Switch and Bait: Probing the Discriminative Basis of Odor Identification via Recognition Memory

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Abstract

When people misidentify everyday odors, as they often do, their errors may conceivably lie in faulty perceptions or in faulty access to the names. Discussions of the matter usually focus on the latter, as if people had no problems with perceptual accuracy. (The problem of faulty access may get attention because its high subjective impact makes it particularly memorable, when it does occur.) However, studies have demonstrated breakdowns in ability to discriminate quality, from which it follows that people will misidentify items through perceptual confusions. Furthermore, misidentifications often contain considerable information about the identities of items, as if people simply did not perceive the items accurately, but perhaps fuzzily or with some perceptual bias. Recognition memory, with a 2-day interval between inspection and test, provided a vehicle to address two questions on this topic: (i) Would people notice that we had switched items and had presented for recognition items that matched their misidentifications rather than the original items inspected? (ii) Would people not only fall for the false bait, but actually identify the switched items correctly, and thereby imply that they were 'tuned' to perceive those odors? People commonly failed to notice the switches, i.e. took the bait and commonly identified the switched items with veridical names. Although subject to further study, the outcome suggests that when people give such names as garlic for vinegar, orange for lime, soy sauce for molasses and many others, the errors often lie largely at a perceptual stage of processing, i.e. at input rather than output. **Chem. Senses 21: 35–44, 1996.**

Introduction

When asked to identify the odors of everyday objects, such as coffee, molasses, pencil shavings and strawberry, out of normal context most people will get almost half correct. This has held true for sets with as few as 10 and as many as 80 items (Sumner, 1962; Desor and Beauchamp, 1974; Lawless and Engen, 1977; Cain, 1979, 1982; Eskenazi *et al.*, 1983, 1986a; Rabin and Cain, 1984; Murphy and Cain, 1986; Engen, 1987). With relatively little corrective feedback, subjects will improve and indeed may approach perfection. For instance, a third of subjects achieved identification of 80 out of 80 items with just three rounds of feedback in Cain's (1979) study.

Perfect identification of 80 everyday odors may hardly seem impressive to laypersons, who might expect to perform as well even without feedback. Only when they participate in the task do people appreciate its difficulty. Participants will find that they can, with one degree of confidence or another, assign labels. Nevertheless, many labels will be wrong. Different people will miss different items and, in the absence of corrective feedback, the same person will miss somewhat different items on different occasions (Cain *et al.*, 1995). Do these errors occur principally at a perceptual stage of this semantic memory task of identification or do they occur at a stage where subjects seek to retrieve labels from memory? Sometimes the subject may recognize the existence of a problem. In some instances, it may seem subjectively one of access, whereby the correct name fails to present itself. In other instances, it may seem one of perceptual clarity. The odor will seem hard to apprehend until its name comes to mind spontaneously or with external help. What seemed rather amorphous at one instant suddenly crystallizes. Relatively often, however, the subject hardly notices any difficulty, but simply gives an incorrect answer. Since various studies have shown that subjects will make errors of discrimination even in direct comparisons of one substance with another (e.g. Eskenazi *et al.*, 1983, 1986a,b; Martinez *et al.*, 1993; de Wijk and Cain, 1994), some errors of identification seem likely to arise principally from perceptual limitations. This matter has heretofore received virtually no experimental attention.

Errors of odor identification can vary from near misses to very far misses (Cain, 1979, 1982; Lawless and Zwillenberg, 1983; Lyman and McDaniel, 1986, 1990). The label apricot for peach constitutes a near miss, for example. Other examples include cigar butt for cigarette butt, wine for whiskey, peppermint for spearmint and caramel for molasses. Subjects commonly have high confidence in the correctness of their near misses and sometimes even in their far misses. Far misses generally include more remote specific labels, such as glue for molasses or lighter fluid for whiskey, and errors of vagueness, such as fruit for lemon or cooked food for tuna. Only infrequently, however, does a far-miss label carry no semantic information about the stimulus. Over repetitions, subjects can apply their near-miss labels much more consistently than their far-miss labels (Cain, 1979, 1982; Cain *et al.*, 1995). Indeed, the closer the labels come to veridicality, the more consistently subjects can use them.

The relationship between veridicality and consistency of label use would suggest a likely association between semantic and episodic memory for odor. Specifically, in a task of episodic memory, where consistency of experience from inspection to test should facilitate performance, subjects might remember the previous occurrence of odors they have labeled veridically at inspection better than the occurrence of odors they have labeled non-veridically. Correlational analyses have revealed that they do (Rabin and Cain, 1984; Murphy *et al.*, 1991; Jehl *et al.*, 1994). In this investigation, we first sought to confirm the relationship experimentally in a 2-day span of long-term odor memory. Then we sought to put the association to use to study whether errors of odor identification characteristically arise at perception or at retrieval.

