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**Odor experience as an affective state: Effects of odor
pleasantness on creativity**

Bastone, Linda M., Ph.D.

City University of New York, 1992

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ODOR EXPERIENCE AS AN AFFECTIVE STATE:
EFFECTS OF ODOR PLEASANTNESS ON CREATIVITY

by

LINDA M. BASTONE

A dissertation submitted to the Graduate Faculty in
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Abstract

ODOR EXPERIENCE AS AN AFFECTIVE STATE:
EFFECTS OF ODOR PLEASANTNESS ON CREATIVITY

by

Linda M. Bastone

Advisor: Professor Howard Ehrlichman

A substantial body of research supports the claim that mild affective states influence a variety of cognitive and behavioral variables. Still, it is not clear whether these effects should be attributed to the affective states themselves or to the cognitions associated with these states. In order to examine the influence of affective feelings on creativity, pleasant and unpleasant odors were used to induce affect while minimizing associated cognitive involvement.

Ninety subjects (45 men, 45 women) completed practice versions of two putative measures of creativity (the Remote Associates Test [RAT] and the Alternate Uses Test) and a non-creative, cognitive task (digit deletion) and then worked on the tasks in the presence of either a pleasant odor, an unpleasant odor, or odorless air.

The results provided only limited support for the main experimental hypothesis. As predicted, the unpleasant odor group provided fewer alternate uses on average than both the

pleasant and the no-odor groups and the groups did not differ in their performance on the digit deletion task. Contrary to prediction, the odor groups did not differ in their performance on the RAT. Therefore, the Alternate Uses results cannot be interpreted more broadly as an effect of odor pleasantness on creativity.

The failure to obtain odor effects on the RAT may be explained in part by the limited effects of the pleasant odor on mood. Differences in the cognitive requirements of the two creativity tasks might also have led to the inconsistent results. Coming up with one answer in response to a number of criteria (as in the RAT task) seems to require a more deliberate or controlled approach than does the Alternate Uses Test which requires the production of a variety of responses to satisfy only limited demands. As Ehrlichman and Bastone (1991) hypothesized, behavior on tasks that require controlled processes may not vary as a function of odor pleasantness whereas behavior on tasks that are more automatic may be influenced by odor experience. If this interpretation is correct, the results have important implications for understanding affect-cognition interactions.

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Joan and William Bastone.

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Introduction

The idea that affect can influence a variety of cognitive and behavioral variables has received a good deal of attention in recent years. In fact, Isen (1984) has defined feeling states (or moods) as "pervasive, global, generalized affective components or states that influence seemingly non-affect related events" (p. 185). In contrast to strong emotions, these feeling states do not interrupt thoughts, but subtly color and redirect them. Despite the growing body of research evidence which supports this claim, there are still questions regarding the precise mechanisms by which affective states influence cognitive and behavioral variables. Most important, it is not clear whether previously demonstrated effects should be attributed to affect *per se* or to the cognitions associated with affective states (e.g., thoughts about the self, thoughts about failure). As Ehrlichman and Halpern (1988) pointed out, it is a well-established research finding that cognitive material can prime related cognitions; therefore, if mood effects can be attributed to the mnemonic effects of affect-related cognitions, then they are not very instructive. This issue has been raised by several researchers as it pertains to observed effects of mood on memory (Blaney, 1986; Isen, 1984; Rholes, Riskind, & Lane, 1987). Similar considerations apply to observed effects of

mood on other cognitive and behavioral processes (e.g., evaluations, helping, and problem-solving).

One reason this question persists is that it is difficult, if not impossible, to tease apart the effects of affect from those of related cognitions because the procedures used to induce moods may also elicit specific cognitions. To separate out the influence of the affective feelings themselves, it would be useful to have a method of affect induction that minimizes related cognitions. While it may not be possible to induce affect totally devoid of associated cognitions, several theorists have proposed that affective experience can occur with minimal cognitive involvement (Hoffman, 1986; Livesey, 1986; Ortony, Clore, & Collins, 1988; Schachtel, 1959). According to these authors, those affective experiences with the simplest or lowest level of cognitive involvement include responses to physical or sensory aspects of stimuli. Thus, the feelings elicited by smelling pleasant and unpleasant odors could qualify as affective states with minimal cognitive involvement. Consistent with this view of odor experiences as affective states, recent studies have suggested that pleasant and unpleasant odor experiences can elicit cognitive and behavioral effects like those of more cognitively complex feeling states.

The purpose of the present research was to replicate and extend a study by Bastone and Ehrlichman (1991) in which

odors of different valence produced different levels of performance on a putative measure of creativity. The earlier experiment demonstrated that subjects who smelled a pleasant odor performed better than those who smelled an unpleasant odor on the Remote Associates Test (RAT; Mednick, Mednick, & Mednick, 1964). Replicating and extending the results to additional creativity tasks would provide important evidence that valenced (positive and negative) feeling states can produce affect-related alterations in ongoing cognitive processing even when such states are induced by minimally cognitive sensory experiences.

Before describing the present research, I will review the evidence for the claim that affect influences behavior and cognition. Then, I will discuss the factors that make it difficult to disentangle influences of affective feelings from those of associated cognitions. Next, I will argue that odor experiences may be useful in this respect, and lastly, I will review the evidence for the claim that odor experiences are sufficient to elicit changes in cognition and behavior similar to those demonstrated with more cognitively complex feeling states.

Evidence That Affect Influences Cognition and Behavior

A substantial body of research evidence suggests that one's affective state (and in particular, positive affect) facilitates recall of information congruent with that state (Blaney, 1986; Isen, Shalcker, Clark, & Karp, 1978; Nasby &

Yando, 1982; Teasdale & Fogarty, 1979, Teasdale & Russell, 1983). For example, when people are in a positive mood they tend to recall happier memories than when they are in a negative mood. The influence of affect on memory has been related to the concept of "accessibility" or "priming" (Wyer & Srull, 1981); affect has been hypothesized to function like a category name or other organizing unit as a cue to prime related cognitive material. When aroused, an affective state may selectively activate memories, themes, perceptual categories and thoughts that have been associated with it in the past (Bower, 1987).

Several theorists have proposed that by serving as retrieval cues for mood-congruent material in memory, affective states influence other cognitive processes including judgment, evaluation, expectations, problem-solving, and decision-making (Isen, 1984; Bower, 1981; 1987). Social behavior may also be influenced by mood. For example, studies using a variety of positive affect inductions (receiving cookies or a dime, experiencing success, reading elation statements, and being exposed to sunshine) provide convergent evidence that feeling good tends to make people more likely to help others (Adelman, 1972; Berkowitz & Connor, 1966; Cunningham, 1979; Isen, 1970; Isen & Levin, 1972; Weyant, 1978). The effects of negative mood on helping behavior are less straightforward; some studies have shown that negative affect results in

decreased helping, whereas others have demonstrated increased helping, or no effect (Berkowitz, 1987; Cialdini & Kenrick, 1976; Kidd & Marshall, 1982; Manucia, Baumann, & Cialdini, 1984; Weyant, 1978).

Isen (1984) proposed a cognitive explanation of the effects of mood on prosocial behavior: by activating pleasant thoughts, positive moods may cause people to interpret requests for help and those asking for help in a more favorable manner. To test whether mood effects on helping are mediated by the accessibility of such mood-congruent thoughts, Clark and Waddell (1983) had subjects free associate to a description of a situation in which helping was possible. The results supported Isen's explanation: there was a significant effect of mood on initial affective associations. Subjects in the positive affect condition provided a greater number of positive associations and were more likely to mention helping actions than subjects in either the negative or neutral conditions. In addition, subjects in the negative mood condition showed a non-significant tendency to provide more negative first affective associates than the positive or neutral affect groups.

Several studies have shown that moods may affect ratings of ambiguous stimuli in a manner congruent with current feelings. For example, Isen and Shalke (1982) demonstrated that subjects in whom negative affect was

induced via negative feedback on a test rated ambiguous scenes as significantly less pleasant than control subjects, whereas subjects who found a dime rated them as significantly more pleasant than controls. Kuykendall, Keating, and Wagaman (1988) demonstrated similar effects of both happy and sad moods induced by having subjects read self-referent statements on ratings of the pleasantness of neutral words.

Analogous effects have been obtained on judgments about the frequency or likelihood of positive and negative events. In a series of studies, Johnson and Tversky (1983) demonstrated that subjects who read a brief newspaper report of a tragic or sad event showed increases in their estimates of the frequency of risks and other undesirable events, regardless of the similarity between the news report and the event. Reading an account of a desirable event produced a similar global decrease in estimates of the frequency of risks and life problems. The authors argued that the mood induced by reading the news items resulted in judgments compatible with that state. Similar results were obtained in a field study conducted by Forgas and Moylan (1988). Subjects who had seen a happy film were significantly more optimistic about the likelihood of future events (nuclear war, improvements in personal fortune, and the economy) than those who had seen sad or aggressive films. Compared to pre-movie judgments, happy movies showed a strong effect on

ratings, whereas sad movies were relatively ineffective.

In addition to influencing cognitive content, there is evidence that affective states may influence cognitive organization. Isen and her colleagues (Isen, 1987; Isen et al., 1987) argued that by cuing positive material in memory, which has been shown to be more extensive and diverse than other material (e.g., Boucher & Osgood, 1969; Bousfield, 1950; Matlin & Stang, 1979), positive affect creates a complex cognitive context. If a more complex context is present when one is happy, material may be multiply encoded and multiply retrievable (Isen, 1987; Isen, Johnson, Mertz, & Robinson, 1985). Thus, thinking may be more flexible as a function of positive affect (Isen, 1990; Murray, Sujan, Hirt, & Sujan, 1990; Showers & Cantor, 1985).

Negative affect may also influence cognitive organization. Isen (1987; 1990) argued that because material related to sadness may be structured more specifically and kept in relative isolation from other thoughts, sad feelings may cue only a small range of thoughts very closely related to sadness or its cause. Similar claims have been made regarding the cognitive consequences of anxiety states. For example, Mueller (1978) argued that anxiety leads to more shallow processing of semantic material, thereby reducing the quality of elaborations and associative paths. Hoffman (1986) suggested that affect may play a role in determining which

sector of the environment -- foreground or background -- becomes the primary target of cognitive processing. The number of background experiences associated with a stimulus may tend to diminish with increased negative affect, although immediate associations may be unaffected. On the other hand, increases in positive affect should result in increased unusual (or less immediate) associations.

Several lines of research have explored the consequences of these hypothesized mood-induced changes in cognitive organization. For example, Isen et al. (1985) hypothesized that happy people would provide more unusual or diverse word associations than a neutral affect control group. Results of an experiment in which word association tasks were used to manipulate affect showed that after giving their associations to ten positive words, subjects provided more unusual responses to neutral stimulus words than control subjects. In contrast, responding to negative words had no effect on the unusualness of later word associations. This might be explained by the fact that a manipulation check (ratings of familiar and unfamiliar words) indicated that the task had not induced a negative mood.

In another experiment, Isen et al. (1985) examined the effects of comedy film and free-gift mood inductions on the associates subjects gave to either positive, negative or neutral prompt words. The results indicated that both

positive affect and positive words produced more unusual associates as compared to their comparison groups. The positive affect subjects gave significantly more uncommon associates than the control group to neutral (but not positive or negative) words and subjects in the neutral affect condition (but not those in the positive condition) gave more unusual associates to positive stimulus words than to neutral or negative words.

