they may initiate rapid or intense smoking behavior but be quickly signaled to stop by feelings of dizziness or nausea. Should they choose to continue smoking at this point, smokers might further adjust the topography of their smoking so that they do not get sick; this intentional regulation of consumption could also mitigate total counterregulation in restrained smokers given that binge eating behaviors are frequently conceptualized by feelings of loss of control (Wolfe et al., 2009).

Finally, the possibility remains that if smokers do engage in binge behaviors (as suggested by pervasive, anecdotal reports of "chain smoking") their binges are quantitatively different from the definition of a smoking binge used here. Existing research includes very few reports of attempts to quantify discrete periods of ad lib, heavy smoking, and standard definitions of a "smoking binge" have not been reported. The definition of a smoking binge used here was based on the size of a smoking pretreatment shown to be associated with counterregulated smoking (Chait et al., 1985), working backwards from the effect that I hoped to reproduce. Nonetheless, this definition of a smoking binge was arbitrary – particularly because a binge might differ in size for smokers of differing rates. Therefore, although participants in this study reported smoking two or more cigarettes in succession from time-to-time, the kind of non-compensation for periods of heavy smoking characteristic of rigidly restrained smokers in the lab may not be reflected in this definition of a smoking binge.

In short, results of this study do not suggest that a PTT is an appropriate analog of binge behavior in smokers' natural environments. Several limitations of how smoking binges were assessed however, suggest that studies including using more sensitive measures of smoking

behavior, and data-driven definitions of binges are necessary to properly address this hypothesis. Future research designed to characterize dysregulation of smoking in participants' natural environments is needed.

7.5 SUMMARY

This first attempt to adapt a PTT paradigm for smokers provided provisional support for the feasibility and utility of the paradigm to detect regulation and non-regulation of smoking in the lab. Indeed, preliminary data suggest that smokers, like eaters, attempt regulate their consumption following a preload challenge. While the amount of total compensation following a preload was objectively small, it was also somewhat consistent with other studies of behavioral compensation in PTTs and other experimental designs.

Also consistent with research in eaters, we found that an interaction between restraint style and preload condition (marginally) predicted total smoking on the taste-test. Specifically, while flexibly restrained smokers showed regulation of smoking following the cigarette preload, rigidly restrained participants showed no similar trend. Given that these findings replicated the results of Westenhoefer et al (1994), one possibility is that non-regulation (rather than counterregulation) is the modal outcome among rigidly restrained, preloaded consumers when opportunities for additional ad lib smoking occur. Studies taking further steps to ensure that smokers are not saturated by the preload will provided better tests of rigid smokers' behavior driven more by cognitions than symptoms of over-smoking.

Finally, data did not show any association between smoking behavior on the PTT and binges in participants' natural environment. Consequently, although we were able to demonstrate

differences in participants' smoking regulation in the lab, we did not find evidence that similar patterns of regulation occur elsewhere. On the other hand, several limitations our measures of total smoking outside of the lab (i.e., reliance on self-report, arbitrary definition of smoking binges) suggest that studies including more sensitive measures of smoking behavior, as well as data-driven definitions of binges are needed to properly address this hypothesis.

8.0 GENERAL DISCUSSION

Smokers who will not, or who cannot quit smoking are often amenable to reducing the amount that they smoke. Very little is known however, about which general approach is best to help smokers to smoke less. In contrast, strategies for reducing eating are well-described. Thus, research on reducing eating (i.e., dietary restraint) was used to inform this preliminary study of smoking restraint. In particular, rigid and flexible restraint styles have been associated with different eating reduction outcomes: flexible restraint has been associated with successful reductions in intake and rigid restraint has been associated with unsuccessful attempts to cut-down. A fundamental hypothesis of this study was that rigid and flexible styles of smoking restraint would be similarly related to smoking behavior and reduction outcomes. Results of this study suggest both similarities and differences in the ways that restraint style is related to eating and smoking.

Briefly, results of a factor analysis of the original rigid and flexible restraint scale items produced a single scale measure of restraint style that largely reflected flexible restraint (aspects of rigid restraint were tentatively represented by low scores on the scale). This scale was then used successfully to validate a novel flexible restraint style manipulation; attempts to validate the rigid manipulation appeared unsuccessful but were also difficult to interpret. Contrary to predictions and research on eaters, smoking restraint style (as determined by the manipulations) was not associated with smoking behavior outside of the lab. On the other hand, results did show

that smokers' restraint styles were associated with regulation of smoking behavior in a laboratory setting. In a preload taste-test paradigm adapted for smokers, data showed that a flexible restraint style was reliably associated with significant down-regulation of smoking behavior following a restraint-challenging, cigarette preload, while the absence of flexible restraint (and perhaps a rigid restraint style) was not associated with any observable, regulatory effect.

In this general discussion, the results of each segment of the study are consolidated and reviewed to suggest if the tenets of Westenhoefer's restraint style theory hold in smokers. Implications for the effects of smoking restraint on smokers' attempts to cut down are also discussed. General strengths and limitations of the study, and suggestions for future research in this novel area of study are described.

8.1 FIT WITH EXISTING THEORY AND RESEARCH

8.1.1 Restraint Style Theory and Research on Dietary Restraint

Of primary interest is whether findings from this study are consistent with Westenhoefer's (1991; et al., 1999) theory about Rigid and Flexible restraint style, as well as research on eaters directly addressing the theory (reviewed in Section 1.4). We first consider the findings related to flexible restraint style.

Findings from this study show that Westenhoefer's flexible restraint construct is associated with smoking behavior as predicted by theory and similar research in eaters. For instance, the paper-and-pencil measure of flexible smoking restraint used in this study was associated with established measures of self-reported, variability in smoking rate, as well as a

sense of relative control over smoking behavior (i.e., smoking for pleasure rather than need); these correlates of flexible smoking restraint are similar to those of flexibly restrained eaters who similarly report variability in the amount that they eat and better perceived control over their eating compared to rigidly restrained eaters (see Sections 1.4 and 1.5).

Contrary to theory and previous research however, the flexible restraint style manipulation was not associated with self-reported ad lib smoking in participants' natural environments. Concerns about how ad lib smoking was measured however, suggest that the relationship between restraint style and ad lib smoking should be tested using more precise measures of smoking outcomes.

Questions about the adequacy of the measurement of ad lib smoking are also raised by the contrast with laboratory findings. Data from the PTT showed that the flexible restraint manipulation was associated with down-regulation of smoking. Successful regulation of smoking among flexibly restrained smokers is both consistent with Westenhoefer's theory, and with the performance of flexibly restrained eaters on a PTT (Westenhoefer et al., 1994); findings were even consistent (although not always significantly so) across smoking outcomes. Even when flexible restraint was operationalized by participants' perceptions that their smoking limits remained intact after the preload, results were the same. In short, data indicate that a flexible restraint style is generally associated with the tendency (and hence capacity) for regulating smoking behavior.

Data supporting the current conceptualization of rigid restraint in smokers were less robust. For instance, analysis of Westenhoefer and colleagues' (1999) smoker-adapted Rigid and Flexible scales did not yield a separate measure of rigidity. Rigidity, therefore, was quantified with low scores on the paper-and-pencil measure of flexible restraint (Balanced Consumption).

While the inverse of scores on the flexible measure was a conceptually preferred method for representing rigid restraint style (i.e., the constructs could be treated as true opposites), the scale did not provide objective assessments of key elements of rigid restraint, such as characteristically rigid behaviors (e.g., the tendency to strictly adhere to smoking limits) and cognitions (e.g., feelings of guilt and shame when limits are transgressed). Not surprisingly therefore, scores on the Balanced Consumption scale did not support the efficacy of the rigid manipulation.

An important limitation of Balanced Consumption as a validator of the rigid restraint manipulation is that the contents of the scale has little overlap with the topics addressed in the rigid manipulation, even though both the scale and the manipulation reflected aspects of the construct described in theory. This lack of overlap suggests the need for refinement of the definition of rigid restraint. Future research should attempt to isolate a few, key components of the construct, and then develop assessments and manipulations that address them directly. In particular, clarification regarding the typical smoking pattern of a rigidly restrained smoker would be useful to compared and contrast with the well-developed description of a flexible smoking pattern. Objective behavioral patterns to compare and contrast would be helpful for reliably distinguishing between rigid and flexibly restrained smokers.

On the other hand, results from the laboratory suggested that the rigidly restrained, cigarette-preloaded smokers behaved similarly to Westenhoefer et al (1994)'s rigidly restrained eaters: both the "rigidly" restrained smokers and eaters showed no evidence of regulated consumption on the PTT. In this study, this effect cannot be entirely attributed to low levels of smoking in the flexible group, as there was a very small, non-significant trend for the rigid group to smoke slightly more than participants who received the water preload when total smoking was defined as cumulative puff duration. As described above, it remains unclear whether any "rigid"

effects on behavior observed in the lab reflect true rigidity or whether they are "null" effects; i.e., representations of smokers' behavior in the absence of an effective restraint style manipulation. Unfortunately, a control group that did not receive either restraint style manipulation is needed to address this hypothesis. Yet, based on the results of the laboratory study in which the rigid manipulation group performed similarly to the rigidly restrained eaters in Westenhoefer et al (1994), it appears as though the manipulation exerted at least some of its intended effects. Overall, the construct of rigid restraint (as it currently stands) may have some limited utility for predicting how smokers will react to a challenge to smoking restraint. Compared to the flexible restraint construct however, the utility of rigid restraint style could be greatly improved were its definition and measures refined.

Taken together, with the exception of its effects on self-reported ad lib smoking, data indicate that Westenhoefer's rigid and flexible restraint constructs performed similarly to eaters, and largely as expected by theory in this sample of daily smokers. These data support the utility of distinguishing between rigidly and flexibly restrained smokers, as the two may compensate for periods of heavy smoking differently when such periods occur.

8.1.2 Fit with Other Models of Behavior Regulation

In addition to being generally consistent with restraint style theory, laboratory results from this study are also somewhat consistent with other models of behavior regulation. For instance, the Boundary Model has been used to explain how some smokers might limit their smoking during transitions from uninhibited smoking to quitting (Kozlowski & Herman, 1984). In the model, smokers define "acceptable" boundaries of consumption (e.g., perceived as "safe enough") within physiologically-plausible limits (i.e., between withdrawal and toxicity). These boundaries

are then used to guide consumption instead of smoking until a person feels sated. According to the model, when smokers have smoked beyond the "acceptable" boundary, they may abandon further attempts to limit their smoking and proceed to smoke until they are satisfied (i.e., counterregulation). On the other hand, if the limit is somewhat flexible and can be adjusted to accommodate occasional episodes of increased consumption, perceived transgressions will be less frequent, and gaps in restraint should be less likely. While counterregulation among the smokers who perceived that their boundaries were violated was not observed, the notion that limit violations lead to outcomes *other* than successful smoking regulation is consistent with the findings from this laboratory study.

Similarly, although the Limit Violation Effect (LVE; Collins & Lapp, 1991, 1992) has not been explicitly applied to reductions in smoking behavior, the original Abstinence Violation model (Marlatt & Gordon, 1985) has been widely used to describe the processes underlying failed attempts to quit smoking (e.g., Chornock et al., 1992; Shiffman et al., 1996). According to the models, when self-imposed prohibitions (or limits) on smoking are violated, people who attach greater failure-meaning to limit violations are expected to experience a "violation effect" (i.e., abandonment of limits, guilt, and shame) and then continue to consume further beyond their limits. For both models, the meaning the person assigns to the violation is the critical factor that determines whether subsequent regulation of consumption occurs (Collins & Lapp, 1991; Marlatt, 1985). Results of our analysis in which we grouped smokers by their perceived effects of the preload were consistent with LVE theory: "broken" limits were associated with non-regulation while intact limits were associated with smoking that compensated for the preload. Future research investigating the mechanisms through which smokers falter in their attempts to smoke less should investigate the effect of affect (e.g., guilt, shame) associated with limit

violations to determine whether the complete tenets of LVE theory apply among persons attempting smoking reduction, and what (if anything) grossly differentiates LVE from restraint style theory. Indeed, participants' affective reactions to limit violations were not assessed in this study, but should be assessed in similar, future work.

8.1.3 Challenges to Restraint Style Theory Applied to Smokers

Given the trend for both smoking restraint styles to be associated with smoking behavior on the PTT in a way that is consistent with restraint style theory, the question remains why restraint style was unassociated with smoking behavior outside of the lab. Some possible reasons for this laboratory – real world disconnect include participants' restricted range of total, daily smoking. Only participants who smoked between 15 and 20 cigarettes per day were eligible for the study. This strict eligibility criterion likely limited variability in total smoking among participants thus reducing the likelihood that restraint style-smoking rate associations would be observed. Similarly, measures of ad lib smoking were gathered largely through self-report, and self-report measures of total smoking have been shown to be biased by rounded estimates of total consumption (Shiffman, in press); rounded estimates of total smoking could have further reduced variability within the smoking data reported by the sample.