Regarding the origin of errors, we may ask: Do subjects assign a label such as soy sauce for an item like cheddar cheese merely because they cannot think of a better label (retrieval failure) or because they actually perceive the item as soy sauce (perceptual failure)? To probe the matter, we can present cheddar cheese for inspection and soy sauce as bait in an episodic memory test, and ask the subject whether we had presented the soy sauce earlier. A subject who had assigned the label soy sauce because of poor discrimination should recognize the soy sauce as 'old'. Moreover, if the original label reflected how the subject had actually perceived the item, the person should not only call the bait 'old', but should also go on identify it correctly as soy sauce. Such an expectation follows from the rule that subjects will use veridical labels consistently. In this case, the label would in essence become veridical *post hoc*, but should nevertheless serve as a veridical label in that case.

Experiment 1

This experiment explored the relationship between episodic odor memory and semantic memory in a paradigm that anticipated the switch and bait maneuver in the next experiment. The experiment explored the joint questions of whether subjects would remember the prior occurrence of items they had identified with veridical labels better than those they had not and whether they remembered the prior occurrence of items they labeled consistently better than those they did not.

Method

Subjects

Ten young subjects (four males and six females) recruited from the Yale community participated for pay in two sessions each.

Materials

Stimuli for the first session comprised 40 common odoriferous items (see Table 1). Their likely familiarity to the subjects and their discriminability, one from another, constituted criteria for selection of items. In only one instance, leather, did we find it necessary to augment the natural object with a synthetic fragrance (PolyIFF, International Flavors and Fragrances). Stimuli for the second session comprised a subset of ten from the first session and a subset of 10 distractors chosen from a set of 24.

Subjects sniffed the items from opaque white plastic jars (180 ml capacity) held under their noses. Gauze prevented visual identification of the contents. The jars needed in a particular session sat behind a screen when not in use.

Procedure

At the beginning of the first session, subjects were told merely that the experiment entailed odor identification and memory. Each subject received the 40 items in a unique order. The subject could sample an item repeatedly before responding with as specific a label as possible.

The second session took place 2 days after the first. In it, a subject received 20 test trials, 10 with items from the first session (old) intermixed in sequence with 10 distractors (new). Each subject had a different set of 20. Five of the 10 old comprised those that the subject had identified correctly in the first session. The other five old comprised items that the subject had failed to identify correctly. (In most cases an assistant without knowledge of the hypothesis chose the correct and incorrect items for the second session. She was asked to choose items that seemed clearly correct or incorrect, but where the incorrect labels represented other real-world items. This meant that she avoided choosing items that had been labeled 'weird smell' and the like.) The 10 new items were drawn at random from their set.

In the first segment of the second session, the subject sought to recognize whether an item was old or new and rated confidence in the judgment on a scale of 1–5, where one reflected very low confidence and five very high confidence. After the subject had smelled all 20 test items for recognition, the experimenter presented all of the items again, this time for identification. Orders of presentation for recognition and for identification varied irregularly from subject to subject.

Results

The subjects identified an average of 44% (SD = 11) of the items presented in the first session. This meant that the experimenter could choose five correctly identified items for recognition testing from a pool of about nine and five incorrectly identified items from a pool of about 11.

The number of confidence ratings per subject fell below that necessary to construct individual memory operating characteristic (MOC) curves for the probability of calling an old stimulus old versus probability of calling an old stimulus new. [The MOC, like the receiver operating characteristic (ROC) curve, shows the relationship between two probability density functions.] The number did allow construction of such curves for the groups, as indicated below. These have heuristic value. For statistical comparisons, however, we treated the ratings on a subject-by-subject basis in the manner of Serafine *et al.* (1986) that entailed the linear conversion of the ratings 1–5 for old (can be viewed as +1 to +5) and 1–5 for new (can be viewed as −1 to −5) into a single scale of 1–10, where 10 represented highest confidence old and 1 highest confidence new.

The average rating, on the scale of 10, for correctly identified items in the first session equaled 9.24 (SD = 0.84), whereas the rating for incorrectly named items equaled 6.46 (SD = 2.25) and the rating for new items equaled 3.67 (SD = 1.62) [$F(2,9) = 37.88$, $P < 0.001$). Newman–Keuls tests ($P < 0.01$) confirmed the differences in ratings in all three pairwise combinations. In this and the next experiment, the ratings always gave answers compatible with analysis of the aggregate confidence ratings from which we erected MOC curves. Figure 1 shows the curves and their respective integrated areas of 93 and 74% for items identified correctly and incorrectly in the first session. Integrated area provides a non-parametric index of strength of memory. By a theorem of the theory of signal detection, the integrated area under an MOC curve will equal percent correct performance in a two alternative forced-choice task (Egan, 1975).