According to context theory, the cognitive context in which material appears may influence the interpretation of that material (Medin, 1983). Further, the specific items present in memory and their interpretation can influence the way in which the entire set of material is organized (e.g., Tversky & Gati, 1978). Thus, if positive and negative affect influence cognitive context, stimuli ought to be grouped differently as a function of affective valence. Isen and Daubman (1984) conducted a pilot study and three experiments to test this claim. The results indicated that positive affect, induced in each of three ways (refreshments, free gift, amusing film) led subjects to rate significantly more weak exemplars as category members than the control groups (no manipulation and neutral film). Positive affect subjects (free gift and humorous film inductions) also grouped stimuli (color chips) into larger units than did control subjects (neutral film manipulation). In a related study, Isen and Daubman (1986, as cited in

Isen, 1987) demonstrated that positive affect subjects sorted stimuli (aspects of their perceived selves) in more different ways than control subjects.

In two of their experiments, Isen and Daubman (1984) included a negative affect group (disturbing film manipulation). These subjects showed a nonsignificant tendency to rate weak exemplars as members of the categories and to group more colors together. These trends are not easily explained by available theory and do not seem to fit with previously observed results. Even if negative material is cued by negative affect, such material should not be as extensive as positive material and therefore should not require or promote increased chunking and broader organization. As the authors pointed out, given that only one type of negative affect induction was used, it is difficult to draw general conclusions from these results.

Murray et al. (1990) hypothesized that positive affect may lead to more general effects on categorization than those reported by Isen and Daubman (1984). They argued that the diversity and variety of cognitive associations resulting from positive affect ought to lead to more flexible categorization (i.e., the perception of relationships among concepts as well as distinctions between them). In their Study 1, a modified Velten procedure was used to induce positive, negative and neutral moods. Performance on a sorting task revealed that within the

positive mood condition only, the number of categories used to sort familiar television programs differed as a function of processing goal; subjects asked to focus on differences formed significantly more categories than subjects who were asked to focus on similarities or those who were given no processing goal. In keeping with Isen and Daubman's (1984) results, positive affect subjects did show a "natural" tendency to focus on similarities. That is, when given no processing goal, positive mood subjects formed significantly fewer categories than the neutral and the negative mood subjects.

Two additional experiments provided support for the claim that positive affect promotes cognitive flexibility (Murray et al., 1990). When given a specified amount of time to list similarities among and differences between two television shows, positive mood (Velten) subjects listed significantly more features, more distinct types of cues, and more unusual features than neutral mood subjects. A second study in which subjects were given unlimited time to list similarities and differences revealed no effect of mood (positive or neutral video clips) on the number of features listed. However, positive mood subjects provided significantly more distinct types of features, significantly more unusual features, and took less time to complete the tasks than did neutral mood subjects.

Positive affect has also been shown to influence decision making. Isen and Means (1983) found that subjects who had experienced success were more efficient than controls in their consideration of a large amount of information needed to perform a car choice task. The success group reached their decisions more quickly and were less likely to reconsider pieces of information than the control group. In a medical decision making study, Isen, Rosenzweig, and Young (in press) found that success subjects reached a tentative choice of a person most likely to have a target illness earlier in their protocols than did control (no manipulation) subjects. The success group also showed less confusion, evidence of a more integrative approach, and a tendency to go beyond the requirements of the task (e.g., to consider diagnoses or treatments for the other patients). Evidence from several experiments also suggested that people experiencing positive affect tend to adopt the simplest strategy, consider fewer alternatives and do little or no checking of information (Isen, Means, Patrick, & Nowicki, 1982).

Because Murray et al. (1990) included a negative affect condition in only one of their experiments, it is difficult to draw conclusions about the role of negative feeling states in categorization. In fact, anxiety states have been shown to lead to the rejection of weak exemplars from category membership (Mikulincer, Kedem, & Paz, 1990) and to

the production of more categories in a sorting task (Mikulincer, Paz, & Kedem, 1990). Anxiety appears to hinder one's ability to see alternate dimensions along which to categorize stimuli. Nonetheless, it is not clear whether other negative feeling states would result in similar effects.

The process of bringing together apparently disparate material in a useful but unaccustomed way is central to several conceptualizations of the creative process (e.g., Mednick, 1962; Koestler, 1964). In this sense, the effects of positive affect on categorization and unusualness of word associations could be construed as effects on creativity. Isen, Daubman and Nowicki (1987) conducted a pilot study and three experiments to test more directly the relationship between positive affect and creative problem solving. In two experiments, subjects who viewed an amusing film performed better than a neutral film group on the Duncker (1945) candle task. Similar results were obtained in two experiments which examined effects of positive affect on performance on the Remote Associates Test (RAT), a measure designed to assess individual differences in creativity (Mednick, et al., 1964). A strengthened gift manipulation and a comedy film induction resulted in significantly more correct answers to moderately difficult RAT items than control (and arousal) manipulations. Further, in an experiment with children, Greene and Noice (1988)

demonstrated that subjects who received compliments and gifts produced more atypical category exemplars and were more likely to solve the Duncker candle task than control subjects.

The results of these experiments suggest that creativity, which is usually thought of as a stable characteristic of people, can be facilitated by transient pleasant affective states. Because Isen et al. (1987) included a negative affect condition in only one experiment and manipulated it in only one way (disturbing film) the effects of negative feeling states on creative problem solving are less straightforward. In fact, these researchers concluded that negative affect may not have significantly impaired performance on the Duncker candle task because even in the absence of any affect induction, very few subjects in the pilot study were successful. More recently, Isen (1990) reported that negative moods induced by tense music and reading statements reflecting anger or anxiety did not affect performance on the RAT. However, preliminary results of another study suggested that reading negative self-statements may impair performance on this task.

There is evidence that at least some negative affect states lead to narrowed attention or reduced cue utilization (Bruner, Matter, & Papanek, 1955; Easterbrook, 1959; Erikson, 1954; Sarason, 1956). For example, in a helping

study conducted by Isen (1970), positive affect (success) and negative affect (failure) subjects differed in the amount of information they could recall about what had happened when a confederate was in the room. In a second study, the failure group showed significantly lower recall about an encounter with a confederate even though they were offered a monetary incentive.

Easterbrook (1959) concluded that the number of cues utilized in any situation tends to get smaller with an increase in negative emotion or arousal. However, not all cues seem to be neglected equally; background cues are most likely to be neglected. This reduction in the range of incidental cue utilization may hurt performance when tasks require a wide range of cues, but may enhance performance on tasks that require undivided attention to central cues. Negative affect may also result in behavioral rigidity; people might be less likely to change to a new direction because they pay less attention to information that is not directly related to ongoing activities (Mathews & Canon, 1975).

Mueller (1979) suggested that anxiety directs one's attention to physical features of words (acoustic properties, order of presentation, phonetic similarities) and that this occurs to the relative neglect of semantic content. If so, one could argue that negative affect ought to lead to effects opposite to those of positive affect on

creativity tasks, and in particular, tasks that require the processing of semantic information. There is some evidence that this is the case. Matthews (1986) found that mood (displeasure) showed a stronger deleterious effect than did arousal on tests of verbal flexibility and originality. Given these results, Isen and her colleagues failure to demonstrate consistent effects of negative moods on RAT performance is surprising.

The Role of Affective Feelings Versus Affect-Related Cognitions in Observed Mood Effects

As stated above, because induced moods may also elicit specific cognitions, it is unclear whether the previously demonstrated effects on cognitive and behavioral variables should be attributed to affective feelings themselves or to the cognitions associated with such feelings. In some respects, all of the manipulations used in the studies described above share certain elements, apart from their influence on mood, that could account for their effects on cognition and behavior. In addition to their manipulation of thoughts, many of the induction procedures are verbal in nature and tend to invoke a self-referenced cognitive set. However, mood manipulations may differ in the extent to which they directly manipulate cognitions. According to Isen (1984), hypnotic inductions, the Velten procedure, and recalling events directly manipulate cognition, whereas procedures such as success experiences and facial posturing

only indirectly manipulate cognition. Musical inductions could also be added to the latter list (Blaney, 1986). Certainly, when researchers manipulate affect by having people think about certain ideas, observed effects on cognition are not very surprising. Nonetheless, even more "indirect" manipulations may be problematic in this respect.

For example, it could be argued that the thoughts associated with the mood manipulation used by Clark and Waddell (1983) and Isen and Shalcker (1982; receiving positive or negative feedback on a test) were responsible for effects on thoughts about helping and ratings of ambiguous scenes. In addition, Johnson and Tversky (1983) suggested that their demonstration of a global pessimism effect as a result of reading stories (as opposed to a specific effect on risks directly related to story content) argues against a cognitive priming interpretation. However, it is conceivable that the stories elicited thoughts such as "the world is a dangerous place," which resulted in the observed effects on judgments. Unfortunately, the data do not lend themselves to an explicit test of this distinction.

Similarly, Isen et al.'s (1985) finding that a positive word association task led to more unusual word associations could be explained without recourse to mood at all; the cognitive material itself (the positive prompt words) may have directly primed related material in memory. In fact, the finding that positive stimulus words resulted in more

unique associates than neutral stimulus words supports this interpretation. It is also possible that the mood inductions that involved more indirect manipulations of cognition (refreshments, comedy film and free gift) resulted in more unusual associational patterns because the cognitions associated with the induced feeling states cued a broader range of associations. In other words, each of the induction procedures may have increased the amount of material or diversity of that material in memory because it directly or indirectly manipulated cognitive components of positive affect. Isen et al.'s (1985) failure to obtain an effect of the negative word association manipulation may be due to the fact that the associates to negative words do not tend to be negative (Cramer, 1968; Pollio, 1964) and therefore, are not likely to invoke negative cognitions.

Unfortunately, the majority of the research that has examined the relationship between negative affect and cognitive organization has focused on effects of one type of state, variably labeled as anxiety or arousal. Further, there has been little attempt to tease apart effects that can be attributed to mood *per se* from those due to related cognitions. In fact, observed effects on task performance are typically attributed to the cognitions that occur during anxious states. For example, several theorists (e.g., Sarason, 1972; Wine, 1971) have proposed that anxiety induces a general attentional deficit as people divert

attention toward self-deprecating thoughts. These negative self-referenced thoughts are believed to be responsible for deleterious effects on task performance.

Odor Experience and Affect

As noted above, the idea that odors may directly generate affect is in keeping with claims made by theorists such as Hoffman (1986) and Livesey (1986). Olfactory experience has often been linked to affect (e.g., Engen, 1982). This linkage seems to rest on several foundations (see Ehrlichman & Bastone, in press). For example, the most salient aspect of people's reactions to odors is liking versus disliking and numerous studies have demonstrated the saturation of odor experience with hedonic tone (e.g., Wright & Michaels, 1964; Yoshida, 1979). There is also evidence that pleasant odors can enhance and unpleasant odors can depress mood.

Baron (1990) found that subjects exposed to pleasant ambient scents (air fresheners) rated their affect as more pleasant and more positive than did subjects in a no-odor condition; however, the groups did not differ in their ratings of good versus bad feelings. On the other hand, Ehrlichman and Halpern (1988) reported that pleasant (mint, orange, almond, or chocolate) and unpleasant (pyridine) odor groups differed significantly from each other in their ratings of both good and bad mood; however, neither group differed significantly from the no-odor (water) group.

