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Discrimination without description.
Are the differences conceptualised or fully subconscious?

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Abstract

This paper uses an innovative analysis of an individual's cognitive processes to investigate a real-life example of processing rendered subconcious by a mask that shared characteristics with the varied feature. In about half the participants, integrative performance on the object was better than analytical performance on the feature. The cognitive processes mediating this achievement varied among assessors. In a few, the integrative judgment discriminated levels of the feature directly through sensory processes (subceptually). The others succeeded by implicitly using the analytical concept to achieve feature discrimination in overall object recognition.

Keywords: object-feature recognition; multiple discrimination; subception; implicit processing

Introduction

Subconscious perception

One technique for investigating subconscious perceptual performance (subception) is to mask the stimulus. The usual criterion of awareness of a stimulus is the person professing experience of that feature of the situation in terms of its culturally recognised concept. Hence if that analytical response was not affected by the stimulus while another response was, the evidence is that the stimulus was perceived subconsciously via that other response. A mask can be penetrated in this way by a response that is more integrative than the conceptually specific response. An example is a judgment or action on the whole situation that was sensitive to the target stimulus despite the mask confusing or distracting the descriptive analysis of that feature. The experiment reported here used degree of preference for a version of the participant's usual drink of coffee as the integrative judgment and the intensity of that sample's bitterness as the analytical judgment. The stimulus was the taste of caffeine in the drink and the mask was the complex flavour of the roasted coffee beans from which the drink originated.

This type of evidence is widely used to demonstrate theoretical principles of unconscious processing. Limiting cases are set up in the laboratory. Typically, the stimulus is so brief or weak that it could never be identified. A mask can be used to weaken the signal from the stimulus relative to background noise. Yet the stimulus can still affect a response to which it is relevant, as in priming (e.g., Forster & Davis, 1984; Lamme, Zipser & Spekreijse, 2002).

The general investigation of subception is considerably more difficult. Often stimuli are present for at least some seconds, as is the case with tastants in foods and drinks. Also the stimuli are normally at strengths that would be perceived readily in isolation, such as caffeine in water at the levels that are natural in coffee. To be ecologically valid, experiments need in addition to use masks that are available in the situation being investigated, like the many bitter compounds in roast coffee.

A common further problem is that the measurement of subception has to be retrospective. That is, the interest is in what can be said now about what might or might not have been in consciousness at some time in the past. The issue is whether or not what was said or done about the situation at that earlier time was influenced by awareness of the analytical concept used in the current explicit verbal criterion of conscious processing of the stimulus. Was the initial preference for a cup of coffee influenced by the effect of caffeine on taste that was conceptualised as bitterness in the later test? The experiment reported here addresses that question for each of its participants.

Normed discrimination

Detection sensitivity 'threshold' has been used to identify past occurrence of subconscious perception (e.g., Cheesman & Merikle, 1986; Merikle & Reingold, 1998; reviewed by Merikle, Smilek & Eastwood, 2001). The particular feature of an object or situation was detected by an integrative response such as expressing a preference for the object having that feature over objects that lacked it. Yet the feature was not detected later by a response specifically describing that feature. The paradigmatic case is a supposedly subliminal flash on a cinema screen of the brand name of an icecream followed by an increase in sales of that brand to the audience, with the participants subsequently denying that the brand's name was shown on the screen.

Booth, Conner and Gibson (1989) pointed out that discriminative sensitivities can be used for the same purpose. They briefly described an experiment in which a stimulus within a familiar object was presented at varied levels with constant masking. As stated above to illustrate the principles of subception, the stimulus was the taste of caffeine and the mask was the flavour of the individual's usual drink of coffee. Individuals' Weber fractions for caffeine were calculated for judgments of degree of preferences and intensity of bitterness (*bitter* being the standard term for conceptualising the stimulus). Booth and colleagues found that, in over half the participants, the integrative judgments of preference were sensitive to differences between levels of the stimulus but later analytical judgments of bitterness were not. Such a pattern of performance could be regarded as the discriminative analogue of perception without conscious detection.