Another reason why data might not have indicated an association between restraint style and ad lib smoking is that the measures of smoking behavior used in this study consisted of daily totals of whole cigarettes or of binges consisting of multiple whole cigarettes. Results from the laboratory suggest that smoking regulation related to restraint style and/or challenges to restraint is likely a subtle phenomenon, with regulation occurring within cigarettes, perhaps with number of puffs or total puff time (Scherer, 1999). Thus, smoking behavior assessed at the level of daily

smoking rate or whole cigarette binges may not reflect variations in total smoking that occur within the larger context of an attempt to smoke less. Future studies of smoking regulation in the context of a reduction attempt should employ more sophisticated measures of smoking behavior, such as palm-top computers to assess smoking patterns (e.g., time between cigarettes perhaps constituting flexible regulation or binge behavior), electronic smoking topography devices to assess changes in smoking topography following challenges to restraint (e.g., variation in number of puffs or total puff time during ad lib smoking), and biochemical measures of total smoke exposure (e.g., urinary continine) to objectively quantify the success of the reduction attempt. Detailed, quantitative data reflecting smokers' total exposure could result in restraint style-ad lib smoking behavior relationships that are similar to those observed in the lab.

A related challenge for restraint style theory in smokers is whether it can explain how regulation might occur at the level of puff duration and number of puffs instead of through more tangible outcomes, such as skipping whole cigarettes. Specifically, data from this study showed regulation at the level of fewer total seconds of puffing, for example, which raises questions about whether smokers were consciously compensating for the preload during the taste-test. One possibility consistent with Westenhoefer's theory is that less total smoking in the flexible group could be related to changes in the purpose of participants' smoking after the limit-challenging preload. For example, flexibly restrained smokers may have been smoking for pleasure during the preload, but become cognitively (even if not physically) sated by smoking the two preload cigarettes. Thus, the function of their smoking may have changed for the taste-test from pleasure to utility. In other words, flexibly restrained participants may have stopped savoring each puff (as they might have done during the preload) and started smoking strictly for the purpose of tasting the cigarette and completing the task, and the perceived purpose of smoking could be

related to participants' smoking topography. Studies addressing flexibly restrained smokers' cognitions following a boundary-challenging preload are needed to confirm or disprove this hypothesis.

Thus, while data do support some similarities between eating and smoking restraint, some challenges regarding the translation of dietary restraint research methods to smoking reduction are noteworthy. In addition to how the two restraint styles were reflected in our assessments of ad lib consumption, our paper and pencil measure of smoking restraint style adapted from eaters was limited, particularly in that it did not produce a satisfactory measure of rigid restraint. Problems with the PTT paradigm were also apparent. For instance, compared to eaters, our participants became saturated more quickly than expected which likely limited variability in the amount of smoking that occurred during the tasting. More specifically, physiological limits may have prevented true counterregulation from occurring. Outside of the lab, counterregulation (as defined conservatively for eaters, Section 1.5.1) may not occur in smokers, either. If smokers are sufficiently sensitive to the adverse effects of smoking too much or too quickly, smokers' "binge" behavior may be truncated at the level of non-regulation due to symptoms of nicotine toxicity (e.g., nausea) or over-smoking (e.g., dry mouth). In short, while we replicated some of the laboratory findings characteristic of rigid and flexibly restrained eaters, direct application of the original eater questionnaires and paradigms to smokers could have affected smokers' performance on the measures in unanticipated ways.

8.1.4 Summary

Overall, the results of this study showed that the construct of flexible restraint, and to a lesser extent, rigid restraint, can be used to describe how smokers' attempts to smoke less can be

differentially successfully smoking regulation – at least in a laboratory setting. A brief restraint style induction was shown to promote flexible restraint in smokers in the short term, therefore suggesting that restraint styles might be somewhat malleable and perhaps a viable target for intervention, should it eventually be shown to affect smoking reduction outcomes.

In the laboratory, flexible restraint style was associated, as predicted by restraint style theory, with regulation of smoking following a challenge to smoking restraint. Questions remain, however, about the rigid restraint style manipulation and its subsequent effects on smoking. In particular, rigidly restrained smokers were expected to evidence counterregulated smoking on the taste test, however only less robust evidence of dysregulation (non-regulation) was observed. Several limitations of the rigid manipulation, the measure of rigid restraint, and the absence of a restraint style control group to demonstrate that the effects of the rigid manipulation were not null, suggest that further research is needed to clarify the association between rigid smoking restraint and smoking behavior on a PTT.

Nonetheless, results of this very preliminary study suggest that restraint style shows some associations to regulation of smoking behavior, and that these associations are causal: i.e., smokers can be induced to respond somewhat differently to stimuli that challenge limits on smoking behavior, at least in the lab. Data also suggest that smokers and eaters appear to approach the challenge of regulating and reducing behavior in similar ways, and that the approaches that are associated with successful regulation of one behavior are also likely associated with successful regulation in the other. In other words, data suggest that there is potential for restraint style to have similar predictive utility in smokers as it does in eaters. Future research using large-scale epidemiological designs is needed to test this hypothesis, and to help clarify how restraint style might be related to smoking behavior beyond a laboratory setting.

8.2 LIMITATIONS

A number of limitations in the design of this study are worthy of mention. Perhaps the most significant limitation of this study was the small sample size. Specifically, data supporting several key hypotheses were in the expected direction (e.g., restraint style group differences in perceived limit violations from the PTT, down-regulation of smoking on the PTT following the cigarette preload) but they failed to reach statistical significance; the lack of power in this study for detecting restraint style effects limited its utility for making clear suggestions about how restraint style affects smoking behavior, and the utility of the PTT for illustrating smoking regulation, to name a few. While several steps were taken to increase recruitment (e.g., increasing the advertising budget, enlisting help from additional research staff, extending the run of the study) in order to meet the target sample size (N=140 PTT completers), changes to participant eligibility criteria (e.g., restricting the sample to 15-20 CPD smokers; Section 4.3.1.1) made recruitment more difficult. Eventually time constraints restricted the total sample to n=126 total participants and n=95 PTT completers.

The sample used in this study was also a sample of convenience, recruited from flyers and other media advertisements. Thus, the restrained smokers who participated in this study may not have reflected the larger pool of restrained smokers, as participants were self-selected. For example, restrained smokers with very high self-efficacy for reducing smoking may not have felt the need to participate in the study because they were already restraining their smoking to their satisfaction.

Another limitation of the sample is that participants' smoking rate was highly restricted by the eligibility criteria for the study: although we initially selected a narrow range of smokers for whom a single-size preload would be appropriate, we narrowed the sample further when the

preload was difficult for lower-rate smokers to tolerate. The net result was a sample with almost no variability in daily smoking rate; this limited our power for detecting any hypothesized restraint style–smoking behavior associations.

Several limitations are also related to the paper-and-pencil measures of smoking restraint and restraint style. For instance, because the focus of this study was not on questionnaire development, we adapted Westenhoefer et al's (1999) restraint style questionnaire for smokers to validate the restraint style manipulation, instead of developing a new measure altogether. This adaptation, however, did not include modifications to address a number of the well-described, psychometric limitations of the scale (e.g., Gorman & Allison, 1995; Stewart et al., 2002). As such, the smoker-adapted version of the scale manifested many of the same problems inherent in the original scale, such as low-face validity of "rigid" restraint items and multiple items not reflecting restraint style at all (e.g., "I prefer to take small puffs to control the amount that I smoke"). The smoker scale also included new problems, such as very few total items and no explicit measure of rigid restraint style. Investigators with interests in smoking restraint style are *strongly* encouraged to develop a novel measure of smoking restraint style from the bottom-up, including new items with improved face-validity for both rigid and flexible restraint constructs, as well as items with more content specific to smoking restraint and its challenges (e.g., withdrawal symptoms and restriction of smoking).

Given the limitations of the measure used to validate (in particular) the rigid restraint manipulation, our attempts to characterize the specific effects of each restraint style manipulation were hindered by the lack of a control group that did not receive either restraint style manipulation. The absence of a restraint style control made it particularly difficult to ascertain if smokers' behavior in the rigid condition was truly representative of a rigid restraint style, or if it

reflected a relatively null effect of the manipulation. Consequently, we remain unsure if the rigid restraint style manipulation affected participants' restraint as intended.

Similarly, mixed findings across smoking reduction outcomes (i.e., cumulative puff duration and number of puffs) create uncertainty about the robustness of the regulation and non-regulation findings in the lab. While data were consistently in the direction suggesting that flexibly restrained smokers regulated their intake while rigidly restrained smokers did not, results were not consistently statistically significant across outcomes. These mixed data detract from the interpretability of the results and raise questions about whether significant findings were erroneous, or if other factors that should have been controlled for were somehow impeding more sizeable effects from emerging.

A limitation of this study that may have particularly affected the association between restraint style and smoking in participants' natural environment, is that measures of ad lib smoking were based on retrospective self-report. Although Time Line Follow-Back (TLFB) has been shown to have better reliability than overall estimates of behavior (e.g., Cooper et al., 1981), measures that are more sensitive to changes in consumption within a day, such as the spacing and timing of each cigarette detectable with electronic diaries or smoking topography devices, could have better characterized participants' ad lib smoking behavior. Similarly, breath CO was the only biochemical measure of smoking used in this study. Breath CO has limited utility for quantifying consumption over an extended period of time because of its short-half life which limits its sensitivity to detect smoking within the day (6-9h; SRNT Subcomittee on Biochemical Verification, 2002). Biochemical measures of total smoke exposure, such as urinary cotinine concentrations, could have provided more precise information about how total smoke exposure, particularly when participants are smoking ad lib, outside of the lab (Murphy et al.,

2004). Future studies should not rely exclusively on retrospective self-report to detect differences in regulation of smoking and total smoke exposure.

Finally, while a PTT has been very useful for understanding regulation of eating and even alcohol drinking in a laboratory setting (e.g., Herman & Mack, 1965; Palfai, 2001), factors that uniquely affect regulation of smoking following an episode of heavy smoking may limit the utility of this design. Specifically, unlike research on eating, smoking preloads may be more likely to create ceiling effects for taste-test consumption, or adverse effects from the preload, such as dizziness and nausea. Moreover, physiological signals of smoking satiety following a preload sufficient to trigger limit violations may prevent counterreuglation of smoking at a clinically meaningful level altogether. Substituting denicotinized cigarettes for smokers' usual brands for the preload might allow smokers to perceive that their limits on smoking have been violated, without saturating their tolerance for further smoking on the taste-test. On the other hand, because few smokers smoke denicotinized cigarettes outside of the lab, this particular modification may have limited ecological validity. On a practical level, researchers who are "weak of stomach" are advised to consider alternate paradigms, as overestimates of the appropriate preload dose can make participants sick. Nonetheless, a small number of studies of reporting that eaters have vomited during food preloads, as well (e.g., Lowe et al., 2001); in other words, some researchers may still find this paradigm acceptable "as is" for future work in smokers and eaters, even if the ideal preload dose for a particular sample has not been established.

8.3 STRENGTHS

This study adds to existing research in eaters and smokers by developing and illustrating the first experimental manipulation of restraint style. Specifically, this study is the first to demonstrate that flexible restraint style may be malleable (at least in the short-term) with a brief intervention. Thus, to the extent that flexible restraint style is related to smoking behavior, interventions targeting restraint style could improve regulation of consumption, at least under certain, prescribed circumstances. Similarly, until this study, previous associations between restraint style and smoking behavior were cross-sectional. Thus, this study also provided the first evidence that restraint style -- rather than characteristics of the participants who naturally adopt a rigid or flexible restraint style -- is associated with regulation of smoking on a PTT. Because there are no previous attempts to manipulate restraint style, the procedures used in this study can be used to suggest how investigators might manipulate dietary restraint style, or restraint of other behaviors of interest (e.g., drinking, shopping, sexual behavior).

This was also the first study to adapt and validate a PTT for smokers. In particular, results demonstrated that down-regulation of smoking can be detected in a PTT design, regulation of intake can be disrupted with the appropriate preload, and that a taste-test cover story is accepted by smokers; we also demonstrated the effects of a 2-cigarette preload for moderate-rate smokers. For investigators considering research including a PTT design, we also demonstrated the importance of operationalizing total smoking with measures of smoking topography and the need to assess regulation within cigarettes. Indeed, PTTs are widely used to assess regulation of eating and alcohol drinking (e.g., Palfai, 2001; Westenhoefer et al., 1994), and the development of a comparable paradigm for smoking research can help facilitate comparisons of how different behaviors are regulated on the task.