Analyses of ratings of Differential Emotions Scale (DES; Izard, 1972) items indicated that the unpleasant odor group reported feeling significantly more disgusted than both the pleasant and the no-odor groups. Rotton, Barry, Frey and Soler (1978) reported that subjects in two malodor conditions (butyric acid, ammonium sulfide) experienced a more negative mood as indicated by a number of Mood Adjective Checklist (MACL) scales (higher scores on aggression, anxiety, fatigue, sadness; lower scores on elation, concentration, affection) and reported feeling less comfortable and pleasant than subjects in a no-odor condition. Similarly, Rotton (1983) found that subjects exposed to a malodor felt significantly less pleasant, less aroused and less dominant than did subjects in a no-odor condition.

Taken together, these studies indicate that the hedonic quality of odors can influence subjects' self-reported affect. However, Cann and Ross (1989) found no differences in self-reported mood (MACL and rating scales) between subjects who sat in a room permeated with either an unpleasant odor, a pleasant odor, or no odor. The most consistent effects appear to be on general scales such as pleasant/unpleasant or good/bad mood. Nonetheless, the effects of pleasant and unpleasant odors on mood may not be symmetrical. In a series of experiments, Bastone and Ehrlichman (1991) demonstrated consistent effects of

negative odors on self-reported mood and only limited effects of pleasant odors. In two experiments in which a between-subjects design was used, repeated measures analyses of variance indicated that pleasant odors (almond and lily of the valley) did not result in significant changes in mood ratings. Unpleasant odors (thiophene and butyric acid) did lead to increased negative affect, and in particular, to changes in subjects' ratings of how pleased-annoyed they felt. A third experiment, employing a within-subjects design, obtained similar results: subjects' ratings of how pleased-annoyed they felt indicated that mood worsened significantly following exposure to the unpleasant odor (thiophene) but did not improve significantly following exposure to the pleasant odor (almond).

In part, these findings may be due to the fact that in general, participants entered the experimental situations in good moods. The failure of the pleasant odor experience to significantly enhance this state may reflect something like a ceiling effect. Nonetheless, this apparent asymmetry in odor may be useful in terms of understanding the more general relationship between positive and negative affective reactions, particularly in light of the fact that it has not been observed with other mood induction techniques. In fact, other procedures have tended to show the opposite, namely, that positive moods are more easily induced in the laboratory.

Odor Effects on Cognition and Behavior

The ability of odors to produce affective states with minimal cognitive involvement makes them of particular relevance to the present discussion. A number of recent studies provide evidence that odor experiences are sufficient to elicit the kinds of changes that have been demonstrated with more cognitively complex affect manipulations. For example, Ehrlichman and Halpern (1988) demonstrated that pleasant and unpleasant odor experiences biased memories toward hedonically congruent content. Women in the pleasant odor (almond) condition recalled significantly more happy memories to neutral cue words than those in the unpleasant odor (pyridine) condition. The two odor groups also differed in their mean ratings of how happy or unhappy the experiences were at the time they occurred. However, neither group differed significantly from the no-odor controls.

Several researchers have explored the possibility that odor experience can lead to evaluations that are congruent with odor valence. In a series of experiments, Baron (1981; 1983; 1986) examined whether pleasant odors would elicit positive evaluations of other people. Support was obtained for the hypothesis that perfume may affect others' impressions of the wearer. However, reactions were not uniformly positive and were also influenced by other aspects of the social situation. Rotton et al. (1978) found that

compared to no odor, malodors (butyric acid and ammonium sulfide) reduced attraction toward both similar and dissimilar strangers, but only when subjects were told that the stranger was not experiencing the unpleasant odor. In addition, Rotton, Frey, Barry, Milligan, and Fitzpatrick (1979) demonstrated that a moderately unpleasant odor (ethyl mercaptan) produced more aggression (shocking a confederate) than an extremely unpleasant odor (ammonium sulfide) only when men were not provided with an aggressive model.

Rotton (1983) had subjects evaluate paintings, people in photographs, and descriptions of people in the presence of an unpleasant odor (ethyl mercaptan) or no odor. Subjects in the malodor condition judged paintings as less professional and worthy, and gave significantly lower ratings of the well-being of the photographed individuals than did the control group. The malodor group also rated moderately favorable descriptions of others as significantly less likable than the no-odor group; however, malodor did not affect ratings of highly favorable, highly unfavorable, or moderately unfavorable descriptions. In contrast, Cann and Ross (1989) found that men's ratings of the attractiveness of women pictured on slides did not differ across pleasant odor (spray cologne), unpleasant odor (ammonium sulfide), or no-odor conditions. The authors reasoned that the failure of the odors to induce a change in mood (as evidenced by self-reports) was responsible for the

absence of an effect on attractiveness ratings. However, the fact that the slides were chosen to represent relatively attractive and unattractive women may have biased the results against their hypothesis. There is evidence that affective states can influence responses to ambiguous or neutral stimuli but not to clearly positive or negative stimuli (Bower, 1981; Isen & Shalker, 1982; Kuykendall et al., 1988). Therefore, it is unlikely that the experience of an odor (even if accompanied by a change in mood) would significantly affect one's ratings of relatively unambiguous stimuli.

When Bastone and Ehrlichman (1991) had subjects evaluate relatively neutral stimuli, no effects of odor valence were obtained on ratings of physical attractiveness of faces. However, field dependent (but not field independent) subjects' ratings of the personalities of people in photographs and their ratings of words varied as a function of odor valence. That is, when field-dependent subjects smelled a pleasant odor (almond) their personality and word ratings were more positive than when they smelled an unpleasant odor (thiophene). While the findings raise interesting questions regarding possible individual differences in the extent to which affective experiences may influence cognitive processes, this issue is beyond the scope of the present paper.

Odor experience may also affect performance. In a study of work-related task performance, Baron (1990) had subjects in a pleasant odor condition smell five pleasant fragrances before working in the presence of a pleasant odor; subjects in a neutral condition smelled five neutral scents prior to performing the tasks in an unscented room. Results indicated that subjects in the pleasant odor group set higher goals and were more likely to employ an efficient strategy than control subjects. In addition, Warm, Dember, and Parasuraman (1991) found that two pleasant odors (lily of the valley and peppermint) enhanced performance on a visual sustained attention task. However, contrary to their predictions, the odors did not affect self-reported stress and workload. Unpleasant odor experiences may also influence performance. Rotton (1983) demonstrated that subjects exposed to a malodor performed significantly worse than subjects who were not exposed to an odor on a complex (proofreading) task but not a simple (arithmetic) task.

In addition, Bastone and Ehrlichman (1991) found that pleasant and unpleasant odor groups differed significantly in their performance on items from the Remote Associates Test (RAT), but that neither group differed significantly from the no-odor group. Further analyses indicated that the pleasant odor group performed significantly better on the seven moderately difficult items than the unpleasant odor group; the no-odor group mean fell between but did not

differ significantly from either of the odor group means. In contrast, the odor groups did not differ significantly in their performance on the seven easy RAT items. These results parallel those of Isen et al. (1987; Studies 3 and 4) in which positive affect manipulations (candy and comedy film) resulted in improved performance relative to control subjects on the moderately difficult RAT items.

The recent studies by Baron (1990), Rotton (1983), Ehrlichman and Halpern (1988) and Bastone and Ehrlichman (1991) are all consistent with the idea that odor experiences can influence cognition and behavior in ways similar to affective states. However, in contrast to the observed effects on memory recall, task performance, and creative problem solving, effects of pleasant and unpleasant odor experiences in other domains (evaluations, thoughts about helping, aggression, and frequency/likelihood judgments) have been absent or less consistent. For example, Bastone and Ehrlichman (1991) failed to obtain differences between pleasant (almond or lily of the valley), unpleasant (thiophene or butyric acid), and no-odor groups in judgments about the frequency of risks, the likelihood of positive and negative events, and the extent to which associations to vignettes included references to helping.

It is surprising that in the three experiments conducted by Bastone and Ehrlichman (1991) even the unpleasant odor experience, which resulted in marked changes

in mood, did not influence subjects' performance on tasks that were chosen specifically because previous research had demonstrated mood effects in these domains. The premise of this research program was that pleasant and unpleasant experiences produced by odors are sufficient to elicit cognitive effects similar to those found in studies of mood. However, it is possible that some mood effects reported in the literature are mediated by the positivity or negativity of the feeling state and that other effects require the presence of the cognitions that accompany a mood. Dember, Terezis, and Ricks (1990) offered a similar explanation to account for their failure to obtain effects of positive and negative musical inductions on optimism and pessimism. They argued that perhaps a more "directly cognitive" manipulation like the Velten technique might prove more effective in altering optimistic and pessimistic cognitions. This issue presents an interesting challenge for researchers who study the impact of affect on cognition.

The Present Research

The present research attempted to replicate and extend Bastone and Ehrlichman's (1991) finding that subjects who smelled a pleasant odor performed better on the Remote Associates Test (RAT) than subjects who smelled an unpleasant odor. The experiment also sought to obtain converging evidence that odor pleasantness influences creativity by including Christensen, Guilford, Merrifield,

and Wilson's (1960) Alternate Uses Test in addition to the RAT. To obtain discriminant validity, subjects completed a cognitive, but non-creative, task (digit deletion). Because performance on the digit deletion task was assumed to be susceptible to demand characteristics, it was included to determine whether such processes underlie effects on creative task performance.

It is possible that Bastone and Ehrlichman's (1991) failure to obtain significant differences in RAT performance between each of the odor groups and the control group could be due to a lack of statistical power. Therefore, a larger sample size than that of the previous experiment was used in the present study. To further increase power to detect treatment effects, subjects completed pretest versions of each of the experimental tasks. Including these scores in analysis of covariance (ANCOVA) procedures was assumed to reduce error variance by controlling for systematic individual differences in each of the dependent variables (Maxwell, Cole, Arvey, & Salas, 1991).

The experimental hypotheses were as follows: 1. subjects in the pleasant odor group were expected to correctly answer more RAT items than those in the unpleasant odor group, with the neutral odor group mean falling between; 2. subjects in the pleasant odor group were expected to provide more alternate uses than those in the unpleasant odor group, with the neutral odor group mean

falling between; and 3. the three experimental groups were not expected to differ in their performance on the digit deletion task.

Method

Subjects

A total of 101 subjects (53 men, 48 women), recruited through signs placed in local colleges, participated in a one-hour experimental session. All subjects were paid \$20 for their participation. Because the Remote Associates Test was developed to be used with native English speakers, participant recruitment was limited to native speakers of English. Subjects were randomly assigned to one of the three odor conditions: pleasant, unpleasant, and no odor. Seven subjects' data were excluded from statistical analyses because the manipulation check (ratings of odor pleasantness-unpleasantness) revealed that they did not experience the odor in accordance with its assumed valence (i.e., 3 women and 2 men rated the pleasant odor as neutral or unpleasant; 1 man rated the unpleasant odor as pleasant; and 1 man indicated that he smelled a strong odor in the odorless air). In addition, four subjects' data were excluded because there was evidence that these men did not understand the task requirements. These exclusions resulted in a sample of 90 subjects (45 men, 45 women), with equal numbers of men and women across odor groups.

Materials

The pleasant and unpleasant odors used in the experiment were lily of the valley (10% in Diethyl Phthalate [DEP]) and butyric acid (5% in DEP), respectively. Because

Bastone and Ehrlichman's (1991) pilot testing revealed that participants did not consistently rate "neutral" odorants as neutral (neither pleasant nor unpleasant) in this type of situation, a no-odor control condition was used in the present experiment. It was assumed that by using unscented air, subjects in the control condition would be less likely to actually experience pleasant or unpleasant odors.