That preliminary report left open the key question if coffee preference was decided by unmonitored use of the concept of bitterness before the experimenter introduced the word *bitter*. The assessors observed later to be analytically non-discriminative might nonetheless have been discriminating amounts of the stimulus under its concept when deciding the preferences from the amounts. Such issues can be addressed by a subsequently developed theory of interactions among multiple discriminations from a norm within an individual on an occasion (Booth & Freeman, 1993). That theory has recently been fully implemented in a software tool for calculating a variety of the mental processes that could be mediating the discriminative performance of an integrative judgment. This paper presents the results from such calculations on the data partly reported by Booth *et al*. (1989).

Multiple discrimination scaling

The theory developed by Booth and Freeman (1993) from work such as that by Conner *et al*. (1988) distinguishes what is explicit in observed psychophysical functions from what is implicit in interactions between hypothesised covert functions that also transform

information. The Weber fractions reported by Booth *et al*. (1989) came from two psychophysical functions of distances of the stimulus from the norm of the personally preferred level of the stimulus in the familiar object. Two stimulus-response functions are the minimum for a theory of mental interactions. The functions can be from two stimuli to one response but in this case they are from one stimulus to two responses. One of the responses integrates various processed features of the situation (preference). The other response purports to analyse specifically the stimulus feature (caffeine), by use of the acknowledged term under which to conceptualise such a stimulus (bitter).

Such data provide measures of the following three distinct discriminations (Booth & Freeman, 1993). Each of the two conceptual responses discriminates between levels of the material stimulus. In addition, one of the responses discriminates between levels of the other response. The influence of the analytical descriptor concept on the integrative preference is of more interest here and so that is the direction of conceptual discrimination tested in this paper.

Those three discriminative processes might interact with each other. Such hypotheses bear on the issue of what an assessor had in mind when deciding the integrative judgment of preference. The simplest covert interaction is an influence on the integrative response from the relationship of the analytical response to the stimulus (Booth & Freeman, 1993). In other words, preferences might discriminate between described strengths of the stimulus (the bitterness of caffeine) as well as between levels of stimulation (caffeine concentrations) and/or levels of the conceptualised quantity (bitterness ratings).

In addition, three types of interaction deeper in the mind can be calculated, as follows. The analytically descriptive function might modulate the otherwise direct effect of the stimulus on the integrative response. This process corresponds more closely than the others hypothesised to a sensation or conscious percept that influences preference. Alternatively, description might inform use of the analytical concept in deciding preference. Such a process might be regarded as the intended meaning or outcome of the desired choice. A third pair of possibilities is that the integrative response is influenced by the discrimination of one response concept by the other, either way round. This sort of process resembles reasoning from concept to concept, such as deduction. These more complex hypotheses are tested in this paper as well.

The combinations of normed discrimination distances corresponding to each of those seven types of mental process were calculated from an individual's raw data from a run through the object's variants. Each such cognitive model produces a different set of numbers. The hypotheses are tested against each other by the extent that each accounts for the variance in the integrative response being modelled – in this paper, rated preference. If the analytical

concept of bitterness is involved in the best model of the preferences judged before the descriptive word (*bitter*) was introduced, it can be concluded that the concept was in consciousness at that earlier time. If the best model of preference is the caffeine stimulus on its own controlling preference, then that discrimination of the taste of caffeine could have been subconscious.

Method

Participants

The assessors were 19 women and 9 men between the ages of 50 and 85 years, and 14 women and 10 men between 20 and 45. Both genders and the two age ranges were recruited in order to test for effects of biological age or generational culture, and any interaction with gender (see Figure 1 in Results). The volunteers were highly familiar with the tested object which was their usual drink of coffee. Each reported usually drinking at least 5 cups of caffeine-containing instant coffee a week. Five assessors who also often drank ground coffee were excluded from the analyses of mental processing in case such experience affected details of performance on the samples of instant coffee tested. Eight drank coffee without milk or sweetener, 21 used milk and 18 added some sugar or low-calorie sweetener as well as milk (the effects of which were also checked in Results; Figure 1).