An additional strength of this study is that it represents one of the first attempts to evaluate a model of smoking regulation in the context of a reduction attempt. While there are large epidemiological studies describing the number and characteristics of smokers who make reduction attempts, there are very few studies addressing questions about which reducers are likely to succeed and fail, and why. Research that identifies specific cognitive and behavioral strategies that promote successful smoking reduction is likely to have implications for identifying treatment targets and the development of novel interventions; this study hints at the benefits of adopting a flexible restraint style. Similarly, while smoking research guided by an eating model was awkward at points (e.g., questionnaire development; titrating preload doses, etc.) it was also an efficient way to begin researching strategies for smoking reduction because potentially viable theory and methods had already been developed. Further research in this area will suggest whether smoking and eating reduction are sufficiently similar for future work in these areas to continue to progress in parallel.

Finally, a strength of this study is that it draws explicit parallels between strategies for regulating eating and smoking behaviors. While the literature includes multiple references to the ways in which reducing eating and smoking might be alike (e.g., "food addictions"; Ifland et al., 2009) – including adaptations of theories such as the Boundary Model (Herman & Mack, 1975; Kozlowski & Herman, 1984) and others (e.g., Abstinence Violation Effect; Marlatt & Gordon, 1985) for both behaviors, empirical tests of these hypothesized cross-behavior similarities are seldom reported. Studies testing models across behaviors that use similar terminology and similar experimental designs are even rarer. The parallel between the methods used here and those frequently used in dietary restraint research therefore, has the potential to facilitate focused

comparisons of the strengths and limitations of Westenhoefer's model in both behaviors. Such comparisons might also be useful for suggesting ways in which the model might be improved.

8.4 IMPLICATIONS

The results of this study suggest a number of implications for how restraint and restraint style should be conceptualized, and how the constructs might be related to the outcomes of attempts to smoke less.

The overarching aim of this study was to assess the effects of restraining smoking on smoking behavior and restraint style was the focus of this analysis because research on eaters has shown the constructs to have good predictive value. On the other hand, results of this study also suggest that smoking restraint is likely a multidimensional construct. For example, in addition to restraint style, generalized smoking restraint likely serves as a moderator of the effects of other dimensions of restraint. For instance, the likelihood that a rule for total smoking will be perceived as broken likely depends on whether a person is attending to the rule at all. Other dimensions not previously discussed (but suggested by the preliminary factor analysis) could include a dimension reflecting participants' willingness to engage in reduction-promoting behaviors (e.g., skipping cigarettes, following a smoking reduction plan). Indeed, willingness has been shown to improve prediction of various health-promoting behaviors beyond assessments of a person's intended use of the techniques (Gibbons et al., 1988). Further, this factor would correspond to factors proposed in the dietary restraint literature, such as Behavioral Dieting Control (Ricciardelli & Williams, 1997) and Weight Suppression (Lowe, 1993) that reflect use of reduction-promoting *behaviors*. Another dimension that could be important for completely

characterizing smoking restraint is disinhibition. As demonstrated by Westenhoefer et al (1994) a dimension reflecting smokers' perceptions of their propensity to disinhibit smoking (i.e., binge) may also be important for dividing smokers into groups of those who would potentially counterregulate smoking and those who would not. Future research could include qualitative methods such as focus groups to suggest other dimensions of restraint that could be important for characterizing other dimensions of smoking restraint, and how they might be related to the outcomes of smokers' attempts to smoke less.

Similarly, this study only successfully characterized the effects of restraint style on smoking behavior under specific laboratory conditions. While results suggested that restraint style may be related to regulation of smoking following a limit-challenging preload, how restraint style might be related to other kinds of challenges that occur during an attempt to smoke less is unknown. In eaters, for example, counterregulation on a taste-test has been demonstrated following alcohol drinking and negative mood inductions (Cools et al., 1992; Heatherton et al., 1991b; Herman & Mack, 1975; Herman et al., 1987; Polivy et al., 1988, 1994; Polivy & Herman, 1976, 1999; Schotte et al., 1990). Thus a focus exclusively on restraint style's effects following preload-induced challenges does not reflect the entirety of high risk situations that could result in failed smoking restraint, either in or out of the lab. Indeed, restraint style could be associated with outcomes of other types of challenges: for example, flexibly restrained smokers might be particularly susceptible to lapses in restraint during periods of positive mood (or a positive mood induction) because they might be more willing than their rigid counterparts to indulge in smoking "for fun". Further work is needed to develop and test hypotheses about how rigidly and flexibly restrained smokers might regulate smoking during other challenges to restraint.

Nonetheless, results from the laboratory suggested that participants' reactions to challenges to restraint were related to regulation of smoking on the PTT. This suggests that smokers' perception of, and reactions to challenges to restraint may predict smokers' decisions about when to compensate for prior consumption or when episodes of uncontrolled, mood-dependent behaviors (i.e., AVE-like reactions) reduce the likelihood that regulation of smoking will occur. As indicated by the success of the flexible style manipulation for altering self-reported restraint style, some of the cognitions related to regulation of smoking behavior during a reduction attempt may be malleable. Cognitive Behavioral Therapy (CBT; Beck, 2005) has been established as a useful tool for breaking associations between non-adaptive cognitions, negative moods, and various unwanted behaviors. Therefore, just as the CBT model has been helpful for promoting effective regulation of eating behavior in dieters (Van Dorsten & Lindley, 2008) and helping smokers quit (e.g., Killen et al., 2008), CBT-based interventions may also be effective for helping smokers to smoke less.

Finally, although the focus of this research has been on applying research on dietary restraint to the study of smoking behavior, results of this study suggest a number of ways that research on smoking restraint could be applied to research on eaters, as well. Most specifically, results of this study showed that flexible restraint style is somewhat malleable, and that increases in flexible restraint are associated with greater success at regulating smoking, at least in a laboratory setting. While the current clinical implications of this finding are highly limited for smokers (indeed, flexible smoking restraint has no known associations with total smoke exposure outside of the lab) several studies have shown that flexible dietary restraint is associated with several desirable, clinical outcomes, including reduced risk of binge eating and lower BMI (e.g., Smith et al., 1999; Masheb & Grillo, 2002). Thus, dietary restraint researchers

interested in practical applications of restraint style theory are encouraged to attempt a flexible restraint style manipulation to determine whether similar outcomes can be created from artificially-induced flexible dietary restraint.

9.0 CONCLUSIONS

It is important to advance our understanding of the factors affecting regulation of smoking behavior so that we might improve our ability to affect clinical outcomes in this regard. The present project investigated the effects of rigid and flexible restraint styles on smoking regulation during an attempt to cut-down, both during ad lib smoking and following a challenge to smoking restraint in the lab. Research on dietary restraint has shown that a rigid restraint style is associated with problems regulating eating and that a flexible restraint style is associated with successful regulation of consumption. While this study may have failed to adequately assess ad lib smoking outside of the lab, our laboratory findings were consistent with research on dietary restraint in showing that flexible restraint style is associated with regulation of smoking behavior while the absence of flexibility, which perhaps includes components of rigid restraint style, is not.

Results of this study provide the first empirical evidence that a person's natural approach to reducing smoking can potentially be altered (at least in the short-term) with minimal intervention, and that these alterations might also be related to whether or not smoking behavior is regulated successfully. Thus, to the extent that restraint style does affect regulation of consummatory behaviors, restraint style could prove to be an important target for future interventions. Future research is needed however, to establish a relationship between restraint style and behavior outside of a laboratory setting, and then to ensure that the effects of a restraint

style manipulation extend to participants' natural environments. Indeed, while the specific health effects of successful smoking reduction are sometimes debated (e.g., Benowitz et al., 1986; Tverdal & Bjartveit, 2006), data consistently show that smokers who successfully reduce their smoking are also more likely to attempt, and succeed at quitting smoking altogether (Hyland et al., 2005; Shiffman, Ferguson, & Strahs, 2009): this suggests that further research devoted to smoking reduction is likely to have important, clinical implications.

Finally, the results of this study highlight the benefits and challenges of adapting a well-established, experimental paradigm from another literature (eating and dieting) to study related problems in smokers. Several well-known theories have been generalized from eaters to smokers, and vice versa, yet few empirical tests of these theories in both behaviors have been reported. This study provides an example of the feasibility and utility of extracting constructs, measures (although less successfully so), paradigms, and theory to help inform smoking restraint research, which is comparatively much less developed. Results show that this kind of cross-behavioral comparison can be informative about the target behavior (i.e., restraint style is related to regulation of smoking behavior) and the source literature (i.e., restraint style might be malleable and a target for intervention), as well as for our understanding of the similarities and differences between consummatory behaviors in general. Researchers interested in regulation and reduction of other consummatory behaviors (e.g., shopping, gambling, sex) might also benefit from exploring the effects of restraint style on behavior, and insight from other fields might help to further refine restraint style theory for use across multiple populations.

TABLES

Table 1. Rigid and Flexible Eating Restraint scale items

Item Source	
FR subscale	RR subscale
When I have eaten my quota of calories, I am usually good about not eating any more	I have a pretty good idea of the number of calories in common food
I deliberately take small helpings as a means of weight control	I count calories as a conscious means of controlling my weight
While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it	How often are you dieting in a conscious effort to control your weight?
I consciously hold back at meals in order not to gain weight	Would a weight fluctuation of 5 lbs affect the way you live your life?
I pay a great deal of attention to changes in my figure	Do feelings of guilt about overeating help you to control your food intake?
How conscious are you of what you're eating?	How frequently do you avoid stocking up on tempting foods?
How likely are you to consciously eat less	How likely are you to shop for low calorie

than you want?	foods?
If I eat a little bit more on one day, I make up for it the next day	I eat diet foods even if they do not taste very good
I pay attention to my figure but I still enjoy a variety of foods	A diet would be too boring a way for me to lose weight
I prefer light foods that are not fattening	I would rather skip a meal than stop eating in the middle of one
If I eat a little bit more during one meal, I make up for it at the next meal	I alternate between times when I diet strictly and times when I don't pay much attention to what and how much I eat
Do you deliberately restrict your intake during meals even though you would like to eat more?	Sometimes I skip meals to avoid gaining weight
	I avoid some foods on principle even though I like them
	I try to stick to a plan when I lose weight
	Without a diet plan I wouldn't know how to control my weight
	Quick success is most important for me during a diet

Table 2. Behavioral correlates of rigid and flexible restraint in eaters

	Study	N	Sample	Behavior	RR	FR
Binge Eating	Shearin et al 1994	31	BPD inpatient women	Binge eating	+	N
	Smith et al 1999	223	Health and nutrition study participants	Overeating when alone	+	-
	Westenhoefer 1991	54,525	Dieters	Binge eating frequency	+	-
				Binge eating severity	+	-
	Williamson et al 1995	206	Undergraduate women	Overeating	+	-
BMI	Bond et al 2001	553	Undergraduate women	BMI	N	N
	Masheb & Grilo 2002	148	BED outpatients	BMI	-	-
	McGuire et al 2001	1,226	Weight-gain prevention	BMI	-	-
	Ricciardelli & Williams 1997	144	Undergraduate women	BMI	+	-
	Shearin et al 1994	31	BPD inpatient women	BMI	+	-

	Smith et al 1999	223	Health and nutrition study participants	BMI	+	-
	Stewart et al 2002	188	Nonobese community and university women	BMI	+	+
	Westenhoefer 1991	54,525	Dieters	BMI	+	-
	Westenhoefer et al 1999	1,838	Community sample	BMI	+	-
	Williamson et al 1995	206	Undergraduate women	BMI	+	-
Eating Disorders	Shearin et al 1994	31	BPD inpatient women	Bulimia	+	N
				Anorexia Nervosa	N	+
	Stewart et al 2002	188	Nonobese community and university women	Eating disorder symptoms	+	N
Methods of weight control	Bond et al 2001	553	Undergraduate women	Exercise	+	N
	McGuire et al 2001	1,226	Dieters	Calorie intake	-	-

			% calories from fat	?	?
			% calories from sweets	-	-
			Physical activity	+	+
			Fat-reducing strategies	+	+
Ricciardelli & Williams 1997	144	Undergraduate women	Previous dieting	+	+
			Current dieting	+	+
Smith et al 1999	223	Health and nutrition study participants	Limiting intake	N	+
Westenhoefer 1991	54,525	Dieters	Caloric intake	N	-
Westenhoefer et al 1999	1,838	Community sample	Diuretics	+	-
			Laxatives	+	N
			Appetite suppressant	+	-
			Vomiting	+	N

				Exercise	N	+
Weight Change	Shearin et al 1994	31	BPD inpatient women	Weight fluctuations	+	N
	Westenhoefer 1991	54,525	Dieters	Weight loss	N	+

BMI=Body Mass Index, BPD=Borderline Personality Disorder

FR=Flexible restraint, RR= Rigid restraint

Table 3. Restraint strategies of light and heavy smokers

	Comparison of Smoker Types	Perlick (1977) (n=75)[a]	Hickcox (1995) (n=97)[b, &]	Okeuyemi et al (2002) (n=450)[c]
Smoke cigarette half-way or limit puffs	Light > Heavy	√	√	√
Daily/weekly limit	Light > Heavy	√	√	√
Keep record/ration intake	Light > Heavy	√	√	√
Times when you deliberately refrain	Light > Heavy	√	√	ND

[a] Light smokers = Light-retrained

[b] Light smokers = chippers

[c] Light smokers = occasional and light

ND = No data

[&] Based on data from the "Limit" factor score, which is a combination of all items in the table. Data are not provided separately for each item in the manuscript.