At the beginning and at the end of the experimental session, all participants were asked if the air they were exposed to had any smell. If they respond yes, they were asked to rate the intensity of the odor on a scale anchored by 1 ("extremely weak") and 9 ("extremely strong"), and odor pleasantness on a scale ranging from -10 ("extremely unpleasant") to +10 ("extremely pleasant").

To examine the effects of odor pleasantness on mood, four bipolar mood scales were embedded in a nine-item questionnaire on which subjects were asked to describe their "current state." The mood scales were selected to reflect both the arousal and pleasure-displeasure components of affect ("sleepy-alert," "pleased-annoyed," "depressed-excited," and "tense-relaxed"). To describe their current state, respondents placed a pencil mark on each line anchored by the bipolar descriptors. Scores for each scale ranged from 0 to 14, corresponding to the number of centimeters the pencil mark was from the left anchor. Participants completed this questionnaire four times: at the

start of the experimental procedures, just prior to the presentation of the odor, immediately following odor presentation, and after completing all tasks.

Before any experimental manipulation of affect, the subject was given "practice" versions of each of the tasks to be performed later in the presence of an odor or unscented air. The RAT items included the seven moderately difficult items used in the earlier experiment (taken from Isen et al., 1987) and seven items of moderate difficulty based on a pilot test conducted by Bastone and Ehrlichman (1991). These fourteen items were randomly designated as practice or experimental items. RAT items appeared on separate pages in the packet and subjects were given one minute to complete each item.

Subjects also worked on another measure of creativity, the Alternate Uses Test (Christensen et al., 1960). Again, items were randomly designated as either "practice" or experimental items. Both the practice and the experimental tasks included five objects and their common uses (e.g., box [commonly used for storage]). Subjects were told to list as many interesting and unusual uses for each object as they could think of. Subjects were given one minute to list uses for each of the objects.

Lastly, during both the practice and experimental parts of the session, subjects completed five one-page digit deletion tasks. They were given a sheet of random numbers

and told to cross off as many of the target digits as possible in one minute. After one minute, subjects were told to go on to the next page. The target digits used were: 8, 3, 1, 7, and 4 for each of the five pages used in the practice and experimental portions of the study (Knasko, Gilbert, & Sabini, 1990).

Procedure

Advertisements described the study as an examination of the effects of "environmental stimuli" on task performance. When potential subjects called to find out about the experiment, the researcher told them: "I am studying the effects of environmental stimuli on task performance. In this experiment, I am focusing on the effects of odors on performance on different types of cognitive tasks. To test whether odor experience has any effect on task performance, I will compare the performance of people who smell an odor while working with the performance of those who do not smell an odor while working. You will either smell one odor or breathe unscented air while you take several short written tests. In order to obtain a general understanding of the effects of odors on task performance, we are using several different odors (ranging from pleasant to unpleasant) in this study. I cannot tell you which odor (if any) you would be asked to smell because the choice is made randomly when a participant arrives at the lab. None of the odors are harmful and all have been used in research of this type

before. Nonetheless, if you think you would not be willing to smell an odor (which may be unpleasant) for a total of approximately 20 minutes (with intermittent breaks), then I would suggest that you not participate in this experiment."

When a subject arrived at the laboratory, the cover story was reiterated. In an attempt to limit the effects of prior expectations about odor effects, the experimenter emphasized that available research presents a conflicted view of the effects of odors on performance: whereas some studies shows that smelling an odor may hinder performance, other research indicates that odors can lead to improved performance, and still other research suggests that odors have no effect on performance. The experimenter emphasized that the subject should try to do his or her best on each of the tasks.

The experimenter briefly described the procedures to be followed. The subject was told that he or she would complete practice versions of the three tasks and then work on them in the presence of either a pleasant odor, an unpleasant odor, or odorless air. The experimenter explained that the subject's data would be treated anonymously and that he or she was free to withdraw at any time during the session without forfeiting the payment. This information was also included on the consent form the subject read and signed prior to the start of the session.

After the subject's written consent was obtained, he or she was seated in an adjoining room. Each subject wore a telephone operator's headset to which a teflon tube was attached so that its end could be positioned directly under the center of the nose, approximately one inch from the skin. Once the tube was in position, the experimenter left the room. In the adjoining room, the experimenter determined the subject's assignment to odor condition by noting the placement of the second hand on a clock (i.e., when the hand was between the 12 and the 4, the subject received the pleasant odor, when the hand was between the 4 and the 8, odorless air was presented, and when the hand was between the 8 and the 12, the subject received the unpleasant odor). After leaving the experimental chamber, the experimenter had no further contact with the subject; all instructions were given via an audio tape. A microphone and speaker set up in each room allowed the subject to speak to the experimenter in the event that he or she had a question or wished to withdraw from the experiment.

The subject completed the baseline current state rating sheet and then the "practice" portion of the session began. The experimenter explained that by giving the participant some practice with the experimental tasks, his or her performance ought to be more like it would be in a real-world (e.g., work) setting, where people are rarely asked to perform a task with which they are totally unfamiliar.

Further, in an attempt to equate subjects' expectations about their performance across experimental conditions, each participant was told that, as with any task, performance should improve following the practice session.

Because the main purpose of the experiment was to replicate Bastone and Ehrlichman's (1991) observed effects of odor on the Remote Associates Test (RAT), all subjects completed this test first in both the practice and experimental portions of the session. Each subject worked on the seven moderately difficult RAT items, the five alternate uses items, and then the five digit deletion pages. Prior to each task, the experimenter read a standard set of instructions aloud as the subject followed along on a cover sheet.

After the subject completed the three practice tasks, the odor or odorless air was presented. The experimenter controlled the presentation of the air from the adjoining room. An aquarium pump moved room air first through an activated charcoal filter and then directly to the tube for the no-odor condition, or to a glass jar containing odorant-saturated interflo pellets and then to the participant. An electronic timer controlled a three-way valve so that odors were presented intermittently (i.e, five seconds of odorant followed by five seconds of odorless air) to reduce habituation.

Approximately ten seconds after smelling the air, the subject rated the intensity and hedonic quality of the smell if he or she perceived one, and then completed the second current state sheet. Next, the three experimental tasks were presented in the same order as in the practice segment: the subject completed seven RAT items, five Alternate Uses Test items, and five one-minute digit deletions. Again, the instructions for each task were read to the subject as he or she followed along on the cover sheet. After completing the tasks, the subject filled out the current state rating sheet and rated the intensity and hedonic quality of the odor. Then, the subject left the experimental chamber and the experimenter conducted an interview to assess his or her beliefs about the purpose of the experiment. The experimenter asked whether at any point the subject thought the odor may have affected his or her performance and if so, in what way. In addition, the subject was asked whether he or she believed that other people's performance might be affected by the odor and if so, in what way. Before leaving, the subject was fully debriefed, asked not to discuss the research with other potential subjects, and paid for participating.

Results

Manipulation Checks

Preliminary analyses examined whether the odor manipulation was successful.

Odor ratings. The first question asked was whether the odors were experienced as intended. Namely, the pleasant odor was expected to be experienced as significantly more pleasant, and the unpleasant odor as significantly more unpleasant, than the odorless air. Further, the pleasant and unpleasant odor groups' ratings of odor intensity were not expected to be significantly different from one another. Mean hedonic and intensity ratings for each of the odor groups are displayed in Table 1. As expected, analyses of variance (ANOVAS) revealed that the groups differed in their hedonic ratings both at the start (approximately 1 minute after presentation, $F(2,87) = 163.05, p < .0001$) and the end (approximately 20 minutes after presentation, $F(2,87) = 151.84, p < .0001$) of the experimental portion of the session. Tukey analyses revealed that the pleasant odor group rated the air as significantly more pleasant and the unpleasant odor group rated the air as significantly more unpleasant than the no-odor group at both rating points.

The groups also differed significantly in their initial intensity ratings, $F(2,87) = 76.71, p < .0001$ and their later intensity ratings, $F(2,87) = 78.35, p < .0001$. Tukey analyses of the first rating revealed that the unpleasant odor group

Table 1

Mean Hedonic and Intensity Ratings for the Odor Groups

Odor Group ^c		Odor Ratings			
		Hedonic ^a		Intensity ^b	
		Time 1	Time 2	Time 1	Time 2
Pleasant	<u>M</u> (<u>SD</u>)	5.17 (2.32)	4.83 (2.96)	5.50 (1.64)	5.27 (2.20)
No Odor	<u>M</u> (<u>SD</u>)	-0.93 (2.75)	0.67 (0.91)	1.53 (2.10)	0.37 (0.77)
Unpleasant	<u>M</u> (<u>SD</u>)	-6.87 (2.65)	-6.30 (2.98)	6.90 (1.42)	5.83 (2.23)

^aScale values ranged from -10 ("extremely unpleasant") to +10 ("extremely pleasant").

^bScale values ranged from 1 ("extremely weak") to 9 ("extremely strong").

^cn = 30 for each group.

rated the air as significantly more intense than the pleasant odor group which rated the air as significantly more intense than the no-odor group. At the end of the session, both the pleasant and the unpleasant odor groups' mean intensity ratings were significantly higher than that of the control group but did not differ from each other.

Correlated t-tests examined whether each group's initial ratings of the air differed from that group's ratings at the end of the session. Analyses revealed no significant changes in rated hedonic quality of the air for any of the experimental groups. However, as the means in Table 1 indicate, in general, ratings moved toward neutrality. The pleasant odor group showed no significant change in their ratings of the intensity of the odor from time 1 to time 2. In contrast, the unpleasant odor group rated the odor significantly less intense at the end as compared to the beginning of the odor segment, $t(29) = 2.39$, $p = .02$. The no-odor group also rated the air as less intense at the end as compared to the start of the odor segment, $t(29) = 3.55$, $p = .001$. This finding is in keeping with the experiences reported by a number of control subjects after the session: at first they experienced what they thought was a slight scent in the odorless air but by the end of the session could detect nothing.

Mood effects. Although it was not the primary focus of this research, an important question underlying the

hypothesized effects of odor experiences on creativity is the extent to which odors produce changes in affective states. In this respect, analyses of mood ratings served as a further check on the odor manipulation. In addition, because it is not clear that changes in self-reported affective states are necessary in order to demonstrate effects of odor, the analyses were included to determine whether the hypothesized odor effects could emerge in the absence of effects on self-reported mood.

The issue of odor effects on self-reported mood was addressed by asking two questions. The first question was whether the pleasant and unpleasant odors induced moods that differed from each other and from the no-odor (control) manipulation. ANOVAs tested whether the odor groups differed in their self-reported moods at baseline (the two mood rating times prior to the presentation of the odor) and at each of the two post-odor rating points (1 minute and 20 minutes after odor presentation). Group means for each of the five mood scales are presented in Table 2. As the table shows, there were no significant between-group differences in baseline ratings of mood (Practice 1 and Practice 2).