Materials

The stimulus tested for discriminative subception was the taste of caffeine. Levels of gustatory stimulation were varied by adding measured amounts of caffeine to cups each containing a fixed amount of decaffeinated coffee solids. The mask was the complex taste of roasted coffee, including compounds other than caffeine that stimulate gustatory receptors that evoke effects to which the English word “bitter” is applied. There is a wide variety of receptors for bitter compounds and caffeine is unlikely to stimulate all of those on which roast coffee compounds act. Hence the mask provided a constant level of noise both in peripheral channels processing the stimulus and in centrally convergent channels, as well as providing distractors such as acid tastants, coffee aroma, mildness or strength of roast, and the rest of the object and its situation of use.

Unmarked cups were pre-prepared with a standard amount of decaffeinated instant coffee powder and caffeine at one of approximately equal-ratio (1.5 to 2) steps (5, 10, 20, 35, 50, 80, 120, 180, 270 or 405 mg per cup). Each sample to be tasted was made in the presence of the assessor by adding hot water and the assessor’s usual amounts of milk and/or sugar or sweetener.

Procedure

The participant was presented with each sample of coffee in turn and asked to take one or two good sips before rating that drink. Successive samples were selected from the pre-prepared set in order to minimise biases on each assessor's responses, in the following way.

The first sample contained approximately the amount of caffeine that was usual in instant coffee at that time (35 or 50 mg per cup). The second sample was two or three steps below or above the first. The third sample was one or more steps in the other direction, to an extent projected to be rated by that individual at least as far from the most preferred level of caffeine as the second sample had been in the opposite direction. This algorithm was intended to minimise range bias (Conner *et al*., 1987), while also as far as possible pre-empting centring bias (Poulton, 1979). Two or three more samples were presented at other levels of caffeine, in an effort to even up the ratings above and below ideal ("always choose") for that assessor while filling any large gaps. This procedure was adopted to reduce frequency biases as well as range bias (Parducci, 1963) in each individual's responses. It has the consequence that assessors taste and rate different sets of coffee drinks.

The first set of samples was each rated for preference, from zero meaning "I'd never choose this brand" to nine meaning "I'd always choose this brand." That set of five or six drinks was then presented once more as freshly made samples in a different sequence (usually reverse order). This time, however, after again rating degree of preference, the assessor judged how bitter that sample was, from a score of one for "not at all bitter" to nine for "as bitter as my usual coffee" (mid-point of the response format) and appropriately higher scores for greater bitterness. This approach resolves a number of deficiencies in both category scaling and magnitude estimation (Booth, 2009; Booth *et al*., 1983).

Measurement of discriminative performance

The individuals' Weber fractions of caffeine in our earlier brief report (Booth *et al*., 1989) were calculated from judgments of preference after the individual's function of ratings on caffeine for each run had been 'unfolded' (Coombs, 1964) at her/his most preferred level (ideal point) to give a log-linear relationship (Booth, Thompson & Shahedian, 1983; Conner *et al*., 1988). However, the isosceles triangle assumed in such unfolding cannot be expected to fit the data well if any other influence on the responses is far from its norm. The reason is that quantitative judgments of an object or situation with multiple features fit the surface of a cone away from its top. The psychophysical function for any one feature cuts vertically through the 'side' of a cone at a distance from the apex that depends on how far any other feature is from its apical level on average (Booth & Freeman, 1993). That is, the judged distances from the assessor's norm for the object plotted vertically against stimulus levels

horizontally falls on a perpendicular conic section, i.e. an hyperbola with its rounded peak at the ideal level.