In the second session, subjects correctly identified 51% (SD = 11) of the odorants presented: 45% (SD = 17) of new items, 92% (SD = 22) of those previously identified correctly, and only 20% (SD = 19) of those previously identified incorrectly. The results with the old items conformed to expectations regarding consistency of naming, but 8% errors illustrate how subjects walk a path between knowing and not knowing the odors. What people identify correctly one day, they may fail to identify correctly another day and vice versa.

With the recognition results organized in terms of the consistency of identification, confidence ratings equaled 9.04 (SD = 0.93) for consistently named items and 6.31 (SD = 2.02) for inconsistently named items [$t(9) = 5.03$, $P < 0.001$]. These compared with 9.24 (SD = 0.85) and 6.46 (SD = 2.25) for correctly identified versus incorrectly identified items [$t(9) = 4.21$, $P < 0.001$]. The similarity of the ratings based on veridicality and those based on consistency derived largely from the high overlap between correct identification and consistency. It is noteworthy, however, that among an aggregate of 11 consistent labelings of items

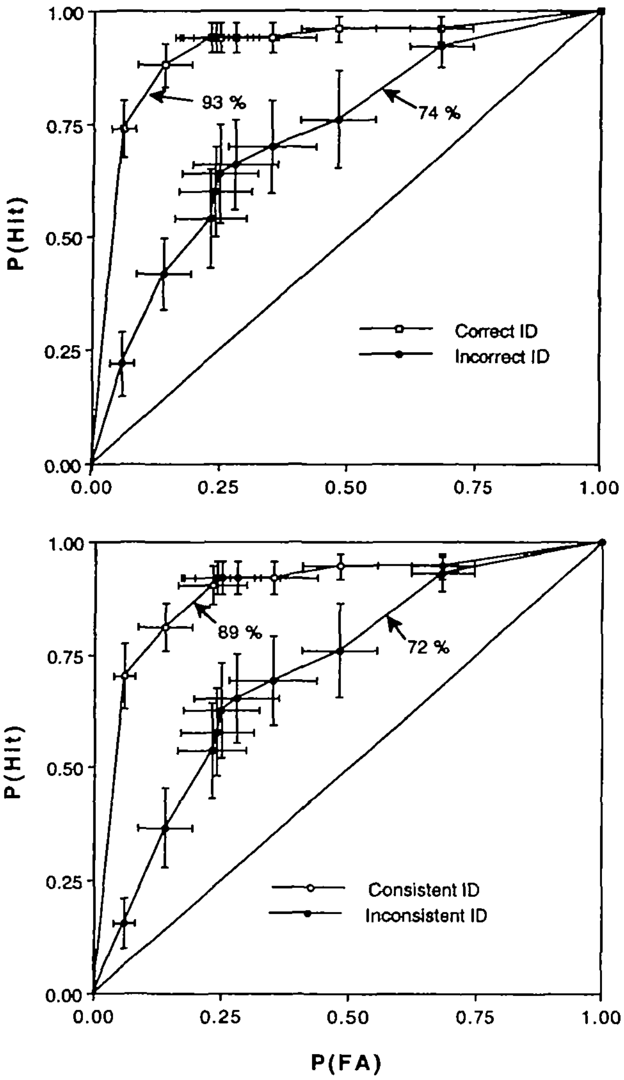

Figure 1 Upper panel shows memory operating characteristic (MOC) curves (probability of calling an old stimulus 'old' versus probability of calling a new stimulus 'old') for items that subjects identified correctly and incorrectly, respectively, between inspection. Lower panel shows curves for items labeled consistently and inconsistently, respectively, at inspection and test. Bars represent standard errors across subjects. Percentages indicate integrated areas under the curves.

Table 1 Items used in experiments

Items inspected in first session		
ammonia	baby powder	banana
barbecue sauce	beer	bleach
bubble gum	cheddar cheese	cigar butts
cinnamon	coffee	corn chips
crayons	dry dog food	white household glue
grass	grape juice	green pepper
honey	horseradish sauce	bar soap
leather	lime	disinfectant
molasses	mothballs	nail polish remover
oregano	peaches (canned)	peanut butter
peppermint	pine shavings	rubber bands
rubbing alcohol	shoe polish	tuna
vanilla	medicated rub (Vicks)	vinegar
wintergreen		
Pool of distractors for second session		
apple	bandage (Band-aid)	black pepper
bourbon	men's cologne (Brut)	burnt toast
chocolate	cloves	coconut
cough syrup	dired onion	garlic powder
ginger	tutti-frutti gum	licorice
machine oil	mustard powder	nutmeg
pencil shavings	popcorn	soy sauce
spearmint gum	tea leaves	turpentine

identified incorrectly in the first session, subjects recognized 10 (91%) as old in the second session, whereas among the 39 inconsistent labelings of these same stimuli, the subjects recognized only 22 (56%) as old. MOC curves afford graphical evidence of the superiority of consistently labeled items over inconsistently labeled ones, with areas under the respective curves equal to 89 versus 72% (Figure 1).