Significant group differences did emerge in the mood ratings obtained immediately after exposure to the air. ANOVAs revealed significant differences in the groups' ratings of: "pleased-annoyed," $F(2,84) = 4.05$, $p=.02$; "disgusted-delighted," $F(2,79) = 11.28$, $p<.0001$; and "tense-

Table 2

Mean Mood Ratings for the Odor Groups

Odor Group ^b		Mean Ratings ^a			
		Practice		Experimental	
		Time 1	Time 2	Time 1	Time 2
"Pleased-Annoyed"					
Pleasant	<u>M</u> (<u>SD</u>)	4.97 (2.94)	6.07 (2.93)	6.17 (2.96)	5.50 ⁺ (2.91)
No Odor	<u>M</u> (<u>SD</u>)	3.86 (2.37)	5.20 (2.30)	5.05 ⁺ (2.32)	5.16 ⁺ (2.15)
Unpleasant	<u>M</u> (<u>SD</u>)	4.56 (3.10)	5.64 (3.56)	7.25 ⁺⁺ (3.38)	7.72 ⁺⁺ (3.76)
"Disgusted-Delighted"					
Pleasant	<u>M</u> (<u>SD</u>)	7.87 (2.90)	8.08 (2.84)	8.55 ⁺ (2.52)	8.59 ⁺ (2.40)
No Odor	<u>M</u> (<u>SD</u>)	9.19 (2.62)	8.74 (2.48)	8.98 ⁺ (2.79)	8.74 ⁺ (2.48)
Unpleasant	<u>M</u> (<u>SD</u>)	8.80 (2.12)	8.10 (3.01)	5.65 ⁺⁺ (3.19)	5.81 ⁺⁺ (3.29)
"Tense-Relaxed"					
Pleasant	<u>M</u> (<u>SD</u>)	8.56 (3.18)	7.48 (3.04)	8.77 ⁺ (3.20)	7.70 ⁺ (3.09)
No Odor	<u>M</u> (<u>SD</u>)	7.66 (2.71)	7.35 (3.23)	7.93 (3.22)	8.02 ⁺ (3.25)
Unpleasant	<u>M</u> (<u>SD</u>)	8.32 (3.55)	6.60 (3.44)	6.47 ⁺⁺ (3.54)	5.41 ⁺⁺ (3.32)

Table 2 cont.

Odor Group ^b		Mean Ratings ^a			
		Practice		Experimental	
		Time 1	Time 2	Time 1	Time 2
"Depressed-Excited"					
Pleasant	<u>M</u> (<u>SD</u>)	8.22 (2.09)	8.94 (2.59)	8.56 (2.86)	8.50 (2.33)
No Odor	<u>M</u> (<u>SD</u>)	8.10 (2.35)	8.48 (2.77)	8.88 (2.67)	8.13 (2.33)
Unpleasant	<u>M</u> (<u>SD</u>)	7.93 (2.84)	8.64 (2.92)	7.76 (2.44)	7.40 (2.47)
"Sleepy-Alert"					
Pleasant	<u>M</u> (<u>SD</u>)	9.40 (4.35)	9.36 (3.85)	8.88 (4.00)	7.08 (3.69)
No Odor	<u>M</u> (<u>SD</u>)	9.30 (3.73)	7.89 (3.97)	8.14 (3.76)	6.70 (4.31)
Unpleasant	<u>M</u> (<u>SD</u>)	9.19 (3.61)	8.42 (4.35)	9.05 (3.91)	8.07 (4.48)

Note: Within each time period, different superscripts denote scale means that differed significantly from each other at $p < .05$.

^aScale values ranged from 0 to 14, corresponding to the number of centimeters the pencil mark was from the left anchor. A score of 7 corresponds to a feeling at the midpoint between the two anchors.

^b $n = 30$ for each group.

relaxed," $F(2,82) = 3.61, p=.03$, at one minute after odor presentation (Experimental 1). Similarly, the groups differed significantly in their ratings of "pleased-annoyed," $F(2,85) = 6.28, p=.003$, "disgusted-delighted," $F(2,83) = 10.42, p=.0001$, and "tense-relaxed," $F(2,85) = 5.76, p=.005$, after 20 minutes of exposure (Experimental 2). As Table 2 indicates, Tukey analyses revealed that in all but one case (ratings of "pleased-annoyed" immediately following odor presentation), the pleasant and the unpleasant odor group means differed significantly in the expected direction. Comparisons also revealed that the unpleasant odor group differed significantly from the no-odor group in the expected direction on all of these ratings except the "tense-relaxed" rating obtained immediately after odor presentation. In contrast, the pleasant odor group and the no-odor group did not differ significantly on any of the post-odor mood ratings.

The second question regarding the effects of odor on self-reported mood asked whether pleasant and unpleasant odors induced moods that differed significantly from baseline (pre-odor) moods. Although this question is related to the first, it is important to examine separately because the pleasant and unpleasant odor groups could have differed in their self-reported mood without either group showing a significant change from baseline.

Repeated measures analyses of variance were conducted for each of the odor groups separately. For each mood item, the four ratings (Practice 1, Practice 2, Experimental 1, Experimental 2) were treated as a within-subjects factor. Analyses indicated that the unpleasant odor group's mood ratings differed significantly across the four rating times for "annoyed-pleased," (Wilks' lambda = 27.00, $p < .001$), "disgusted-delighted" (Wilks' lambda = 24.00, $p < .001$), and "tense-relaxed" (Wilks' lambda = 26.00, $p = .03$). The pleasant odor group showed significant changes in their ratings of how "tense-relaxed" they felt (Wilks' lambda = 25.00, $p = .03$) and how "sleepy-alert" they felt (Wilks' lambda = 25.00, $p = .002$). The only significant within-subjects effect for the no-odor group was in their ratings of how "sleepy-alert" they felt (Wilks' lambda = 25.00, $p = .02$).

Correlated t-tests were used to clarify these results. Analyses revealed that working on the practice tasks may have altered mood: the unpleasant odor group's ratings of "tense-relaxed," $t(25) = 2.95$, $p < .005$, and the control group's ratings of "pleased-annoyed," $t(27) = 2.60$, $p = .02$, and "sleepy-alert," $t(27) = 2.14$, $p < .05$, showed significant changes from the start to the end of the practice segment of the session (Practice 1 to Practice 2). As the means in Table 2 indicate, the pretests resulted in more tension for

the unpleasant odor group and more annoyance and sleepiness for the no-odor group.

Further analyses compared mood ratings obtained immediately prior to odor presentation to ratings obtained during odor presentation. The unpleasant odor group's ratings of "pleased-annoyed" at baseline (Practice 2) differed significantly from ratings one minute after odor presentation (Experimental 1; $t(29) = -3.02$, $p=.005$), and 20 minutes after presentation (Experimental 2; $t(29) = -3.20$, $p=.003$); this group reported that they felt more annoyed during odor exposure than prior to odor presentation. The unpleasant odor group also reported feeling significantly more disgusted at both rating times during exposure to the odor (Experimental 1, $t(27) = 3.22$, $p=.003$; Experimental 2, $t(27) = 3.43$, $p=.002$) than they felt immediately prior to exposure (Practice 2). They also reported feeling more tense during odor as compared to immediately prior to its presentation (Experimental 1, $t(28) = 2.54$, $p=.02$; Experimental 2, $t(28) = 3.06$, $p=.005$).

The pleasant odor group showed only one of the expected changes in self-reported mood following presentation of the odor. This group reported that they were significantly more relaxed immediately after exposure to the odor (Experimental 1) than they were immediately before presentation (Practice 2; $t(27) = -3.04$, $p=.005$); however, pre-odor ratings of this feeling state did not differ significantly from ratings

obtained at the end of the session (Experimental 2). Both the pleasant and no-odor groups reported feeling significantly more sleepy at the end of the session (Experimental 2) than immediately prior to odor presentation (Practice 2), $t(28) = 4.51$, $p < .001$, $t(27) = 2.44$, $p = .02$, respectively.

Effects of Odors on Creativity

Analyses of covariance (ANCOVAs) were used to test the experimental hypotheses; that is, that the odor groups would differ in their performance on the two indicators of creativity (the RAT and the Alternate Uses Test) but not in their performance on the digit deletion task.

The number of items answered correctly served as the measure of successful performance on the RAT and the number of uses listed served as the primary indicator of performance on the Alternate Uses Test. In addition, separate scores indexed the number of "common," "moderately unusual," and "unusual" uses provided by each subject. Lastly, for the digit deletion task the main measure of performance was how quickly the subject worked (i.e., the number of digits correctly deleted plus the number of target digits missed up to the point at which the subject stopped working). In addition, a measure of accuracy was computed as the proportion of digits missed. Separate scores were computed for the practice and experimental versions of each of the tasks.

The intercorrelations among the scores on the main dependent variables are displayed in Table 3; within-group correlations are also provided. As the table indicates, the practice task scores were not very highly correlated. In fact, the two creativity scores (the number of RAT items answered correctly and the number of uses listed) were only moderately correlated. Therefore, separate group comparisons were conducted for each of the dependent variables.

Table 3 also indicates that scores on the practice and experimental versions of the RAT were only significantly correlated for the unpleasant odor group. In contrast, practice and experimental scores on the Alternate Uses Test showed highly significant relationships within each of the experimental groups, ranging from .74 to .77. Digit deletion speed was also quite reliable, with correlations between the practice and experimental tasks ranging from .83 to .90. Scores on the accuracy measure were extremely consistent; all groups showing correlations between practice and experimental scores above .98.

Remote Associates Test. The mean number of correct responses on the RAT items for each odor condition are presented in Table 4. RAT means adjusted for the effect of the covariate (pretest RAT score) are also displayed in the table. The unequal within-group correlations between RAT practice and experimental scores suggested that the ANCOVA

Table 3

Intercorrelations Among Scores on Practice and Experimental Tasks

		Entire Sample (<u>N</u> = 90)							
		1	2	3	4	5	6	7	8
1. RAT									
Practice									
2. Uses									
Practice		.22*							
3. Speed									
Practice		-.13	.19						
4. Accuracy									
Practice		-.14	.03	.02					
5. RAT									
Exper		.49***	.19	.05	-.27**				
6. Uses									
Exper		.22*	.75***	.12	.20	.21*			
7. Speed									
Exper		-.03	.27**	.88***	.16	.07	.25*		
8. Accuracy									
Exper		-.15	.03	.10	.98***	-.25*	.20	.19	
Mean		3.73	14.33	57.92	.07	3.96	16.11	58.52	.06
(<u>SD</u>)		(1.69)	(5.24)	(10.95)	(.06)	(1.61)	(5.81)	(9.93)	(.05)

Table 3 cont.

		Pleasant Odor Group (<u>n</u> = 30)							
		1	2	3	4	5	6	7	8
1. RAT Practice									
2. Uses Practice		.26							
3. Speed Practice		.10	-.11						
4. Accuracy Practice		-.04	-.09	.06					
5. RAT Exper		.26	-.05	.11	-.03				
6. Uses Exper		.30	.74***	-.10	.01	.09			
7. Speed Exper		.08	-.02	.90***	.09	.10	-.09		
8. Accuracy Exper		-.02	-.13	.13	.98***	.00	.02	.07	
Mean (<u>SD</u>)		4.27 (1.44)	15.20 (5.38)	56.65 (10.64)	.05 (.03)	4.13 (1.48)	17.37 (6.33)	57.97 (10.09)	.05 (.03)

Table 3 cont.

		No-Odor Group (<u>n</u> = 30)							
		1	2	3	4	5	6	7	8
1.	RAT Practice								
2.	Uses Practice	.07							
3.	Speed Practice	-.41*	.41*						
4.	Accuracy Practice	-.23	.22	-.13					
5.	RAT Exper	.34	.10	-.02	-.53**				
6.	Uses Exper	.03	.77***	.25	.35	.01			
7.	Speed Exper	-.31	.55**	.83***	.15	-.13	.53**		
8.	Accuracy Exper	-.27	.25	-.04	.99***	-.51**	.36*	.18	
	Mean	3.20	14.37	58.09	.08	3.83	16.93	59.21	.08
	(<u>SD</u>)	(1.52)	(5.36)	(9.97)	(.09)	(1.68)	(6.02)	(8.79)	(.07)

Table 3 cont.