Table 4. RR and FR Items from Hickcox (1995) and their relationship to smoker type

Item Source		
FR (Westenhoefer et al., 1999)	**Hickcox (1995)**	**CH vs HS**
I consciously hold back at meals in order not to gain weight	How often do you deliberately refrain from lighting up a cigarette in order to keep your smoking rate down	>
How conscious are you of what you're eating?	I monitor how much I smoke to control how much I smoke (self-monitoring as coping)	ND
Do you deliberately restrict your intake during meals even though you would like to eat more?	If you could smoke freely and were not concerned about the effects of smoking, would you like to smoke MORE or LESS than you do now?	=
I deliberately take small helpings as a means of weight control	Limit puffs or smoke cigarette halfway	>
When I have eaten my quota of calories, I am usually good about not eating any more	Percent of times refrains despite wanting to smoke	>
I prefer light foods that are not fattening	Switching to lower-tar brand (Okeuyemi)	=
While on a diet, if I eat food that is not allowed, I consciously eat less for a period of	No match	

time to make up for it		
I pay a great deal of attention to changes in my figure	No match	
How likely are you to consciously eat less than you want?	No match	
If I eat a little bit more on one day, I make up for it the next day	No match	
I pay attention to my figure but I still enjoy a variety of foods	No match	
If I eat a little bit more during one meal, I make up for it at the next meal	No match	

RR

I try to stick to a plan when I lose weight	Think of a plan to avoid smoking	ID
Do feelings of guilt about overeating help you to control your food intake	I feel guilty after smoking too much	<

Would a weight fluctuation of 5 lbs affect the way you live your life	I frequently worry about smoking related issues such as the need to control my smoking, concerns over addiction to smoking, etc.	<
Without a diet plan I wouldn't know how to control my weight	If I didn't try at all to control my smoking and just smoked as I wanted, I would probably develop a smoking problem or my smoking would get out of hand	<
I count calories as a conscious means of controlling my weight	Limit number of puffs or smoke half-way (repeat of another q in FR)	>
How likely are you to shop for low calorie foods	Switching to lower-tar brand (Okeuyemi et al., 2002) * repeat	=
I have a pretty good idea of the number of calories in common food	No match	
How often are you dieting in a conscious effort to control your weight	No match	
How frequently do you avoid stocking up on tempting foods	No match	

I eat diet foods even if they do not taste very good	No match
A diet would be too boring a way for me to lose weight	No match
I would rather skip a meal than stop eating in the middle of one	No match
I alternate between times when I diet strictly and times when I don't pay much attention to what and how much I eat	No match
Sometimes I skip meals to avoid gaining weight	No match
I avoid some foods on principle even though I like them	No match
Quick success is most important for me during a diet	No match

ID=Insufficient data, ND= No data

Table 5. Participant characteristics

				Water		Cigarette	
	TOTAL SAMPLE	Questionnaire only/Pilot	PTT SUBSAMPLE	Rigid	Flexible	Rigid	Flexible
N	126	31	95	24	25	22	24
Gender (% M)	53.66	55.17	53.19	45.83	60.00	52.38	54.17
Ethnicity (% C)	50.00%	42.31	52.50	50.00	60.00	50.00	50.00
Age (M, SD)	36.99 (13.69)	39.29 (12.60)	36.31 (14.00)	35.79 (16.68)	37.36 (12.96)	37.05 (13.85)	35.08 (12.96)
Education (% College degree)	27.87	14.29	31.91	34.78	36.00	31.82	25.00
CPD	17.09 (3.55)	16.67 (3.56)	17.21 (3.56)	16.80 (4.61)	17.84 (3.04)	17.45 (2.35)	16.68 (3.93)
Years smoking	19.13 (12.42)	20.33 (10.92)	18.77 (12.88)	19.08 (15.60)	20.02 (12.43)	19.10 (11.48)	16.78 (11.99)
FTND	4.02 (1.79)	4.11 (2.06)	4.00 (1.71)	4.00 (1.91)	3.69 (1.60)	3.67 (1.56)	4.65 (1.64)
Breath CO	21.84 (13.68)	20.89 (14.49)	22.12 (13.51)	22.42 (17.81)	21.04 (10.70)	22.27 (8.35)	22.79 (15.62)
NDSS Total	0.48 (0.91)	0.61 (0.84)	0.44 (0.92)	0.48 (0.97)	0.37 (0.82)	0.54 (0.81)	0.40 (1.10)
Continuity	-0.85 (0.93)	-1.12 (0.93)	-0.77 (0.92)	-0.76 (0.91)	-0.86 (0.96)	-0.64 (0.99)	-0.78 (0.87)

Drive	0.25 (1.10)	0.18 (1.22)	0.27 (1.06)	0.16 (1.06)	0.27 (1.21)	0.24 (1.00)	0.39 (0.99)
Priority	-0.05 (0.98)	0.16 (1.07)	-0.11 (0.95)	0.24 (1.09)	-0.19 (0.82)	-0.29 (0.97)	-0.23 (0.89)
Stereotypy	0.44 (1.08)	0.63 (1.18)	0.38 (1.05)	0.55 (0.98)	0.45 (1.25)	0.43 (0.91)	0.11 (1.03)
Tolerance	-0.02 (1.07)	-0.02 (0.89)	-0.01 (1.13)	-0.19 (1.00)[a,b]	-0.32 (1.05)[c,d]	0.36 (1.25)[a,c]	0.19 (1.17)[b,d]
RESTRAINT	6.81 (2.22)	7.21 (2.55)	6.71 (2.13)	6.26 (2.37)	7.54 (2.15)	6.62 (2.16)	6.33 (1.59)
SCALES							
Rigid							
Flexible	4.09 (2.28)	4.73 (3.18)	3.90 (1.92)	4.39 (1.97)	4.54 (1.61)	3.23 (1.92)	3.35 (1.99)
FACTOR	0.24 (0.32)	0.38 (0.44)[a]	0.20 (0.27)[a]	0.29 (0.39)	0.22 (0.23)	0.15 (0.21)	0.14 (0.19)
SCALES							
Balanced							
Consumption							
Basic Restraint	0.82 (0.37)	0.81 (0.34)	0.83 (0.38)	0.98 (0.34)[a,b]	0.91 (0.37)[c,d]	0.72 (0.36)[a,c]	0.76 (0.37)[b,d]
Self-set	11.39 (4.15)	9.94 (4.29)	11.72 (4.08)	12.30 (4.72)	11.37 (3.76)	11.40 (3.50)	11.80 (4.44)
smoking limit							

[a,b,c,d] cells within rows that share superscript letters are significantly different, $p<0.05$. C = Caucasian, CO = Carbon Monoxide, M= Male aware

Table 6. Final factor loadings

Item	Original Scale Membership	Basic Restraint	Balanced Consumption
I pay a great deal of attention to changes in my health.	SFR	.56*	.03
I pay attention to my health but I still enjoy cigarettes.	SFR	.54*	.03
I try to stick to a plan when I cut back on smoking.	SRR	.46*	.02
Sometimes I skip some cigarettes to avoid smoking too much.	SRR	.45*	.08
How conscious are you of how much you are smoking?	SFR	.36*	-.10
If I smoke a little bit more on one occasion, I make up for it the next occasion.	SFR	-.10	.88*
If I smoked at times when I think I shouldn't I consciously smoke less for a period of time to make up for it.	SFR	-.07	.79*
I deliberately take small puffs as a means of controlling how	SFR	.07	.53*

much I smoke.			
If I smoke a bit more on one day, I make up for it the next day.	SFR	.21	.50*
I alternate between times when I strictly limit my smoking and times when I don't pay much attention to how often and how much I smoke.	SRR	.32	.15
How likely are you to consciously smoke less than you want?	SFR	.34	-.08
Cutting back on smoking would be too boring a way for me to improve my health.	SRR	CL	CL
Do you deliberately restrict your smoking even though you would like to smoke more?	SFR	CL	CL
How often are you limiting your smoking in a conscious effort to control your health?	SRR	F3	F3
I consciously hold back when smoking in order not to hurt my health.	SFR	F3	F3

I smoke cigarettes that I think might be safer, even if they do not taste very good.	SRR	F3	F3
I would rather skip a cigarette than stop in the middle of one.	SRR	F3	F3
Do feelings of guilt about smoking too much help you control your smoking?	SRR	F4	F4
How likely are you to shop for safer-cigarette alternatives?	SRR	F4	F4
Without a plan I wouldn't know how to control my smoking.	SRR	F4	F4
I avoid smoking some cigarettes on principle even though I like them	SRR	NL	NL
How frequently do you avoid "stocking up" when cigarettes are available?	SRR	NL	NL
I count puffs or cigarettes as a conscious means of controlling my smoking.	SRR	NL	NL
I have a pretty good idea of the health consequences of	SRR	NL	NL

smoking.			
I prefer nicotine products that aren't as bad for my health as cigarettes.	SFR	NL	NL
Quick success is most important in a plan to control my smoking.	SRR	NL	NL
When I have smoked my quota of cigarettes, I am usually good about not smoking any more.	SFR	NL	NL
Would a moderate change in how much you smoke affect the way you live your life?	SRR	NL	NL

*Interpreted factor loadings

Excluded items, due to: CL = Complex Loading, NL = No Loading, F3 = Factor 3, F4 = Factor 4

Table 7. Correlations among the original and factor scales

	Rigid	Flexible	Basic Restraint	Balanced Consumption
Rigid	1.00			
Flexible	0.54***	1.00		
Basic Restraint	0.64****	0.71****	1.00	
Balanced Consumption	0.39****	0.67****	0.29**	1.00

***p*<0.01, ****p*<0.0001

Table 8. Correlations between restraint, smoking, and nicotine dependence characterize the Balanced Consumption and Basic Restraint factor scales

	Basic Restraint	Balanced Consumption
CO	0.07	-0.13
CPD	0.00	0.09
Binges per day	-0.15	0.06
FTND	0.07	0.05
NDSS total	-0.11	0.04
Continuity	-0.01	-0.22*
Drive	-0.09	0.00
Priority	-0.01	0.23**
Stereotypy	0.04	-0.06
Tolerance	-0.16	-0.09