Experiment 2

Against the background of superior recognition of correctly or consistently identified items, we may ask whether subjects will recognize as *old* new items that correspond to incorrect names they had given to items at first inspection. In so far as they do, then it would seem that the incorrect labels represented misperceptions, rather than accurate perceptions with labels assigned quasi-arbitrarily. In so far as the subjects not only recognize the bait, but also go on to identify it correctly, we can take this as evidence that they had perceived the original items as just what their incorrect labels indicated.

Method

Subjects

Twenty new subjects (nine males and 11 females) participated in two sessions each. One group of 10 participated in the switch-and-bait manipulation and the other in a sham bait condition that involved no such switching.

Materials

Stimuli for the first session comprised the same 40 as in the first session of Experiment 1 (Table 1). Stimuli for the second session comprised the same 40 targets and the same set of 24 distractors used in the second session of the first experiment plus, for the switch-and-bait group, other items, determined by the responses of the subjects in the first session. Each subject, irrespective of group, received 20 items to recognize and to identify in the second session.

Procedure

The subjects performed the same task as in Experiment 1. In the first session, they sought to identify the items. In the second session, which followed the first by 2 days, subjects sought first to recognize old versus new, rating their confidence in the judgments and then sought to identify the items. In order to choose a subject's items for the second session, an assistant sorted the identification responses from the first session into correct and incorrect. For the switch-and-bait group, she chose five correctly identified and five incorrectly identified items as targets for session two and five more incorrectly identified items with which to perform the switch. These items had received specific incorrect names for which other readily obtainable items could be substituted. The remaining five odorants came from the normal set of 24 distractors.

For the non-bait group, the assistant went through the same process of sorting and selecting, including choosing the bait, but did not actually switch odorants. Therefore, in the second session this group had five correctly identified targets, 10 incorrectly identified targets, including five we called sham bait and five distractors. The sham bait served principally to ascertain whether items chosen to be switched for bait would have proven more recognizable or less recognizable than other old items. Table 3 lists the items chosen as bait and sham bait.

Results

In its recognition performance, the non-bait group essentially confirmed the outcome of Experiment 1, with confidence ratings of 8.76 (SD = 1.44), 6.88 (SD = 1.62), and 2.92 (SD = 0.47)) for the items identified correctly, the items identified incorrectly, and the distractors, respectively [$F(3,9) = 52.9$, $P < 0.001$]. Performance on the sham bait, where the average rating equaled 6.94 (SD = 1.40), implied that the choice of items as potential bait biased recognition performance neither one way nor the other (see Table 2). MOC curves reinforced the picture seen with average confidence ratings (Figure 2). For items other than the bait itself, the bait group performed compatibly with the non-bait group: 8.44 (SD = 1.80), 6.54 (SD = 1.52), and 4.28 (SD = 0.56) for items identified correctly, items identified incorrectly, and distractors, respectively [$F(3,9) = 13.6$, $P < 0.001$, which included the bait as indicated in Table 2]. Within this pattern, the only outcome in any way out of place was the higher score for the distractors (4.28 versus 2.92), which implied lower correct rejection of new items by the bait group.

Table 2 Average confidence ratings (with standard deviations) assigned to items presented for recognition in the second session

	Experiment 1	Experiment 2	
		Bait group	Non-bait group
Correctly identified	9.24^{a} (0.84)	8.44^{a} (1.80)	8.76^{a,b} (1.44)
Incorrectly identified	6.46^{a} (2.25)	6 54^{c} (1.52)	6.88^{a} (1.62)
Distractors	3.67^{a} (1.62)	4.28^{a,b,c} (0.56)	2.92^{a,b} (0.47)
Bait	—	6.73^{b} (1.89)	— —
Sham bait	—	— —	6.94^{b} (1.40)

Entries with same letters in a column significantly different at $P < 0.01$.

Subjects exposed to the bait generally perceived it as old, with an average rating of 6.73 (SD = 1.89), significantly above that of the other distractors in the set (4.28) (Table 2). Figure 3 illustrates that subjects discriminated the bait from the other distractors 73% of the time.

In the second session, subjects in the non-bait and the bait groups identified 38% (SD = 6) and 61% (SD = 8) of test items, respectively [$t(18) = 6.7$, $P < 0.001$]. The difference between the groups came largely from the difference in identification between the sham bait and the bait. Whereas subjects identified only 16% (SD = 13) of the sham bait correctly, they identified 70% (SD = 17) of the bait correctly. The non-bait and bait groups, respectively, identified correctly 98% (SD = 6) versus 94% (SD = 10) of old items previous identified correctly, 14% (SD = 8) versus 22% (SD = 15) of old items identified incorrectly, and 28% (SD = 10) versus 56% (SD = 26) of new items other than the bait.