		Unpleasant Odor Group (<u>n</u> = 30)							
		1	2	3	4	5	6	7	8
1.	RAT Practice								
2.	Uses Practice	.30							
3.	Speed Practice	-.09	.32						
4.	Accuracy Practice	.08	-.18	.18					
5.	RAT Exper	.77***	.49**	.07	.01				
6.	Uses Exper	.38*	.74***	.37*	.14	.62***			
7.	Speed Exper	.10	.34	.90***	.26	.22	.45**		
8.	Accuracy Exper	.05	-.16	.25	.99***	.00	.16	.30	
Mean		3.73	13.43	59.02	.06	3.90	14.03	58.37	.06
(SD)		(1.95)	(4.99)	(12.35)	(.05)	(1.69)	(4.51)	(11.09)	(.05)

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 4

Mean RAT Scores for the Odor Groups

Odor Group		RAT Scores ^a		
		Practice	Experimental	Adjusted ^b
Entire Sample				
Pleasant (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	4.27 (1.44)	4.13 (1.48)	3.88 (2.50)
No Odor (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	3.20 (1.52)	3.83 (1.68)	4.09 (2.50)
Unpleasant (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	3.73 (1.95)	3.90 (1.69)	3.90 (2.46)
Sample Selected Based on Mean Hedonic Rating				
Pleasant (<u>n</u> =19)	<u>M</u> (<u>SD</u>)	4.26 (1.66)	4.11 (1.49)	3.88 (2.56)
No Odor (<u>n</u> =19)	<u>M</u> (<u>SD</u>)	3.58 (1.43)	3.63 (1.71)	3.78 (2.54)
Unpleasant (<u>n</u> =25)	<u>M</u> (<u>SD</u>)	3.72 (1.88)	3.76 (1.76)	3.83 (2.21)
Sample Selected Based on Change in "Pleased-Annoyed"				
Pleasant (<u>n</u> =14)	<u>M</u> (<u>SD</u>)	4.43 (1.65)	4.00 (1.62)	3.78 (2.61)
No Odor (<u>n</u> =15)	<u>M</u> (<u>SD</u>)	3.33 (1.40)	3.80 (1.78)	4.19 (2.57)
Unpleasant (<u>n</u> =15)	<u>M</u> (<u>SD</u>)	4.33 (1.84)	4.27 (1.71)	4.10 (2.51)

^aScores reflect the number of items answered correctly out of a possible seven.

^bAdjusted scores are the values of the experimental scores adjusted for the covariate (practice scores).

assumption of homogeneity of regression might not be met. To test the assumption, a multiple regression was used to examine the covariate by treatment interaction (Tabachnick & Fidell, 1989). The SPSS-PC MANOVA procedure yielded a non-significant interaction, indicating that the assumption was not violated¹.

To determine whether the earlier RAT effect was replicated in the present experiment, ANCOVA tested whether the pleasant and unpleasant odor groups differed significantly in their performance. The comparison of the number of RAT items answered correctly using the number of practice items answered correctly as a covariate revealed no significant group difference. Further comparisons of each of the odor groups' performance with that of the no-odor group were also not significant.

To explore the possibility that the hypothesized effects of odor would require fairly "strong" pleasant and unpleasant experiences, RAT scores for a subset of the sample (subjects who smelled the pleasant odor and rated it as at least "moderately pleasant" [an average rating of +5 or higher across the two hedonic rating scales], subjects who smelled the unpleasant odor and rated it as at least "moderately unpleasant" [an average rating of -5 or lower on the two hedonic rating scales], and subjects who smelled no

¹Tests of homogeneity of regression were performed prior to conducting all ANCOVAs described below. Unless otherwise noted, the assumption was met.

odor and whose average hedonic rating was "neutral" [a mean of 0 on the two hedonic scales]) were analyzed as above. Again, ANCOVAs revealed no between group differences in performance on the RAT items. Mean RAT scores for the selected sample are displayed in Table 4.

It is also possible that the effects of odor might be limited to those situations in which the individual experienced a significant change in mood. To explore this possibility, a mood change score was computed by subtracting a subject's average rating of how "pleased-annoyed" he or she felt during odor (one minute and 20 minutes after odor presentation) from his or her rating of "pleased-annoyed" immediately prior to odor presentation. Given that higher scores on this scale signified more annoyance and lower scores signified more pleasure, a positive change score denotes a change toward a more pleased state following odor presentation and a negative change score indicates a change toward a more annoyed state after odor. The "pleased-annoyed" mood item was used because it is closest to the affective feeling that odors were assumed to influence. In addition, odor experiences similar to those in the present study have been shown to most consistently influence this aspect of one's feeling state (Bastone & Ehrlichman, 1991).

The mood change score was significantly correlated with the mean hedonic rating, $r(90) = .28$, $p = .01$. However, the within-group correlations were quite varied and did not

reach conventional levels of significance, pleasant $r(30) = -.21$; no-odor $r(30) = -.04$; unpleasant $r(30) = .21$.

Unlike average hedonic rating, the mood change variable could not be used to determine a value at which subjects could be said to have experienced at least a "moderate" change in their feelings. Therefore, this variable was used to select out those individuals for whom the odor had the strongest effects on mood. Subjects in the pleasant odor group who scored in the top half of the distribution of mood change scores, subjects in the unpleasant odor group who scored in the bottom half of the distribution, and the half of the subjects in the no-odor group who showed the least change were included in the selected sample. Mean RAT scores for this selected sample are also displayed in Table 4. Once again, ANCOVAs revealed no between group differences in performance on the RAT items.

These results represent a failure to replicate the effect demonstrated by Bastone and Ehrlichman (1991); the main experimental hypothesis was not confirmed.

Alternate Uses Test. Analyses of the Alternate Uses responses took two forms: an examination of group differences in the number of uses listed during odor presentation with the number of practice uses listed as a covariate; and analyses of group differences in the number of "common," "moderately unusual," and "unusual" uses listed during exposure to the odor, using the number of "common,"

the number of "moderately unusual," and the number of "unusual" practice uses, respectively, as covariates.

Overall ANCOVAs first tested for significant group differences. ANCOVA revealed a marginally significant group difference in the number of uses listed, $F(2,86) = 2.83$, $p=.06$. When this analysis was performed for the smaller sample selected based on their hedonic ratings, the obtained F value increased, $F(2,59) = 3.35$, $p=.04$. For the sample selected based on mood change scores, the effect remained only marginally significant, $F(2,40) = 2.77$, $p=.08$. As Table 5 shows, the odor group means for the total sample and each of the selected samples are in the hypothesized order, with the pleasant odor group providing the greatest number of uses on average, the unpleasant odor group providing the fewest uses on average, and the no-odor group mean falling between. The group means adjusted for the effect of the covariate are also presented in Table 5.

Planned comparisons examined whether each of the odor groups differed significantly from the no-odor (control) group. Analyses of the entire sample revealed that the unpleasant odor group mean differed significantly from the no-odor group mean, $t(57) = -2.18$, $p=.03$. For the sample selected based on their odor ratings, the difference between these two groups was only marginally significant, $t(41) = -1.82$, $p=.07$, and the t value did not reach conventional levels of significance for the group selected based on mood

Table 5

Mean Alternate Uses Scores for the Odor Groups

Odor Group		Alternate Uses Scores ^a		
		Practice	Experimental	Adjusted ^b
Entire Sample				
Pleasant (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	15.20 (5.39)	17.37 (6.33)	16.67 ⁺ (6.62)
No Odor (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	14.37 (5.36)	16.93 (6.02)	16.91 ⁺ (6.59)
Unpleasant (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	13.43 (4.99)	14.03 (4.51)	14.76 ⁺⁺ (6.62)
Sample Selected Based on Mean Hedonic Rating				
Pleasant (<u>n</u> =19)	<u>M</u> (<u>SD</u>)	15.74 (6.10)	18.63 (6.28)	17.53 (6.60)
No Odor (<u>n</u> =19)	<u>M</u> (<u>SD</u>)	14.05 (5.69)	16.58 (6.40)	16.80 (6.52)
Unpleasant (<u>n</u> =25)	<u>M</u> (<u>SD</u>)	13.20 (5.03)	13.92 (4.37)	14.81 (5.72)
Sample Selected Based on Change in "Pleased-Annoyed"				
Pleasant (<u>n</u> =14)	<u>M</u> (<u>SD</u>)	17.14 (5.60)	20.57 (5.92)	19.00 (7.64)
No Odor (<u>n</u> =15)	<u>M</u> (<u>SD</u>)	14.93 (5.51)	17.53 (7.19)	17.86 (7.22)
Unpleasant (<u>n</u> =15)	<u>M</u> (<u>SD</u>)	13.87 (4.17)	14.07 (4.83)	15.31 (7.32)

Note. Within a column, different superscripts denote sample means that differed significantly at $p < .05$.

^aScores reflect the total number of uses listed for the five objects.

^bAdjusted scores are the values of the experimental scores adjusted for the covariate (practice scores).

change scores. None of the analyses revealed significant differences between the pleasant and the no-odor group.

A comparison of the number of uses listed during the pretest and the number of uses listed in the presence of odor revealed that the performance of both the pleasant and no-odor groups improved significantly, $t(29) = -2.76$, $p=.01$; $t(29) = -3.58$, $p=.001$, respectively. In contrast, the unpleasant odor group's pre- and post-odor scores did not differ significantly. Similar effects were obtained when the selected samples were examined. In the sample selected based on their hedonic ratings, both the pleasant odor and the no-odor groups improved significantly, $t(18) = -3.04$, $p<.01$; $t(18) = -3.28$, $p<.01$, respectively; however, the unpleasant odor group's practice and experimental scores did not differ significantly. In addition, both the pleasant odor and the no-odor groups selected based on their mood change scores improved significantly, $t(13) = -2.82$, $p<.02$; $t(14) = -2.16$, $p<.05$, respectively, whereas the unpleasant odor group showed no significant change in performance from before to after odor presentation. In other words, as the means in Table 5 suggest, the unpleasant odor appears to have eliminated the normal practice effects.

These results indicate that the experience of an unpleasant odor lessened subjects' ability to produce alternate uses, or reduced "verbal fluency." A related question is whether odor pleasantness influenced the unusualness of the responses given by subjects. To address this issue, the next set of analyses tested for group

differences in the number of common, the number of moderately unusual, and the number of highly unusual uses generated by subjects.

For each object, frequencies for each use listed were obtained. The top third of the distribution of responses were designated "common" responses, the middle third were designated "moderately unusual," and the bottom third were designated "highly unusual." For example, for the object shoe, a "common" use was "to kill a bug" (41 subjects gave this response), a "moderately unusual" use (listed by 14 subjects) was "to hammer," and the "highly unusual" response, "as a mirror," was provided by one subject. For each subject, three scores were computed for the practice items and for the experimental items: the number of common responses, the number of moderately unusual responses, and the number of highly unusual responses. Means for the odor groups are presented in Table 6; means adjusted for the effects of the covariates are presented in Table 7.

ANCOVAs tested for group differences in the number of common uses, the number of moderately unusual uses, and the number of highly unusual uses listed. In all analyses, the appropriate practice score was used as a covariate. The analyses revealed that the odor effect was not uniform across the different types of uses. Analyses of the entire sample and both selected samples yielded no odor effects on the number of common uses listed.