*p<.05, **p<0.01, SFR = Smoker Flexible Restraint, SRR=Smoker Rigid Restraint

FIGURES

Figure 1. Examples of regulatory responses on a preload taste-test

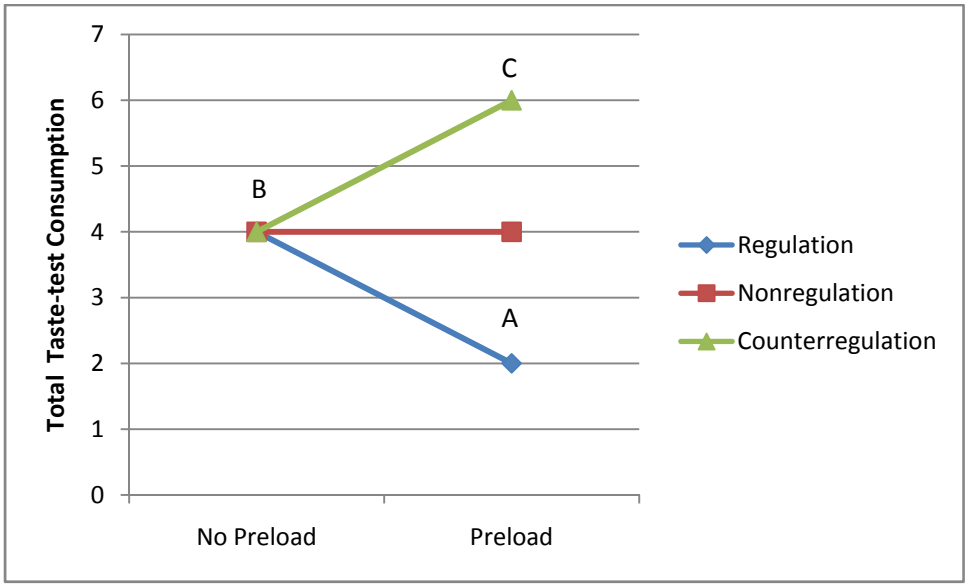

Figure 2. Study procedures schematic

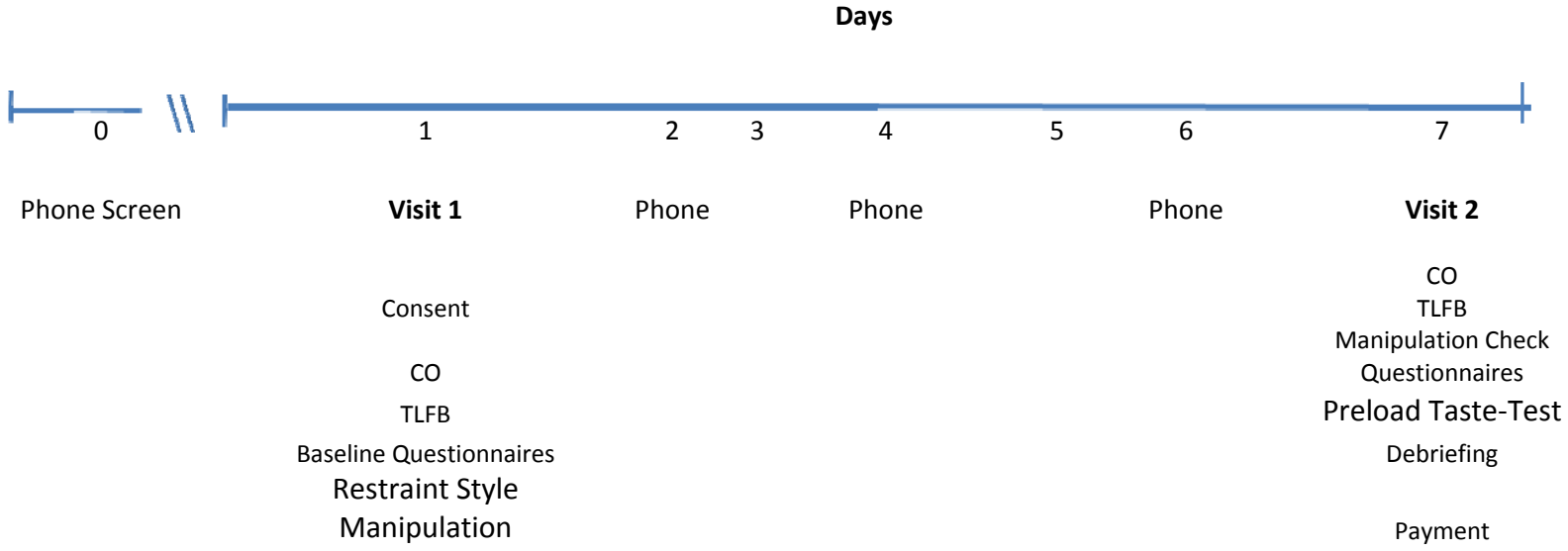

Figure 3. Predicted pattern of results: Counterregulated smoking among rigidly restrained (RR) smokers

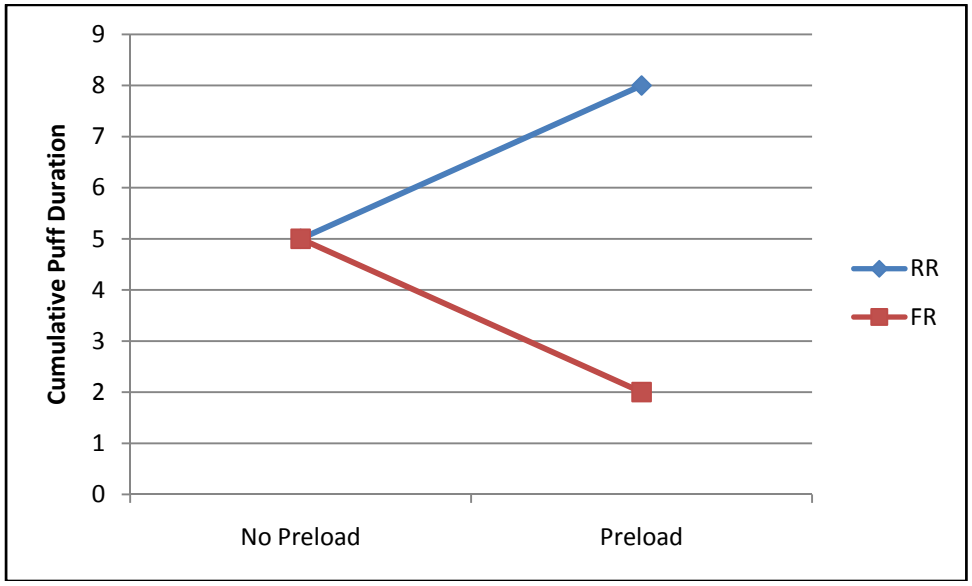

Figure 4. Participant flow

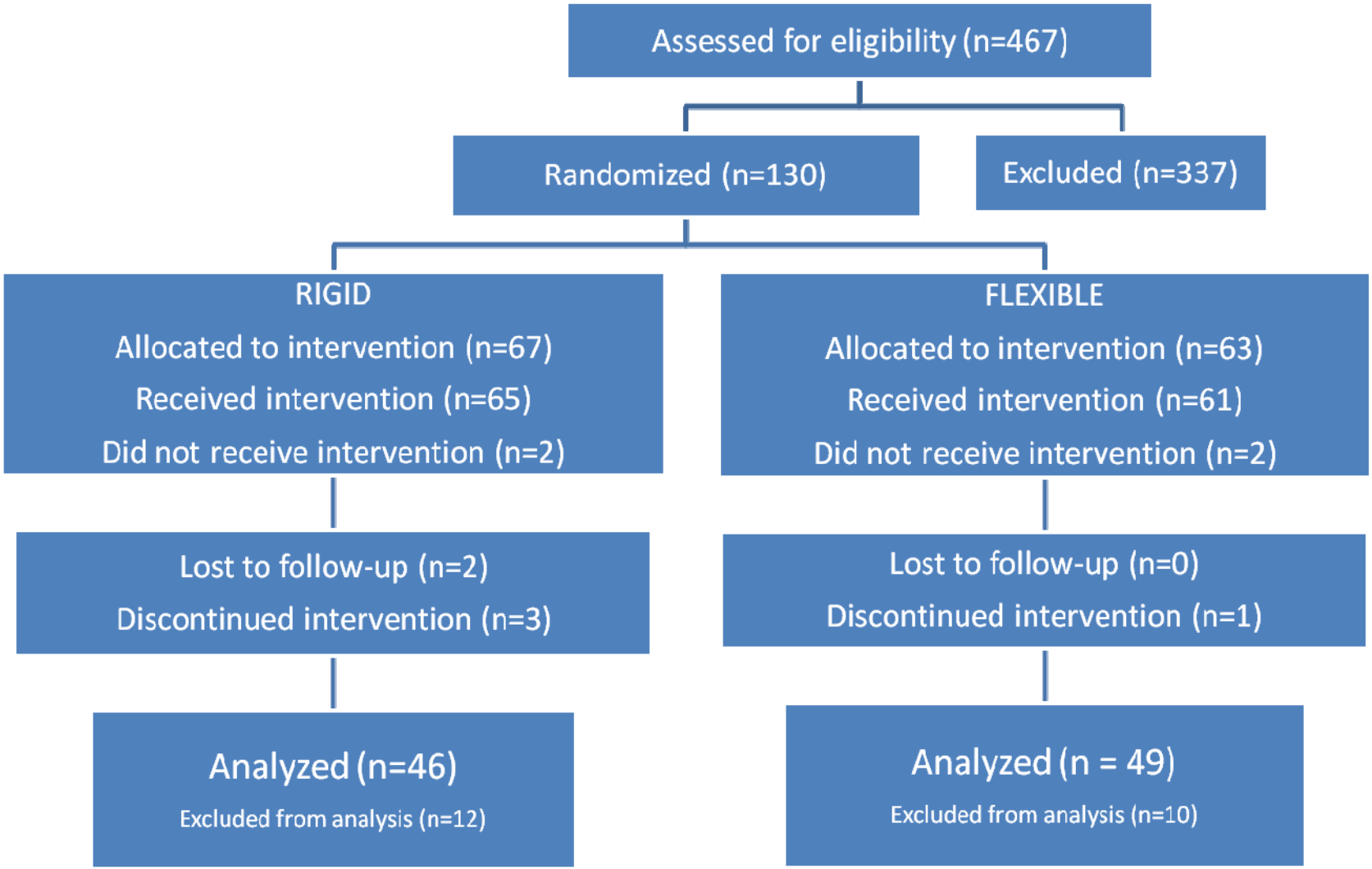

Figure 5. Both restraint style manipulations were associated with significant increases in Basic Restraint. As predicted, only the flexible manipulation was associated with a significant increase in Balanced Consumption. Contrary to hypothesis the rigid manipulation was not associated with decreases in Balanced Consumption. Scale scores are reported in standard units.

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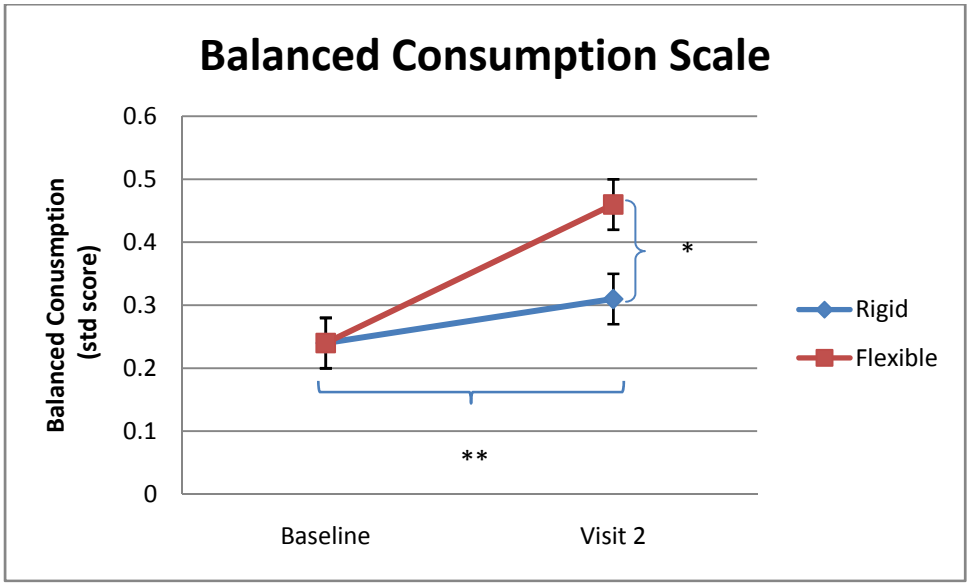