The discriminative performance of a response on the levels of the stimulus is calculated from the best fitting hyperbola estimated by least squares regression, using the classic formula for a JND (Torgerson, 1956), i.e. the Weber fraction plus one. The formula applies also to the conceptualised quantities driving another response when the logarithmic differences (ratios) of the measurement of levels of a material stimulus are replaced by untransformed scores from those ratings. The term JND is replaced by half-discriminated disparity (HDD) because no threshold ("just") is presupposed, the discrimination may or may not be conscious ("noticeable") and neither the material ratios nor the conceptual intervals are presumed to affect the magnitudes of subjective experiences such as sensations ("difference"). The unsigned slope (dR/dS) of the asymptotes to the hyperbola is divided into the square root of the mean square error in responses (dR). The resulting stimulus disparity (dS) is set to halfway between zero and complete discrimination by multiplying it by twice the z value for 25% of the normal distribution of responses, i.e. superposing the 75th percentile of the lower level of the stimulus (S_0) on the 25th percentile of the higher level (S_1) on each other (Conner *et al*., 1988; Thurstone, 1927; Torgerson, 1958).

Multisensory, multiconceptual normed discrimination scaling

The analytical (bitterness) and integrative (preference) psychophysical functions each provide an optimum value for the stimulus (caffeine) as well as an HDD. The level of caffeine interpolated at the "usual bitterness" or "always choose" response anchor is the norm point (NP) from the respective function. The discrimination function of the integrative response (preference) for the analytical concept (bitterness) also has an HDD and NP. The function's HDD is a measure of the assessor's tolerance of deviations from her/his NP.

These HDDs provide the unit for scaling the distance of each sample from that NP for that individual in that session. The resulting discrimination distances can then be compared with each other by least-squared deviates for linear fit to a set of integrative ratings.

Similarity between or among discriminative processes in their influence on integration can be identified as the successful accounting for variance by addition of distances along one dimension. A categorical distinction between two functions (of solo or summed distances) is represented by the distances of the samples' levels from the norm along two orthogonal dimensions. Since Pythagoras's theorem generalises across any number of orthogonals, the square root of the sum of squares generates whatever dimensionality improves the fit to the set of integrative ratings (Booth & Freeman, 1993).

The seven types of mental process characterised at the end of the Introduction can each be labelled by a single word, with a corresponding letter code. One predictor of the integrative judgment of preference is the level of the stimulus, a stimulatory (S) model. This is an observed psychophysical relationship but it can specify a mental process when HDD-scaled distances of stimulus levels from NP are better predictive of the integrative judgments than are any of the other six types of model, each of which implicates the stimulus only indirectly at best.

The analytical ratings of the feature by themselves provide another predictor of the integrative ratings. This calculation tests the hypothesis that the integrative response (preference) is influenced by covert input from the concept behind the analytical ratings of bitterness. Such response (R) models are called conceptual.

The integrative judgment can be influenced covertly by another observed relationship, the traditional psychophysical function for a conceptualised material feature (here of a real object, not in artificial isolation). Best accounting for such object recognition by this hypothesis indicates that successful description of the stimulus feature by the analytical response (S/R) plays a role in those integrative judgments of the samples. Hence this S/R calculation is called a descriptive model of the integration.

Two deeper levels of processing are also considered in this paper, based on models developed since Booth and Freeman (1993). The HDDs from NP can be calculated for the caffeine/bitterness descriptive function on caffeine levels and the data so scaled (S//S/R) used to predict the ratings of preference. This can be interpreted as a perceptual process, since it is descriptive (S/R) of stimulation (S) – in this experiment, most closely corresponding to what has traditionally been called a sensation of taste.

A process on the output side also can be estimated, using the HDDs from NP for bitterness ratings (R) on the caffeine/bitterness function (S/R), an S/R//R model. Since this prediction of the integrative judgment is a response under a description, it has the nature of an intended meaning. So S/R//R processes are called intentions.