In contrast, there was a significant effect of odor on the number of moderately unusual uses listed,

Table 6

Number of Common, Moderately Unusual, and Unusual Alternate Uses Provided by the Odor Groups

		Alternate Uses Scores ^a					
		Practice			Experimental		
Odor Group		Common	Mod.	Unusual	Common	Mod.	Unusual
Entire Sample							
Pleasant	<u>M</u>	5.23	5.00	4.97	5.90	6.43	5.03
(<u>n</u> =30)	(<u>SD</u>)	(2.05)	(2.73)	(3.37)	(2.58)	(4.01)	(2.63)
No Odor	<u>M</u>	4.90	4.90	4.57	6.13	5.57	5.23
(<u>n</u> =30)	(<u>SD</u>)	(1.92)	(2.75)	(2.98)	(2.87)	(2.34)	(2.65)
Unpleasant	<u>M</u>	5.13	4.40	3.90	5.70	4.37	3.97
(<u>n</u> =30)	(<u>SD</u>)	(2.27)	(2.08)	(2.62)	(2.48)	(1.87)	(2.24)
Sample Selected Based on Mean Hedonic Rating							
Pleasant	<u>M</u>	5.84	5.16	4.74	6.11	7.32	5.21
(<u>n</u> =19)	(<u>SD</u>)	(1.71)	(2.95)	(3.51)	(2.18)	(4.41)	(2.70)
No Odor	<u>M</u>	5.00	5.11	3.95	5.84	5.37	5.37
(<u>n</u> =19)	(<u>SD</u>)	(1.97)	(3.11)	(2.99)	(2.43)	(2.63)	(2.75)
Unpleasant	<u>M</u>	5.32	4.12	3.76	5.88	4.16	3.88
(<u>n</u> =25)	(<u>SD</u>)	(2.29)	(2.01)	(2.73)	(2.57)	(1.89)	(2.03)
Sample Selected Based on Change in "Pleased-Annoyed"							
Pleasant	<u>M</u>	5.00	5.57	6.57	6.57	8.43	5.57
(<u>n</u> =14)	(<u>SD</u>)	(2.15)	(2.79)	(3.25)	(2.41)	(4.10)	(2.68)
No Odor	<u>M</u>	4.87	5.33	4.73	6.00	5.33	6.20
(<u>n</u> =15)	(<u>SD</u>)	(2.13)	(3.16)	(3.01)	(3.46)	(2.61)	(2.60)
Unpleasant	<u>M</u>	5.33	4.53	4.00	5.33	4.20	4.53
(<u>n</u> =15)	(<u>SD</u>)	(2.16)	(1.92)	(2.75)	(2.64)	(1.94)	(2.64)

^aScores denote the total number of common, moderately unusual, and unusual uses listed across five objects.

Table 7

Adjusted Means for Common, Moderately Unusual, and Unusual
Alternate Uses^a

		Adjusted Alternate Uses Scores ^b		
Odor Group		Common	Moderate	Unusual
Entire Sample				
Pleasant	<u>M</u>	5.83	6.32	4.80
(<u>n</u> =30)	(<u>SD</u>)	(4.26)	(4.52)	(3.59)
No Odor	<u>M</u>	6.23	5.50	5.19
(<u>n</u> =30)	(<u>SD</u>)	(4.26)	(4.52)	(3.58)
Unpleasant	<u>M</u>	5.68	4.55	4.25
(<u>n</u> =30)	(<u>SD</u>)	(4.26)	(4.54)	(3.60)
Sample Selected Based on Mean Hedonic Rating				
Pleasant	<u>M</u>	5.90	7.11 ⁺	4.93 ⁺
(<u>n</u> =19)	(<u>SD</u>)	(4.13)	(4.91)	(3.71)
No Odor	<u>M</u>	6.02	5.19 ⁺⁺	5.46 ⁺
(<u>n</u> =19)	(<u>SD</u>)	(4.12)	(4.90)	(3.69)
Unpleasant	<u>M</u>	5.91	4.54 ⁺⁺	4.06 ⁺⁺
(<u>n</u> =25)	(<u>SD</u>)	(3.58)	(4.31)	(3.23)
Sample Selected Based on Change in "Pleased-Annoyed"				
Pleasant	<u>M</u>	6.60	8.22 ⁺	4.78 ⁺
(<u>n</u> =14)	(<u>SD</u>)	(4.97)	(4.81)	(3.90)
No Odor	<u>M</u>	6.07	5.24 ⁺⁺	6.40 ⁺⁺
(<u>n</u> =15)	(<u>SD</u>)	(4.81)	(4.63)	(3.63)
Unpleasant	<u>M</u>	5.23	4.51 ⁺⁺	5.13 ⁺⁺
(<u>n</u> =15)	(<u>SD</u>)	(4.82)	(4.67)	(3.70)

Note. Within a column, different superscripts denote sample means that differed significantly at $p < .05$.

^aAdjusted scores are the values of the experimental scores adjusted for the covariate (practice scores).

^bScores denote the total number of common, moderately unusual, and unusual uses listed across five objects.

$F(2,86) = 3.40, p < .05$. As Table 7 indicates, the adjusted means for the groups are in the expected direction, with the pleasant odor group providing the most and the unpleasant odor group providing the fewest moderately unusual responses. However, planned comparisons revealed that neither of the odor group means differed significantly from that of the no-odor group.

Planned comparisons revealed a significant difference between the pleasant odor group mean and the no-odor group mean for the sample selected based on their odor ratings, $t(41) = 2.20, p = .03$, and for the sample selected based on their mood ratings, $t(26) = 2.96, p = .005$. In both cases the pleasant odor group listed significantly more moderately unusual uses than the no-odor group. For both selected samples the difference between the unpleasant odor group and the no odor group was not statistically significant.

Analyses revealed no significant odor effect for the entire sample on the number of highly unusual uses listed. ANCOVA revealed only a marginal effect of odor for the sample selected based on odor ratings, $F(2,59) = 2.69, p = .08$. Planned comparisons revealed that the unpleasant odor group provided significantly fewer highly unusual uses than the control group, $t(41) = -2.27, p < .03$; however, the difference between the pleasant and no-odor groups was not significant. For the sample selected based on their mood ratings, the overall F value did not reach significance. Nonetheless, planned comparisons revealed a significant difference between the pleasant odor group and the no-odor

group, $t(26) = -2.00$, $p=.05$. Contrary to prediction, in this sample the pleasant odor group provided fewer highly unusual uses on average than the no-odor group.

Digit deletion task. Analyses tested whether the pleasant and unpleasant odor groups differed from each other and from the control group in their performance on this non-creative task. Successful performance was considered both in terms of the speed at which a subject crossed out the target digits and the accuracy of his or her performance. The first set of analyses examined performance in terms of how quickly the subject worked at the task (i.e., speed was calculated as the number of target digits deleted plus the number of target digits missed). Then, analyses tested for group differences in accuracy or the proportion of digits missed (measured as the number digits missed divided by [the number deleted plus the number missed]).

As hypothesized, ANCOVA revealed no group differences in digit deletion speed. Analyses of the two selected samples also revealed no effects of odor on this measure of performance. Digit deletion speed means for the entire sample and the two selected samples are shown in Table 8.

The multiple regression procedure used to test the homogeneity of regression assumption for the accuracy measure indicated a significant treatment by covariate interaction for the entire sample, $F(2,84) = 14.51$, $p<.001$, for the sample selected based on hedonic ratings, $F(2,57) = 12.03$, $p<.001$, and for the sample selected based on their mood ratings, $F(2,38) = 5.71$, $p=.007$. In addition,

Table 8

Digit Deletion Speed Scores for the Odor Groups

Digit Deletion Speed Scores ^a				
Odor Group		Practice	Experimental	Adjusted ^b
Entire Sample				
Pleasant	<u>M</u>	56.65	57.97	58.99
(<u>n</u> =30)	(<u>SD</u>)	(10.64)	(10.09)	(8.27)
No Odor	<u>M</u>	58.09	59.21	59.08
(<u>n</u> =30)	(<u>SD</u>)	(9.97)	(8.79)	(8.26)
Unpleasant	<u>M</u>	59.02	58.37	57.43
(<u>n</u> =30)	(<u>SD</u>)	(12.35)	(11.09)	(8.27)
Sample Selected Based on Mean Hedonic Rating				
Pleasant	<u>M</u>	56.23	58.01	58.91
(<u>n</u> =19)	(<u>SD</u>)	(11.58)	(10.78)	(9.62)
No Odor	<u>M</u>	56.73	58.36	58.85
(<u>n</u> =19)	(<u>SD</u>)	(10.66)	(9.99)	(9.61)
Unpleasant	<u>M</u>	59.06	58.03	56.64
(<u>n</u> =25)	(<u>SD</u>)	(12.92)	(11.77)	(8.40)
Sample Selected Based on Change in "Pleased-Annoyed"				
Pleasant	<u>M</u>	57.00	57.51	58.80
(<u>n</u> =14)	(<u>SD</u>)	(11.85)	(10.03)	(8.77)
No Odor	<u>M</u>	58.64	58.39	58.30
(<u>n</u> =15)	(<u>SD</u>)	(10.36)	(9.58)	(8.45)
Unpleasant	<u>M</u>	59.97	58.33	57.13
(<u>n</u> =15)	(<u>SD</u>)	(11.30)	(11.82)	(8.47)

^aSpeed was calculated as the number of target digits deleted plus the number of target digits missed.

^bAdjusted scores are the values of the experimental scores adjusted for the covariate (practice scores).

Bartlett's test indicated that the assumption of homogeneity of variance was not met, Bartlett-Box $F(2,17030) = 14.69$, $p < .001$. A log transformation of the accuracy score and the elimination of 7 outliers resulted in satisfactory tests of both of these assumptions. ANCOVAs revealed no significant between-group differences in digit deletion accuracy for the entire sample or for the two selected samples. Digit deletion accuracy scores are displayed in Table 9.

Table 9

Digit Deletion Accuracy Scores for the Odor Groups

		Digit Deletion Accuracy Scores ^a		
Odor Group		Practice	Experimental	Adjusted ^b
Entire Sample				
Pleasant (<u>n</u> =30)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.003)
No Odor (<u>n</u> =25)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.003)
Unpleasant (<u>n</u> =28)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.003)
Sample Selected Based on Mean Hedonic Rating				
Pleasant (<u>n</u> =19)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.004)
No Odor (<u>n</u> =16)	<u>M</u> (<u>SD</u>)	.03 (.02)	.02 (.01)	.02 (.005)
Unpleasant (<u>n</u> =23)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.004)
Sample Selected Based on Change in "Pleased-Annoyed"				
Pleasant (<u>n</u> =14)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.03)
No Odor (<u>n</u> =12)	<u>M</u> (<u>SD</u>)	.03 (.02)	.03 (.02)	.02 (.03)
Unpleasant (<u>n</u> =14)	<u>M</u> (<u>SD</u>)	.02 (.01)	.02 (.01)	.02 (.03)

^aAccuracy was calculated as the proportion of digits missed. Means were calculated following the log transformation and the elimination of 7 outliers.

^bAdjusted scores are the values of the experimental scores adjusted for the covariate (practice scores).