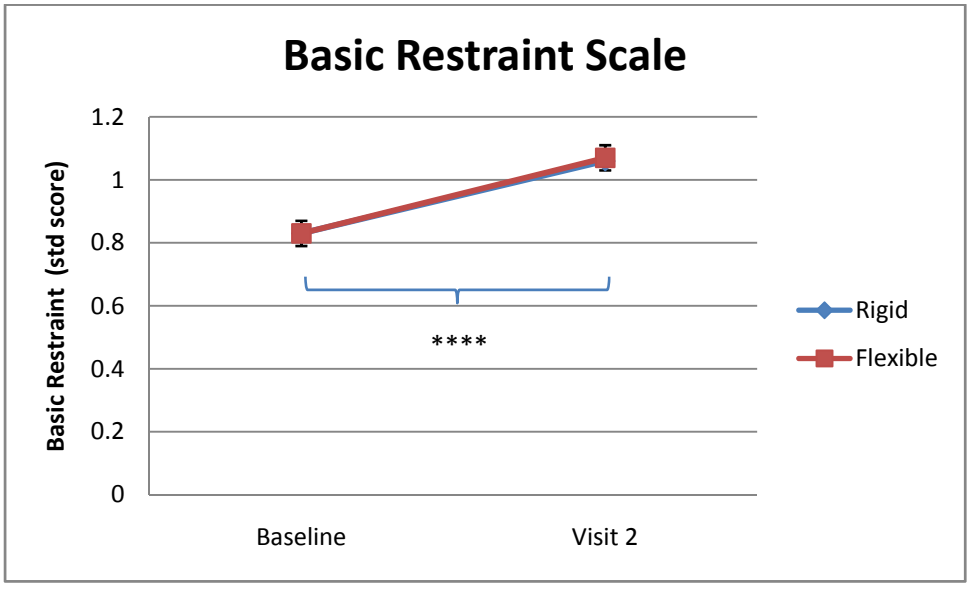

*p<0.05, **p<0.01, ****p<0.001

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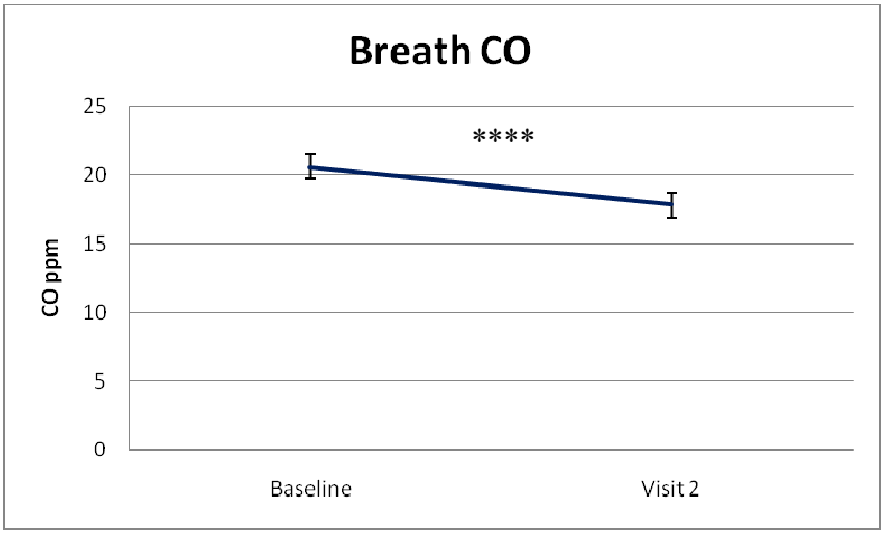
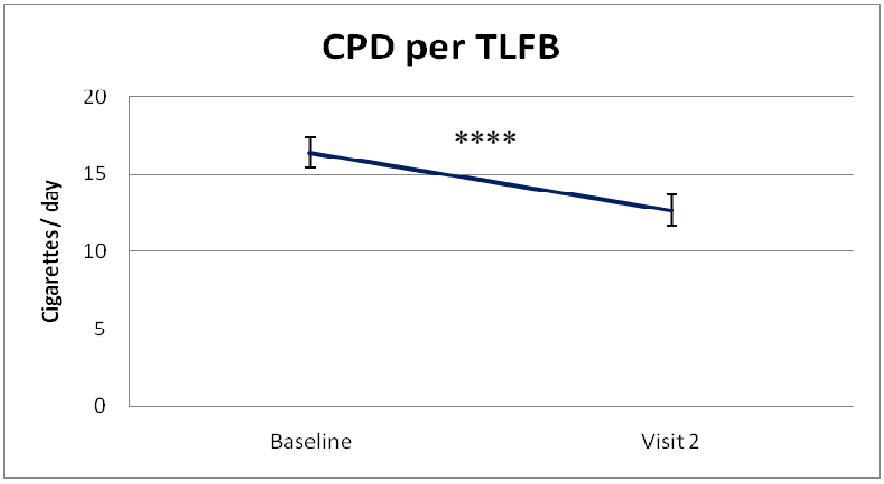
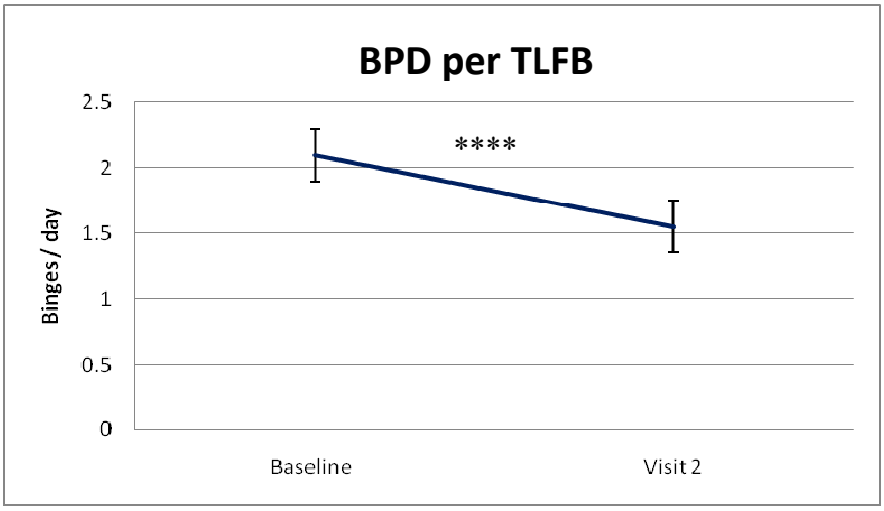
Figure 6. Smoking was significantly reduced from baseline to visit 2 across all measures

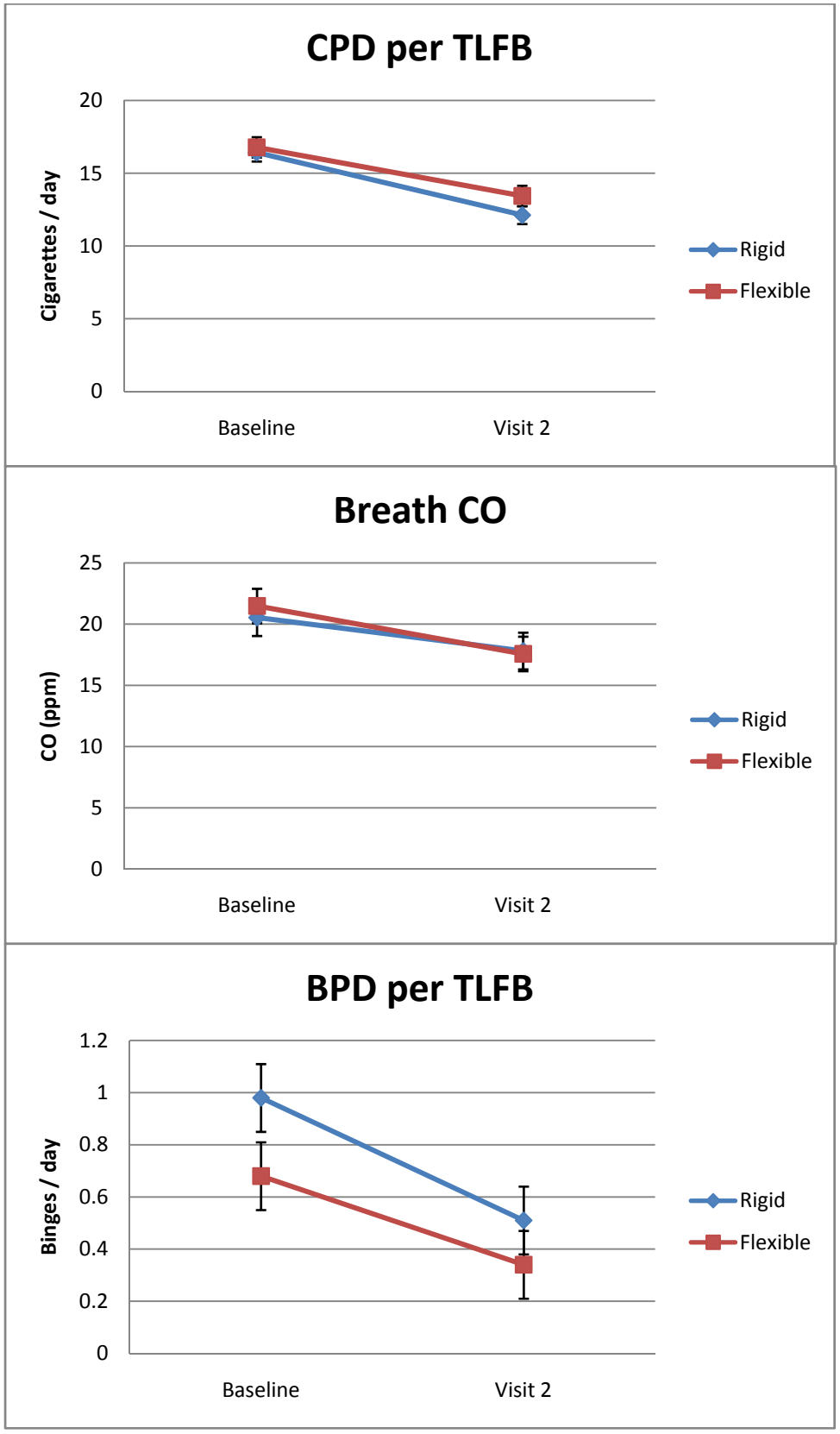






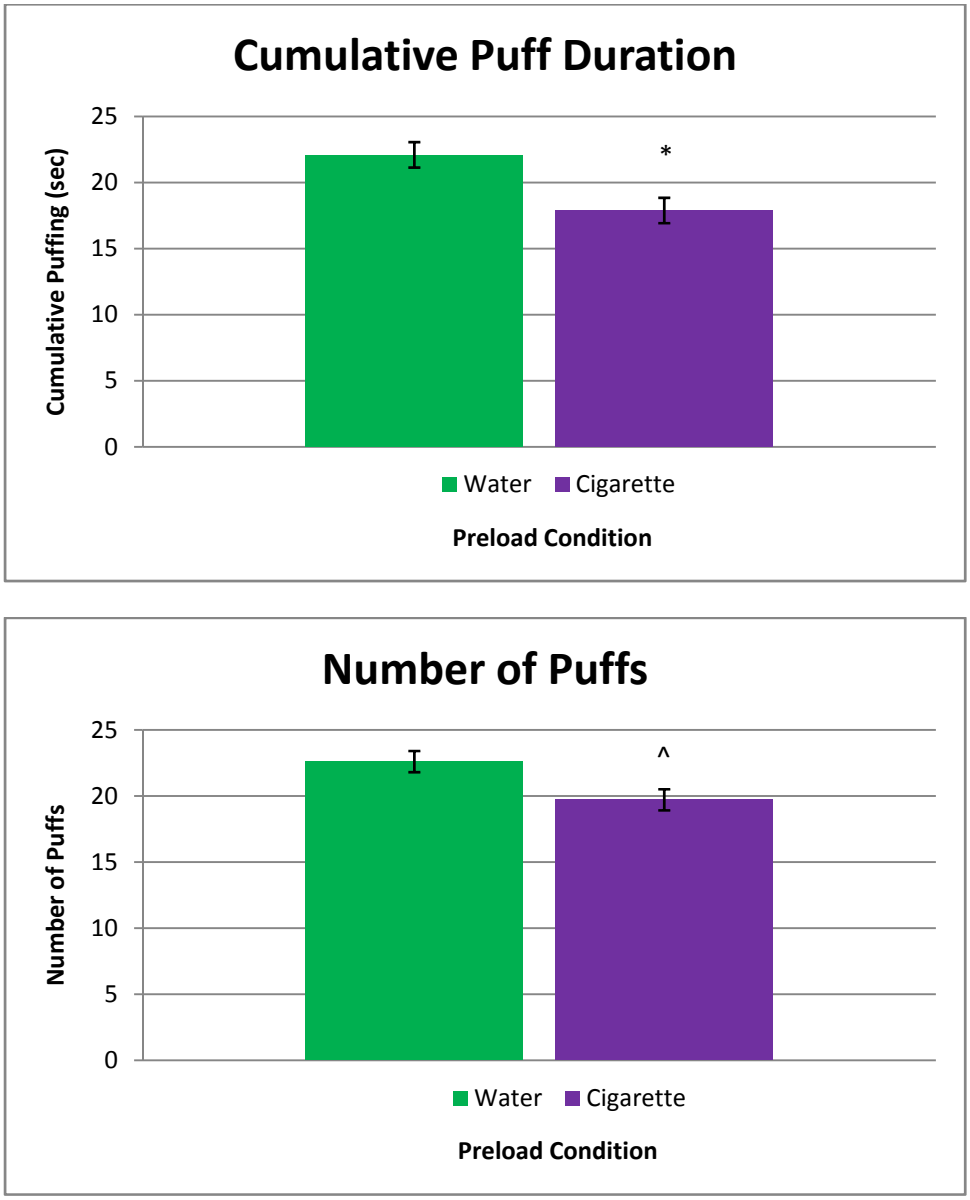
***p<0.001, BPD = Binges Per Day, CPD = Cigarettes per day

Figure 7. The restraint style manipulations were unassociated with reductions in total smoking