After these elemental models of different types of mental process have been estimated from an individual's data for a session, each pair of elements is tested for operation over a single communication channel within the mind. Sameness or superposition is realised quantitatively as additivity. Difference or separation amounts to orthogonality. Therefore each pair of elements, model A and model B, is tested for a similarity between A and B by adding the distances from NP in HDDs to see if the interaction A + B accounts for more of the variance in the judgment being modelled than does either A or B alone. Validated in this

way, the function A + B identifies and measures a channel processing a similarity between A and B that may turn out to contribute to the modelled judgment.

The three functions A, B and A + B are then tested for categorical differences from each other, i.e. to see if they operate over channels that are orthogonal. If the square root of the sum of the squares of HDDs from NP of each pair of functions (e.g., A and B) accounts for more variance in the integrative judgments than does either of the pair's elements alone, that is evidence that distinct aspects of each element interact to influence the modelled response (Booth & Freeman, 1993). Such two-dimensional integration is coded as A Γ B, where Γ (capital gamma) represents the square root of the sum of squares. [Greek u.c. *gamma*]

Both similarity and differences between A and B can occur. That is, the one-dimensional model A + B and the two-dimensional A Γ B can each account for some variance in the integrative response. It is then possible that the three-dimensional model, A Γ B Γ (A + B), is more predictive of the integrative judgments than any of the three pairs, A Γ B, A Γ (A + B) and B Γ (A + B).

The best multidimensional discrimination model of the integrative judgments (preferences) by an individual assessor in a session is used in this paper to address the question if that performance involves implicit processing of differences in analytical response (bitterness) between instances of the object (coffee) and, if so, whether that processing is conscious or may not be. The preference judgments were taken to involve the concept of bitterness implicitly if the best model of preference ratings made before the term *bitter* was mentioned to the assessor nonetheless included data from the subsequent ratings of bitterness, i.e. any of the perceptual (S//S/R), descriptive (S/R) and intentional (S/R//R) models, or the bare conceptual model (R) that shows an explicit influence of the concept on preference. If the bitterness concept were not involved at all in the most successful account of preference, i.e. it was a purely stimulatory model (S), this would be evidence by contrast that the concept was not used in those initial judgments of preference and so the differences in intensity of the taste of caffeine at that stage could have been subconscious.[1]

The above calculations from the raw data for each session for an individual participant have been programmed into a Java applet (Co-Pro 2.29). This tool outputs the HDD and NP for each psychophysical function and the best-fitting model of the mental processes involved (as well as the other valid models that did not cover as much of the variance in the modelled response).

Statistical analyses

The characteristics of individual assessors were compared within or between groups by analysis of ranks or variance as appropriate, using SPSS 16.0.

Results

Better integrative than analytical discrimination

Over half of the participants were better at discriminating between levels of the stimulus (caffeine) by their integrative judgments (preferences) than by their analytical judgments (bitternesses). Initially rated choices by 34 out of the 52 assessors had a lower Weber fraction than intensities rated using the stimulus-specific descriptor (Figure 1). After descriptive ratings were introduced, there were still 28 assessors who were more discriminative in their overall preferences than in their analytic conceptualisation.

Figure 1 here

These individuals with better discriminative integration were likely to have been as aware of the analytical characteristic of all the samples of the object as the other assessors were, because the constant mask shared that characteristic with the varied stimulus. So, by the conventional verbal criterion, they cannot be said to be processing the presence of the stimulus subconsciously. Nevertheless, they failed to distinguish disparities in the intensity of the characteristic coming from the stimulus in this context as effectively as they discriminated stimulus levels in their likings for the samples. Those with that pattern of performance are therefore categorised as "integrative discriminators" of the bitterness of caffeine. Those having a better Weber fraction for analytical judgments than for integration were labeled as "analytical discriminators." An integrating discriminator would be shown to be subconsciously processing disparities in level of caffeine if her or his analytical ratings of bitterness did not account for the integrative performance.