Discussion

The results of the present experiment provide only limited support for the main experimental hypothesis. During the experimental portion of the study, the unpleasant odor group provided fewer alternate uses on average than both the pleasant and the no-odor groups. Further examination indicated that the effect was most evident for the moderately unusual responses, and to a lesser extent, the highly unusual responses. The lack of an effect of odor on performance on the digit deletion task suggests that these effects cannot simply be interpreted as the result of demand characteristics of the experimental situation. In contrast to Bastone and Ehrlichman's (1991) previous findings, the odor groups did not differ in their performance on the RAT items. Therefore, the Alternate Uses Test results cannot be interpreted more broadly as an influence of odor on creativity.

Several differences between the current study and the one which it was designed to replicate may account in part for the differences in the observed results. For example, in the present study the RAT was the first task performed following the presentation of the odor whereas in the previous study the RAT items were presented approximately 20 minutes after the odor (and after the subjects had performed a free association task). Given that there were observed effects on performance on the second task in both studies, one could argue that the effects of odor on cognitive processes appear only after extended exposure.

However, given that in both studies mood effects were observed immediately after the odor was presented and that mood effects have been shown to be of limited duration (Isen, Clark, & Schwartz, 1976), this hypothesis may not be a very plausible one.

The most striking difference between the two experiments involves the addition of pretests in the present study. In the previous experiment, subjects worked on seven easy RAT items before the seven moderate items; however, all of the items were introduced while the odor was present. In the current experiment, the subjects worked on seven moderate items prior to the presentation of the odor or odorless air. It is conceivable that while working on the practice items participants developed "strategies" or approaches to the task. If so, when the air was presented, they may have continued to employ these strategies. In the previous study, the observed effect on performance may have been due to the fact that the subjects had no exposure to RAT items without an odor present. In other words, the observed group differences may have been due to effects of odor on the effectiveness of the strategies developed to answer the RAT items. In the present study, individual differences in the ability to come up with a successful strategy (in the absence of odor) may have overshadowed any effects due to the odor manipulation.

In fact, if the pretest allowed subjects to develop a strategy or particular approach to the RAT task, the process itself may have become more conscious, deliberate, or

controlled than it was initially assumed to be. The pattern of results obtained in three previous experimental tests of the effects of odor experience on cognition suggested that behavior on tasks that require controlled processes do not vary as a function of odor condition whereas more automatic tasks are influenced by odor condition (Ehrlichman & Bastone, 1991). Thus, if the inclusion of the pretest resulted in subjects taking a more consciously controlled or strategic approach to the RAT task, performance on the RAT would not be expected to show the effects of odor. This effect of the pretest was not predicted and therefore the interpretation offered is speculative at best. Nonetheless, if the interpretation is correct, the present results would lend support to Ehrlichman and Bastone's (1991) claim that the affective state induced by pleasant and unpleasant odors will not influence deliberately controlled cognitive processes. Only future research can directly test the adequacy of this claim.

The pretest may also have provided subjects with information about their ability to perform the experimental tasks. Because there are correct and incorrect answers to the RAT items, this task may have been particularly susceptible to this type of influence. It is likely that subjects were aware of the quality of their own performance on the RAT; if they did not provide an answer for a given item, they would be certain that they were not correct. In addition, subjects' comments in the post-experimental discussion revealed that they were unsure of the adequacy of

some of their answers: subjects frequently asked about the correctness of those responses that were in fact incorrect and rarely questioned the adequacy of those responses that were in fact correct. As some indicated in post-experimental questioning, subjects may have deliberately tried to "shut out" the odor or to ignore it and proceed with the task at hand. In effect, subjects may have tried to be consistent -- they had some information about their ability based on performance on the pretest and tried not to allow the manipulation to affect performance during odor.

The fact that the observed correlation between RAT performance during practice and during odor was strongest for the unpleasant odor group may indicate that this group, more than the others, strove to maintain consistency. In fact, several subjects in the unpleasant odor group explained that the unpleasant odor could hurt other people's performance but that it had not affected their own performance because they were able to ignore it. It is interesting that the unpleasant odor group did not show greater consistency than the other groups in their performance on the Alternate Uses Test. Perhaps they were less consistent on this task because the adequacy of their performance on the practice items was less evident or because they had not developed any particular approach to the task.

Lastly, the practice tasks appear to have resulted in changes in mood; in general, they led to more annoyance, tension, and sleepiness. The addition of the odor may not

have been sufficient to counter the mood effects of the practice tasks and similar task effects may have occurred during the odor portion of the experiment. Unfortunately, the data do not allow for an examination of the effects of the practice tasks separate from those of the odor. The failure of the pleasant odor to significantly enhance mood may be due to the opposing effects of the tasks themselves or to the fact that the subtle effects of pleasant odors will only emerge in situations in which the individual starts out in a fairly positive mood, as is typically the case in laboratory research. In sum, the decision to include pretests in the current study to increase statistical power may have backfired. If the pretests influenced the results in any or all of the ways discussed, this modification to the initial procedure may have resulted in more confusion than clarification.

The basic premise of this research was that the experience of odors as pleasant or unpleasant should be sufficient to lead to changes in cognition and behavior that parallel those observed in studies of mood. The hypothesized effects of odor on creative performance were not assumed to necessarily require changes in self-reported mood. In fact, an unresolved issue in this research is whether self-reported changes in mood state are necessary in order for the affect-related changes in thoughts and behavior to occur. Ehrlichman and Halpern (1988) argued that to the extent that the hedonic aspect of affect (as opposed to any accompanying changes in cognition) is

responsible for effects on cognitions and behavior, it may not matter whether pleasantness or unpleasantness is experienced as internal or external. That is, the experience of any valenced state may be capable of influencing cognitions and behaviors in the ways that have been demonstrated with mood inductions. Nonetheless, an understanding of the odor-induced changes in self-reported affective states may help to understand the pattern of results obtained in the present study.

The finding that the pleasant odor group and the control group did not differ significantly in the number of alternate uses they listed is in keeping with the demonstrated mood effects. The failure to demonstrate effects of the pleasant odor on performance could simply be due to the fact that exposure to the pleasant odor did not significantly alter mood. When the sample was limited to those who had demonstrated relatively strong changes in their feelings of "pleased-annoyed," the pleasant odor group provided significantly more moderately unusual uses but significantly fewer highly unusual uses than the no-odor group. The results suggest that for pleasant odors to have the hypothesized effect on the production of at least moderately unusual alternate uses, a change in self-referenced feelings of pleasantness may indeed be necessary.

Although the unpleasant odor group's mood ratings differed significantly from those of both the no-odor and the pleasant odor groups, these effects may not have been sufficient to result in differences in performance on the

RAT. While there is evidence that negative moods can lead to a restriction in thinking (e.g., Easterbrook, 1959), it has not been established that these feeling states should limit one's ability to see relatedness among remote constructs. Isen et al.'s (1987) examinations of mood effects on RAT performance included only positive mood inductions and Isen' (1990) more recent work did not consistently demonstrate effects of negative moods on RAT performance.

The effects of positive and negative affect on cognition and behavior are not necessarily symmetrical, nor should researchers assume them to be (see Isen, 1984 for a discussion of this issue). It may be necessary that at least the pleasant odor group would show a significant change in feeling state, or that both odor groups would show changes, in order to obtain significant differences in RAT performance. Bastone and Ehrlichman (1991) found that both the pleasant and the unpleasant odors resulted in significant changes in mood from baseline and that these mood states differed significantly from those of controls. Still, although the odor groups differed significantly in their performance on the RAT, neither differed significantly from the control group. In the present experiment, even the pleasant and unpleasant odor subjects who demonstrated the greatest change in feeling state did not differ in their performance on the RAT.

In the previous experiment, immediately prior to working on the RAT items in the presence of an odor or

odorless air, the pleasant odor group's ($n = 20$) mean rating of "pleased-annoyed" was 3.01 ($SD = 3.03$), indicating that they felt "somewhat" pleased. In contrast, in the present experiment the pleasant odor group's rating of "pleased-annoyed" immediately prior to working on the RAT was 6.17 ($SD = 2.96$), indicating that they felt only "slightly" pleased. Even when the present sample was limited to those pleasant odor subjects who had shown the greatest change in their ratings of "pleased-annoyed" from pre- to post-odor, the pleasant odor subjects' ($n = 14$) mean rating of "pleased-annoyed" was 5.69 ($SD = 2.90$); this subgroup was still only slightly pleased prior to working on the RAT. These data suggest that in the present experiment, pleasant odor subjects' affective states may not have been sufficiently positive to influence RAT performance. The limited effects of the pleasant odor on mood may also have resulted in an attenuation of the effects on the Alternate Uses Test.

It is also possible that, despite random assignment of subjects to conditions, the previously observed group differences in RAT performance were caused by differences between the groups that existed prior to the presentation of the odor. If so, the groups would have differed even without the introduction of a manipulation. Because no pretest scores are available for that sample, this question cannot be answered. With this possibility as a caveat, it is important to consider the alternative possibility that the effects of odors on creative task performance are not

uniform; some tasks may be more likely to show the effects than others. The present results suggest that the Alternate Uses test may be more susceptible to the influence of odors than the RAT. Thus, one question which must be addressed is why the odors did not affect performance on the RAT items but did affect subjects' ability to produce alternate uses.

The Alternate Uses Test was included in the present study as an additional indicator of creativity -- one that requires divergent thinking. In fact, it may be precisely the differences in the type of thought processes required of the individual taking the RAT as compared to the Alternate Uses Test that account for the inconsistent results. Isen (1984) claimed that positive feelings lead to more varied and better integrated thoughts. In other words, both divergent as well as convergent processes may be affected by positive mood states. In contrast, much of the research involving the effects of negative moods has stressed the restriction or reduction in thought content resulting from negative feelings; negative affect seems to lead to less divergent thoughts. Therefore, given their effects on mood, unpleasant odor experiences might be expected to lead to a restriction in cognitive content, but not necessarily to a decline in the ability to perceive relatedness. The finding that the unpleasant odor group performed worse than both the control group and the pleasant odor group on the Alternate Uses Test (which involves divergent thought processes) but not the RAT (which involves both divergent and convergent thought processes) is consistent with this interpretation.

In fact, given its relationships with other measures, there is reason to believe that the RAT is more a measure of convergent than divergent thinking (Taft & Rossiter, 1966).

The distinction between tasks that involve primarily convergent thought processes and those that involve primarily divergent thought processes is similar to the distinction discussed earlier between more and less consciously controlled cognitive processes. Perhaps coming up with one answer in response to a number of criteria (as in the RAT task) requires a more deliberate or strategic approach than does a task like the Alternate Uses Test which involves the production of a variety of responses to satisfy only limited demands.

Given the results of the present study, it is difficult to draw general conclusions about the influence of odors on creative thinking. There is even some question about whether the Alternate Uses Test should be considered a creativity measure at all. Brody (1972) argued that while divergent thought may play a role in creative performance, its primary function may be to provide a person with alternatives from which to choose. Nonetheless, the findings support the more general claim that pleasant and unpleasant odors can have effects on performance that are comparable to those of mood. In conjunction with earlier research, the results support Ehrlichman and Halpern's (1988) proposal of a functional equivalence between odor experience and affect. The results also suggest that there may be some limits to this claim. Future research will

attempt to specify these limits by examining the effects of odors on a wider range of cognitive tasks, including tasks that require more consciously controlled cognitive processes (or convergent thinking) and tasks that require less conscious control (or divergent thinking). The immediate goal of the research will be to test the hypothesis that odor experiences influence less consciously controlled cognitive processes but not more consciously controlled cognitive judgments.

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