As in Experiment 1, consistency of naming proved an important correlate of recognition. In the non-bait group, excluding the sham bait itself (see below), confidence ratings assigned to consistently named items equaled 8.61 (SD = 1.49) and those assigned to inconsistently named items equaled 6.50 (SD = 1.31) [$t(9) = 4.71$, $P < 0.001$]. (For

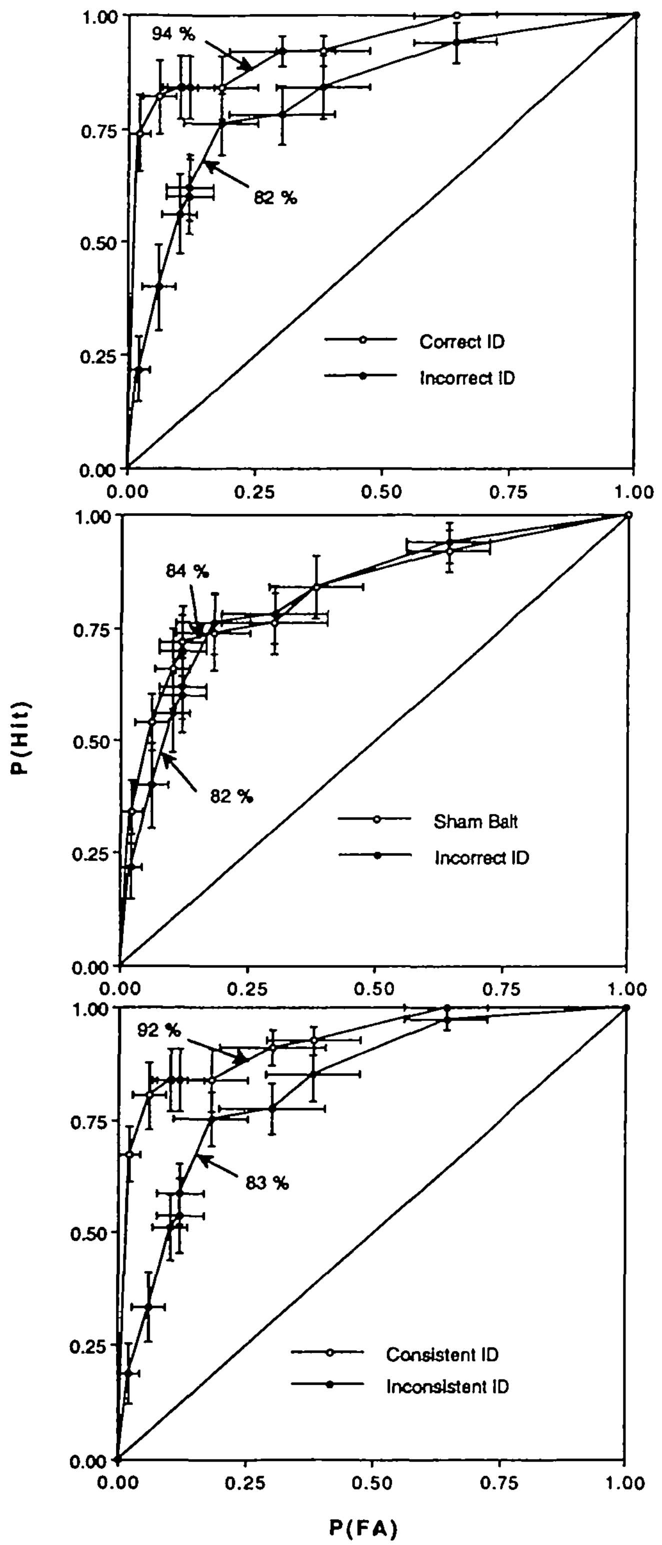

Figure 2 Top panel shows MOC curves for items that subjects identified correctly and incorrectly, respectively, at inspection. Curve for incorrectly identified items excludes data for bait controls (sham bait). Middle panel shows MOC curve for items that subjects identified incorrectly at inspection (same curve as in top part) and MOC curve for items identified incorrectly and chosen as sham bait. Bottom panel shows curves for items labeled consistently and inconsistently, respectively, between inspection and test. Bars represent standard errors across subjects. Percentages indicate integrated areas under the curves.