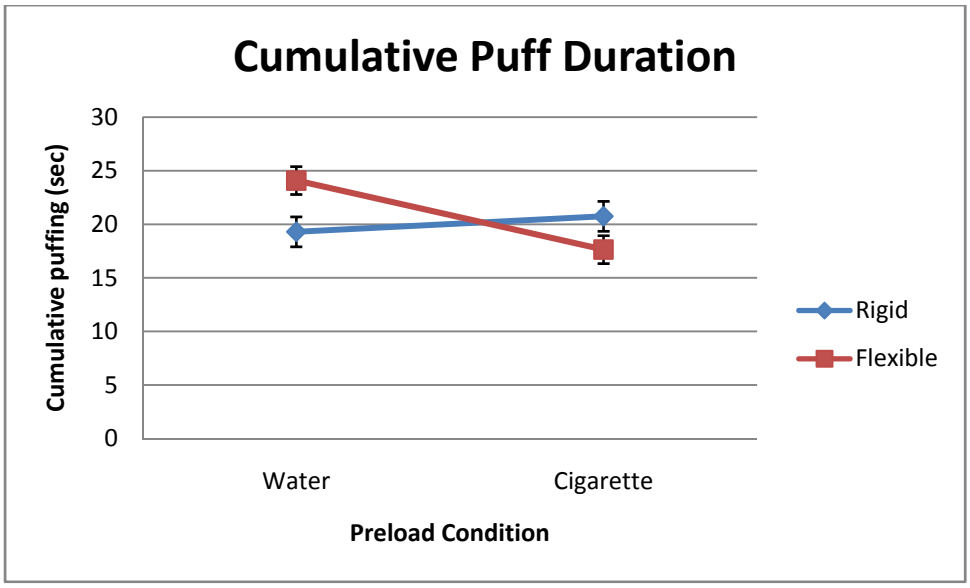
BPD = Binges Per Day, CPD = Cigarettes per day

Figure 8. Participants smoked less on the tasting following the cigarette preload than after the water preload



^$p<0.10$, *$p<0.05$

Figure 9. Participants who received the Flexible manipulation and the cigarette preload down-regulated their smoking on the PTT (cumulative puff duration). There was no evidence of smoking regulation when smoking was defined as number of puffs. Data presented are adjusted means



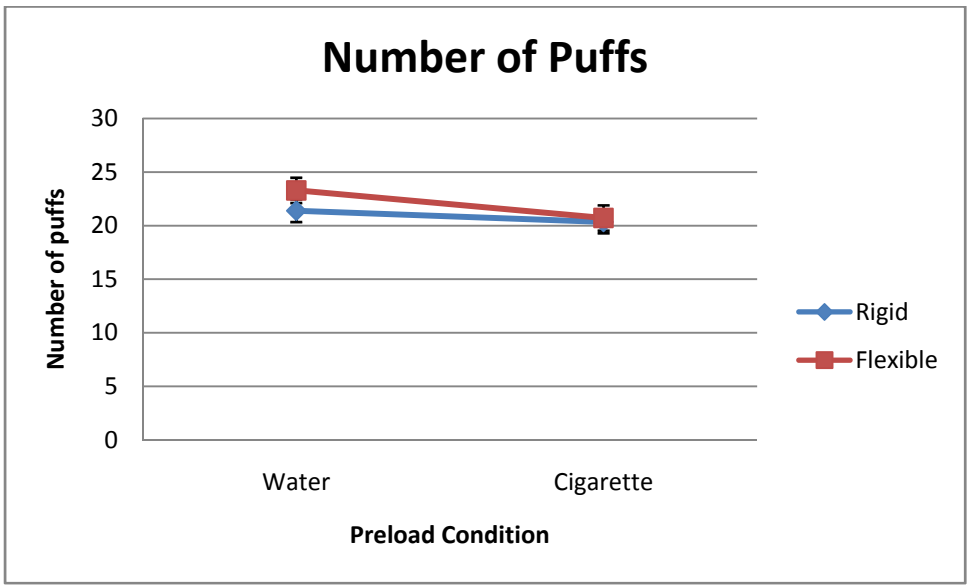
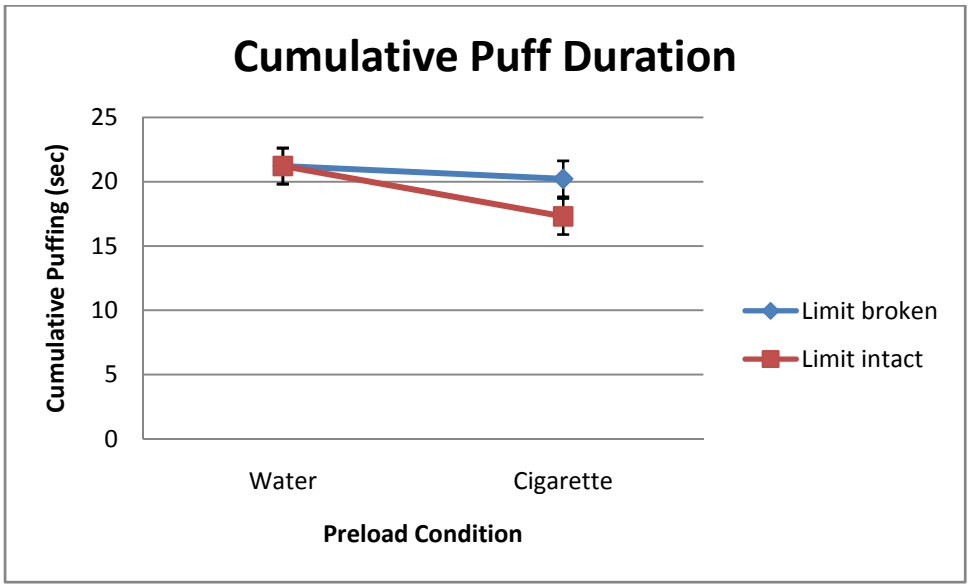
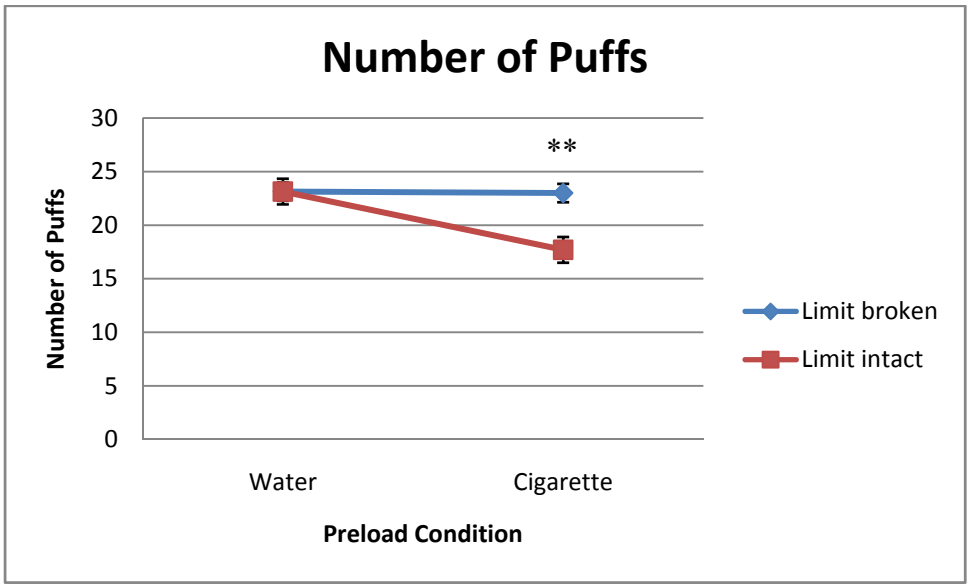


Figure 10. Participants who perceived the cigarette preload as "breaking" their rules for smoking had significantly more total puffs on the taste-test. A similar, non-significant trend was observed for cumulative puff duration.





**p=0.02

APPENDIX A

RR AND FR SUBSCALES ADAPTED FOR SMOKERS

Please read each question carefully and choose the answer that is most true for you.

1. **I alternate between times when I strictly limit my smoking and times when I don't pay much attention to how often and how much I smoke.**

   True..... ❑

   False ..... ❑

2. **I smoke cigarettes I think might be safer, even if they do not taste very good.**

   True..... ❑

   False ..... ❑

3. **I consciously hold back when smoking in order not to hurt my health.**

   True..... ❑

   False ..... ❑

4. **Cutting back on smoking would be too boring a way for me to improve my health.**

   True..... ❑

   False ..... ❑

5. **Do feelings of guilt about smoking too much help you to control your smoking?**

   Never..... ❑

   Rarely ..... ❑

Often .....

❑

Always .....

❑

6. **How often are you limiting your smoking in a conscious effort to control your health?**

Rarely .....

❑

Sometimes .....

❑

Usually .....

❑

Always .....

❑

7. **Quick success is most important in a plan to control my smoking.**

True .....

❑

False .....

❑

8. **Without a plan I wouldn't know how to control my smoking.**

True .....

❑

False .....

❑

9. **If I smoke a bit more on one day, I make up for it the next day.**

True .....

❑

False .....

❑

10. **Would a moderate change in how much you smoke affect the way you live your life?**

Not at all .....

❑

Slightly .....

❑

Moderately .....

❑

Very much .....

❑

11. **I prefer nicotine products that aren't as bad for my health as cigarettes.**

True .....

❑

False .....

❑

12. **I deliberately take small puffs as a means of controlling how much I smoke.**

True.....

❑

False .....

❑

13. **I try to stick to a plan when I cut back on smoking.**

True.....

❑

False .....

❑

14. **Do you deliberately restrict your smoking even though you would like to smoke more?**

Always .....

❑

Often .....

❑

Rarely .....

❑

Never.....

❑

15. **I avoid smoking some cigarettes on principle even though I like them.**

True.....

❑

False .....

❑

16. **How likely are you to shop for safer-cigarette alternatives?**

Unlikely .....

❑

Slightly unlikely .....

❑

Moderately likely .....

❑

Very likely .....

❑

17. **I have a pretty good idea of the health consequences of smoking.**

True.....

❑

False .....

❑

18. **I would rather skip a cigarette than stop in the middle of one.**

True.....

❑

False .....

❑

19. **If I smoke at times when I think I shouldn't, I consciously smoke less for a period of time to make up for it.**

True.....

❑

False .....

❑

20. **When I have smoked my quota of cigarettes, I am usually good about not smoking any more.**

True.....

❑

False .....

❑

21. **How conscious are you of how much you are smoking?**

Not at all .....

❑

Slightly .....

❑

Moderately .....

❑

Extremely .....

❑

22. **If I smoke a little bit more on one occasion, I make up for it at the next occasion.**

True.....

❑

False .....

❑

23. **How likely are you to consciously smoke less than you want?**

Unlikely .....

❑

Slightly unlikely .....

❑

moderately likely .....

❑

Very likely .....

❑

24. **I count puffs or cigarettes as a conscious means of controlling my smoking**

True.....

❑

False .....

❑

25. **I pay a great deal of attention to changes in my health.**

True.....

❑

False .....

❑

26. **How frequently do you avoid "stocking up" when cigarettes are available?**

Almost never .....

❑

Seldom.....

❑

Usually ..... ❑

Almost always..... ❑

27. **Sometimes I skip some cigarettes to avoid smoking too much.**

True..... ❑

False ..... ❑

28. **I pay attention to my health, but I still enjoy cigarettes**

True..... ❑

False ..... ❑

APPENDIX B

INFORMATIONAL PACKET: RESTRAINT STYLE MANIPULATION

Tips for Cutting Down on Smoking

Small changes can make a big difference in reducing your chances of having smoking-related problems. Here are some strategies to try. These strategies are the best way to help you meet your goal of cutting down on smoking.

(RR manipulation)

1. SET A SMOKING LIMIT: Put a firm limit on the number of cigarettes you smoke per day. Have an exact number in mind.
2. ALWAYS MAINTAIN CONTROL OF YOUR SMOKING: Remind yourself that smoking more than your limit is the same as letting your smoking get out of your control. Challenge yourself to smoke the same amount every day.
3. STICK TO YOUR LIMIT: Focus on sticking to your limit for cutting down. People who have a specific limit and who stick to it (no matter what!) are more likely to succeed.
4. DON'T GIVE IN: Remember that smoking more than your limit is like breaking a very important promise to yourself.
5. TURN BAD FEELINGS INTO ACTIONS: Think about how bad you felt the last time that you smoked when you were trying not to. Remember that bad feeling to help you skip that next cigarette.

(FR manipulation)

1. SET A SMOKING LIMIT: Set a rough limit for the number of cigarettes you will smoke per day. Have an approximate number in mind.
2. DON'T BE A CONTROL FREAK: Remind yourself that smoking more than your limit does not mean that your smoking is out of your control. You should expect that on some days you'll smoke more; just balance out with days of smoking less.
3. BE FLEXIBLE WITH YOUR LIMITS: Focus on making your plan flexible. People who make up for periods of heavy smoking with lighter smoking later on are more likely to succeed.
4. BE FORGIVING: Remember that smoking more than your limit on one day does not mean that you have broken your promise to cut down. Just plan and do smoke less later on.
5. TURN GOOD FEELINGS INTO ACTIONS: Think about how good you felt when you first decided to limit your smoking. Remember that good feeling to help you decide when not to smoke.