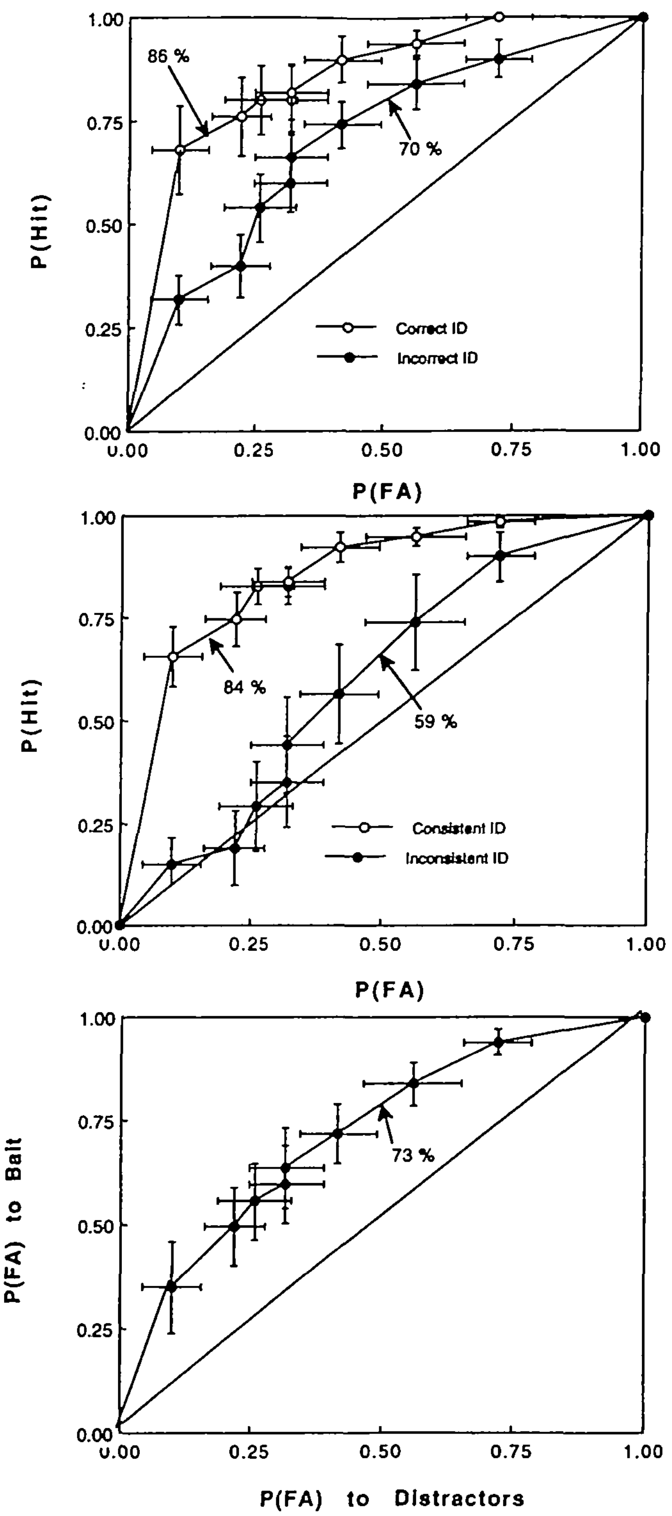

Figure 3 Top panel shows MOC curves for items that subjects identified correctly and incorrectly, respectively, at inspection. Middle part shows curves for items labeled consistently and inconsistently, respectively, between inspection and test. Bottom part shows a curve for false alarms to bait versus false alarms to nonbait distractors. Bars represent standard errors across subjects. Percentages indicate integrated areas under the curves.

comparison, confidence ratings assigned to correctly named items equaled 8.76 and those assigned to incorrectly named items equaled 6.88 [$t(9) = 4.48$, $P < 0.0001$].) In the bait group, excluding the bait, confidence ratings assigned to consistently named items equaled 8.59 (SD = 1.00) and to inconsistently named items equaled 4.94 (SD = 2.23) [$t(9) = 6.40$, $P < 0.001$]. (For comparison, ratings assigned to correctly named items equaled 8.44 whereas those assigned to incorrectly named items equaled 6.54 [$t(9) = 2.38$, $P < 0.05$].) MOC curves illustrate the point also (Figure 3).

Table 3, which offers a comparison of individual responses to the sham bait and bait, reveals that the responses commonly contained considerable information about the stimuli. For instance, a food usually evoked a food-relevant response and often a close one (near miss). Similarly, household chemicals evoked 'chemical' responses. Nevertheless, the responses also revealed the imprecision of olfaction, an imprecision that most people probably take in stride. Subjects would almost never, if ever, make any of the apparent confusions on the basis of sight, yet one might argue that objects probably smell just as different from each other as they look. Here we can see, for example, the mere seven (14%) correct identifications out of 50 that the non-bait group made to the sham bait in the second session and the 16 instances (32%) where they gave the same response in both the first and second sessions. In 14 out of those 16 cases (88%), the subjects called the stimulus *old*. Of the other 34 cases, where they emitted a different name on the first and second sessions, the subjects called the stimulus *old* 20 times (59%). Chi-square (1) = 10.1, $P < 0.01$ for the 2-by-2 comparison of same-different versus old-new.

The bait group emitted the name of the original stimulus only twice (4%) in 49 instances (one trial of the 50 accidentally omitted). The group emitted the same response in both the second and first sessions 33 times (67%). In 22 of those cases (65%), the subjects called the stimulus *old*. Of the other 16 cases (33%), where they emitted a different name on the first and second sessions, the subjects called the stimulus *old* seven times (47%). Chi-square (1) = 4.7, $P < 0.05$ for the 2-by-2 for the 2-by-2 comparison of same-different versus old-new.

Hence, consistency did not associate with recognition quite so strongly in the bait group as in the others. This might seem somewhat surprising except when we realize that recognition of an old stimulus among the bait was actually a false alarm, i.e. an error to be avoided. In our substitution of products, we could not know how well the stimulus we put in place of the original conformed to the subjects' conception of those items. When we substituted shaving cream for disinfectant, white wine for beer, black licorice for molasses, cooking oil for bleach and so on, we had to hope that we obtained the brand or type that the subject had in mind. It did not work perfectly, but it worked surprisingly often.

Discussion

Both experiments indicate that semantic processing influences recognition memory for odors. Since a correct name for an item suggests availability of better semantic information than an incorrect name, then correctly named items should be remembered better. One could even argue the extreme position that all encoding of odors in memory is semantic, and is thereby given more-or less well in the verbal label, with none perceptual. In such a case, to be recognized as old at testing an item would have to evoke a criterion amount of same semantic information evoked at inspection. The bait, which from subjects' own responses we could reasonably expect them to identify, would evoke the requisite amount of semantic overlap. By the strict semantic position, however, subjects should presumably have done more poorly than they actually did on items named inconsistently (see Figures 1–3).

At the other extreme, one could argue that the relevant encoding of odors into memory is strictly perceptual and that the labels subjects give reflect the perceptual image more or less faithfully, but play no necessary role in recognition. By the perceptual encoding explanation, the advantage for correctly identified items would lie in the consistency of their perception from one time to another. Nevertheless, by the simple rules of labeling used here, a label might be more specific than the perceptual code and might, therefore, not represent all aspects of it. An item labeled correctly or incorrectly by the name raisins, for example, may fail to smell exactly like raisins, but it might at the moment smell more like that than like any other item. That test item, irrespective of whether it is actually raisins, might smell generally the same on another occasion, but perhaps then it might seem to have shifted a little toward the smell of olives. When presented for recognition, it may still seem to merit a rating of old. The subject knows by the overlap of perceptual images that it had been presented previously, even though it doesn't smell exactly the same. Hence, the subject could recognize inconsistently labeled items too. By such an interpretation, we would expect the labels given to the bait at the end of the recognition session

Table 3 Individual responses to sham bait and bait

Subject	Stimulus	First response	Second response
Sham bait			
1	lime	_lemon*_	_lemonade*_
	pine shavings**	lemon furn. polish	wood shavings**
	vanilla	chocolate	cough syrup
	tuna	_salmon_	_salmon_
	shoe polish	_furnace oil_	_heating oil_
2	barbecue sauce	paprika	barbecue sauce
	beer	_red wine_	_red wine_
	lime	_lemon_	_lemon_
	white glue	turpentine	nail polish
	oregano	_tea leaves_	_tea leaves_
3	cheddar cheese	_Swiss cheese_	_Swiss cheese_
	cigar butts	_cigarette ashes_	_cigarette butts_
	horserad. sauce	_mustard_	_mustard_
	lime	lemon	Handiwipes
	leather	Band-aid	tea
4	barbecue sauce	thyme	treated wood
	dry dog food	sunflower seeds	dust
	horserad. sauce	onion salt	celery
	green pepper	celery	furniture polish
	canned peaches	canned pineapple	canned pears
5	lime	_lemon_	_lemon_
	corn chips	_popcorn_	_popcorn_
	honey	_soy sauce_	_soy sauce_
	wintergreen	spearmint	wintergreen
	green pepper	spinach	celery
6	vanilla	dried dates	perfume
	oregano	sweet basil	herbal tea
	molasses	raisins	olives
	cheddar cheese	butter	butterscotch
	tuna	peanut butter	rotten fish
7	pine shavings	crayon wax	oil paint
	molasses	instant coffee	tea
	shoe polish	_turpentine_	_paint thinner_
	lime	lemon	Lemon Pledge
	corn chips	pretzels	popcorn
8	oregano	dill	tarragon
	lime	lemon	lime
	molasses	peanut oil	musty
	shoe polish	machine oil	shoe polish
	rubbing alcohol	turpentine	nail pol. remover
9	molasses	_beef broth_	_beef broth_
	vanilla	almond	old grass
	shoe polish	_kerosene_	_kerosene_
	nail polish remover	strawberry wax candle	soap
	beer	whiskey	beer
10	shoe polish	motor oil	paint thinner
	canned peaches	grapes	fruit mix
	honey	tobacco	honey
	cigar butts	_cigarette ashes_	_cigarette ashes_
	molasses	_yams_	_yams_
Bait			
11	cigar butts	_cigarette butts_	_cigarette butts_
	lime	_orange juice_	_orange juice_
	molasses	dates	salt
	grass	_lettuce_	_lettuce_
	disinfectant	_shaving cream_	_shaving cream_
12	cigar butts	_cigarette ashes_	_cigarette ashes_
	tuna	spicy lunch meat	egg roll
	lime	_over-ripe orange_	_orange_
	molasses	black licorice	molasses
	peppermint	spearmint	fresh mint
13	canned peaches	_canned pears_	_canned pears_
	lime	_lemon_	_lemon_
	cigar butts	_cigarette butts_	_cigarette butts_
	vinegar	_garlic_	_garlic_
	beer	white wine	beer
14	cigar butts	_cigarette butts_	_cigarette ashes_
	beer	_wine_	_wine_
	grass	_cucumbers_	_cucumbers_
	grape juice	cranberry juice	apple sauce
	lime	_grapefruit_	_grapefruit_
15	grass	_onion_	_onion_
	corn chips	popcorn	toast
	cheddar cheese	_soy sauce_	_soy sauce_
	coffee	burnt toast	toast with honey
	green pepper	_celery_	_celery_
16	lime	_lemon_	_lemon_
	shoe polish	turpentine	Vicks
	horserad. sauce	_dill pickle_	_pickle_
	green pepper	cucumbers	watermelon
	canned peaches	apricot jam	ice tea/lemon/ sugar
17	cheddar cheese	_yeast & water_	_yeast_
	lime	_lemon_	_lemon_
	molasses	_soy sauce_	_soy sauce_
	green pepper	_cucumber_	_cucumber_
	wintergreen	spearmint	red licorice
18	beer	cantaloupe	watermelon