APPENDIX C

RESTRAINT STYLE-SPECIFIC PHONE MESSAGES

Table 9. Telephone messages received by participants on days 2, 4 and 6 during the study week.

RR	FR
Remember not to smoke more than your limit under any circumstances. If you do, you're letting yourself and the study down.	Remember that it's OK to smoke more than your limit once in a while. As long as you plan to smoke less later on, you're not letting anybody down.
If you smoke more than your limit, it's because you need to do more to keep cutting down. You may not have good control over your smoking yet.	If you smoke more than your limit, it's not because your smoking is out of control. Even the best-controlled smokers occasionally smoke a little more now-and-then.
Plan to keep smoking the same amount every day. Use this plan even on the days when you really want to smoke more.	Plan to smoke a little less than your limit on some days. This can help you feel better on the days when you really want to smoke more.

APPENDIX D

TASTE-TEST RATING FORM

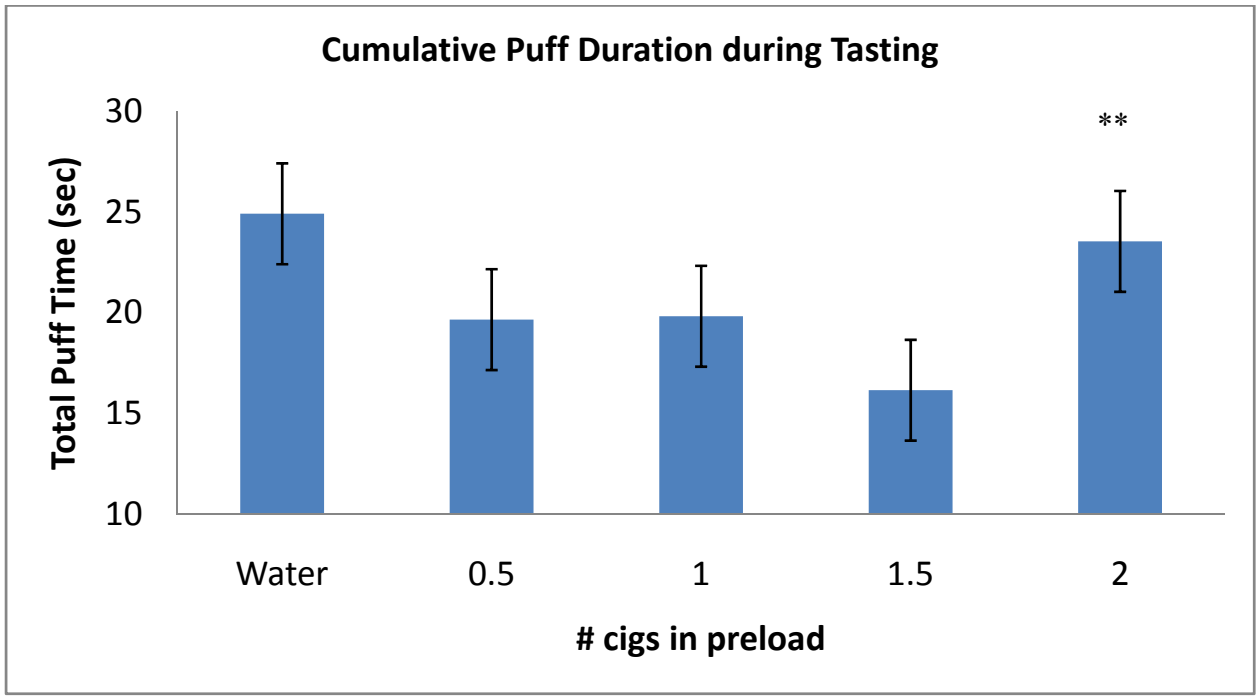
Directions: Circle the number indicating the taste of this cigarette on each of the following rating scales.

Stale									Fresh
1	2	3	4	5	6	7	8	9	10
Bitter									Sweet
1	2	3	4	5	6	7	8	9	10
Harsh									Smooth
1	2	3	4	5	6	7	8	9	10
Light									Heavy
1	2	3	4	5	6	7	8	9	10
Tasteless									Flavorful
1	2	3	4	5	6	7	8	9	10
Disappointing									Satisfying
1	2	3	4	5	6	7	8	9	10
Strong									Mild
1	2	3	4	5	6	7	8	9	10
Relaxing									Stimulating
1	2	3	4	5	6	7	8	9	10
Bland									Savory
1	2	3	4	5	6	7	8	9	10
Displeasing									Pleasurable
1	2	3	4	5	6	7	8	9	10

APPENDIX E

PILOT TESTING OF THE PRELOAD DOSE

Figure 11. During piloting, participants who received the 2-cigarette preload smoked significantly more than all other cigarette preload groups during the taste-test.



**$p<0.01$

APPENDIX F

FACTOR LOADINGS IN THE FIRST ITERATION FACTOR ANALYSIS

Table 10. Factor loadings for each item entered into the first iteration factor analysis.

Item	Factor 1: Basic Restraint	Factor 2: Balanced Consumption	Factor 3: Health Concerns	Factor 4: Unwilling to Restrain
1. Sometimes I skip some cigarettes to avoid smoking too much	0.58*	0.09	-0.03	-0.02
2. I pay a great deal of attention to changes in my health.	0.54*	0.01	-0.20	0.32

3. How likely are you to consciously smoke less than you want?	0.47*	-0.06	-0.12	-0.16
4. I try to stick to a plan when I cut back on smoking.	0.44*	-0.01	-0.01	0.24
5. How conscious are you of how much you are smoking?	0.44*	-0.16	-0.07	-0.05
6. I pay attention to my health but I still enjoy cigarettes.	0.38*	0.14	-0.14	0.05
7. I alternate between times when I strictly limit my smoking and times when I don't pay much attention to	0.37*	0.15	0.07	0.14
8. I avoid smoking some cigarettes on principle even though I like them	0.32	0.26	0.14	-0.06
9. I count puffs or cigarettes as a conscious means of controlling my smoking.	0.30	0.05	0.01	0.00
10. When I have smoked my quota of cigarettes, I am usually good about not smoking any more.	0.26	-0.06	0.23	-0.13

11. If I smoke a little bit more on one occasion, I make up for it the next occasion.	-0.05	0.89*	-0.06	-0.09
12. If I smoke a bit more on one day, I make up for it the next day.	-0.01	0.79*	-0.08	-0.02
13. I deliberately take small puffs as a means of controlling how much I smoke.	0.12	0.47*	0.09	0.12
14. If I smoked at times when I think I shouldn't I consciously smoke less for a period of time to make up	0.24	0.45*	0.07	0.05
15. How frequently do you avoid "stocking up" when cigarettes are available?	-0.07	0.25	0.10	0.02
16. I smoke cigarettes that I think might be safer, even if they do not taste very good.	-0.08	0.14	0.54*	0.21
17. I consciously hold back when smoking in order not to hurt my health.	0.26	0.03	0.50*	0.10

	0.27	-0.21	0.42*	0.00
19. I would rather skip a cigarette than stop in the middle of one.	-0.16	0.02	0.35*	-0.04
20. I prefer nicotine products that aren't as bad for my health as cigarettes.	0.05	0.12	0.26	-0.14
21. Would a moderate change in how much you smoke affect the way you live your life?	0.05	0.01	-0.25	0.19
22. Cutting back on smoking would be too boring a way for me to improve my health.	0.36*	-0.06	-0.39*	-0.04
23. How likely are you to shop for safer-cigarette alternatives?	0.15	0.03	0.10	0.50*
24. Without a plan I wouldn't know how to control my smoking.	-0.10	0.03	0.07	0.42*
25. Do you deliberately restrict your smoking even though you would like to smoke more?	0.36*	0.14	0.19	-0.42*

26. Do feelings of guilt about smoking too much help you control your smoking?	0.31	-0.05	0.15	-0.40*
27. Quick success is most important in a plan to control my smoking.	-0.06	0.13	0.18	0.22
28. I have a pretty good idea of the health consequences of smoking.	-0.11	0.08	0.10	-0.26

APPENDIX G

SCORING ALGORITHM FOR RESTRAINT STYLE FACTOR SCALES

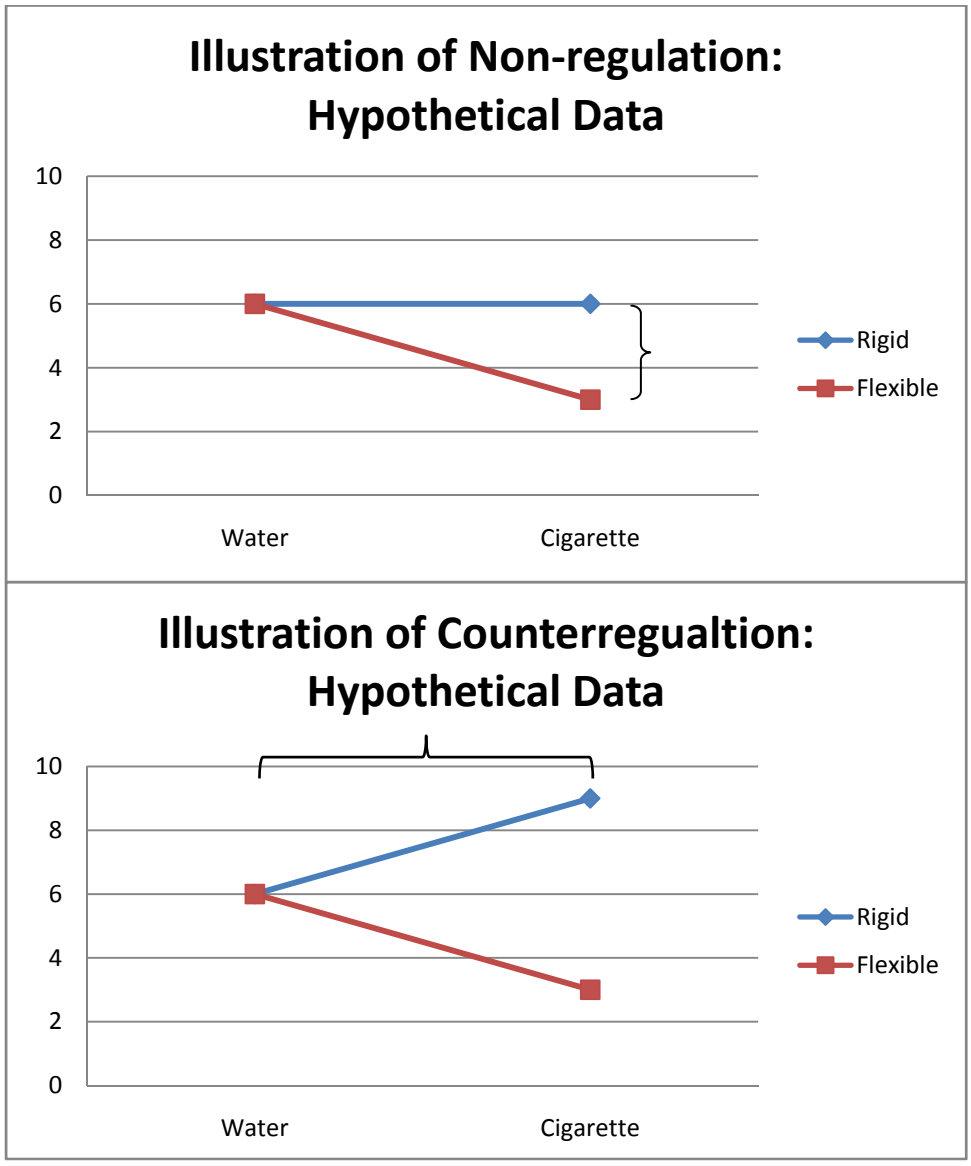
Basic Restraint = item11*(-**.08**) + item12*(-**.01**) + item13***.05** + item14***.13** + item2***.30** + item4***.21** + item1***.22** + item6***.17** + item5***.16** + item3***.15** + item7***.14**

Balanced Consumption = item11***.50** + item12***.28** + item13***.13** + item14***.12** + item2***.04** + item4***.01** + item1***.02** + item6***.02** + item5*(-**.01**) + item3*(-**.01**) + item2***.06**

APPENDIX H

ILLUSTRATION OF NON-REGULATION AND COUNTERREGULATION USING HYPOTHETICAL DATA

Figure 12. Rigidly restrained participants were expected to demonstrate counterregulation following the cigarette preload, although some data suggest that non-regulation is more likely.



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