Table 3 continued

Subject	Stimulus	First response	Second response
	grape juice	*strawberries*	*strawberries*
	disinfectant	*shaving cream*	*shaving cream*
	lime	Lemon Pledge	lemon
	rubbing alcohol	turpentine	floor cleaner
19	lime	*lemon*	*lemon*
	white glue	*fresh coconut*	*coconut*
	corn chips	*popcorn*	*popcorn*
	wintergreen	*spearmint*	*spearmint*
	shoe polish	turpentine	solvent
20	corn chips	popcorn	[accidentally omitted]
	grape juice	*pineapple juice*	*pineapple juice*
	cigar butts	*cigarette butts*	*cigarette butts*
	bleach	*cooking oil*	*cooking oil*
	lime	*lemon*	*lemon*

*Italics indicate equivalent responses in both first and second sessions
**Underlining indicates response in second session equivalent to correct identification of the *original* stimulus

to divide themselves rather indiscriminately between the original stimulus and the bait. Veridical labels to the bait outnumbered labels assigned to the original items by an astounding 17 to 1. This outcome implies that ability to match the name of the bait with the incorrect names given to the original items played a role in the success of the baiting procedure.

In part because of the relative success at recognition of inconsistently labeled items and in part because of the seemingly strong semantic component in recognition of the bait, the present data point toward the operation of both semantic and perceptual encoding of odors into memory. Furthermore, for the bait group, recognition performance on those items incorrectly named (i.e. where a test stimulus never matched the semantic code) essentially equaled performance on the bait (i.e. where the stimulus always matched the semantic code, at least nominally): 70 verus 73% (Figure 3). This outcome suggests equal weight for semantic and perceptual codes for a 2-day retention interval. Shorter or longer intervals could shift the balance one way or the other.

Despite the likely coexistence of semantic and perceptual encoding, the initial errors of identification seem to be predominantly perceptual. As the listing of responses in Table 3 reveals, subjects did not sit in verbal limbo unable to give reasonable approximations to veridical labels. Indeed, the approximations they gave came close enough to suggest in and of themselves simple failures of discrimination. More probative evidence, however, lies in how subjects responded to the bait. That the bait lured anyone into false positive responding implies *ipso facto* some failure of discrimination. If the failure of discrimination came between the name of the bait and the name of the inspected item, then we should have expected all coincidences of naming to yield responses of *old* and none of the failures of coincidence to yield responses of *new*. This did not happen. Although the semantic dimensions seem always to correlate with success in this domain, their role here is almost certainly secondary to perceptual factors. Admittedly though, any dichotomy between perceptual and semantic encoding begins to take on the characteristics of a straw man as data have shown that odor labels can actually alter discrimination (Rabin, 1988; Rabin and Cain, 1989; de Wijk and Cain, 1994). Clearly, then, semantic and perceptual encoding can work hand in glove.

The most important message of the present study, however, is that errors of odor identification occur at input into memory, as well as at output from memory. Subjects literally misapprehend stimuli and it is by no means certain that they can subjectively separate misapprehension from an inability to access names. In an effort to resolve the discomfort of failure, subjects may always feel that they can smell the stimulus accurately, but cannot 'find its handle'. This can, falsely, we think, lead to uncritical statements such as how there is a weak relationship between odors and words (Richardson and Zucco, 1989; Schab, 1991). Such statements merely restate the problem that people make errors of identification and feel frustrated by it. They explain nothing.

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