The direction of the difference in discrimination between the integrative and analytical responses was not associated with the proportion of variance in either sort of judgment by an individual that was accounted for by levels of the stimulus. About half of both analytical and integrative discriminators had a normed psychophysical function with $r^2 < 0.1$, whereas most of the others in each group had r^2 values in the range 0.47 to 0.81.

Multiple discrimination scaling of rated preferences

The interactions among discriminal processes that best accounted for each individual's two sets of integrative judgments were examined in two ways. One formula (an R model) treated the analytical response as a potential conceptual influence on integration (Booth & Freeman, 1993). The other formula (an S model) treated the analytical term as a covert symbolic stimulus, discriminated in equal differences in rated intensity.

In some individuals, the interaction of this sort that accounted for most variance in the integrative judgments was very low ($r^2 < 0.5$ in 17% with the analytical concept treated as a stimulus and 61% with it treated as a response), although 55% of the models with the concept

as a stimulus had $r^2 > 0.8$. Given the difficulty of the perceptual task imposed by this experiment, it is likely that some assessors changed strategy at least once over the series of five samples; if so, it would be logically impossible for a single model of any sort to fit the data.

Integrators and analysts did not differ in the proportion who processed integration purely in terms of the analytical concept. However, the response-driven descriptive processes of integration, conceptually modulated (R/R) or not (R), were numerically higher in proportion to the stimulus-driven perceptual (S//S/R) and stimulatory (S) processes among the integrators than among the analysts. This difference in distribution between the groups approached reliability, $\chi^2(2) = 5.58$, $P = 0.061$. Thus there was no general evidence of more prevalent direct control of integration by the stimulus among integrative discriminators.

Integrative processing after analytical judgments

First we consider the most successful multiple-discrimination model of each person's integrative judgments after a way had been provided to conceptualise the actual disparities between samples. The participants were asked to rate the bitterness of each coffee as well as to rate preference again. These later preferences are explained in this section of Results.

Analytical judgment as response. After the analytical term was introduced, integration was decided by using that concept in a majority (58%) of the 47 assessors (excluding those who also used ground coffee). The proportion of these models did not differ appreciably between integrators (55%) and analysts (61%), but the median of the variance in the integrative judgments that they accounted for was greater among the integrators, Mann-Whitney $U = 144$, $P < 0.01$. There was no clear evidence that this control of integration by the analytical concept (high r^2) was attributable to the control of the concept by the stimulus (low Weber fraction), Spearman's [Greek letter *rho*] $\rho(27) = 0.29$, two-tailed $P < 0.14$. This was true even among models accounting for more than 0.49 of the variance in integration, [Gk. *rho*] $\rho(15) = 0.37$, two-tailed $P < 0.18$. Indeed, in many assessors the analytical judgments showed poor Weber ratios for the stimulus. Hence the good models of integration were likely to depend on the operation of the analytical concept by itself, not on any influence on the concept by the stimulus.

It is worth noting that the integrative processes that involved the analytical concept in some more complex way having $r^2 > 0.49$ were descriptive (S/R) in three assessors and intentional (S/R//R) or perceptual (S//S/R) in one each. Two assessors had a caffeine-stimulatory (S) model of these initial preferences.

Analytical judgment as stimulus. A complementary picture emerged when the analytical scores were treated as conceptual stimulation alongside the material stimulation

from the varied levels of the stimulus. A majority of the assessors (67%) processed the material (caffeine) and conceptual (bitterness) stimuli as separate influences on the integrative response (preference). However, integration by a few assessors (11%) discriminated some similarity between the material stimulus and the conceptual stimulus (that is, operating as a single mental process), with or without some residual difference in the concept as well (through a second process). The best model for integration in each of the remaining assessors (four out of 47) was only the material (7%) or only the concept (7%) as stimulus.

Hence the findings from this use of normed discrimination scaling indicated that distraction by the task of descriptive analysis rather seldom destroyed all influence of the material stimulus on the integrative judgments.

Integrative processing before analytical judgments

That evidence for analysis during integration has provided a basis for considering if the analytical concept had some role in the integrative judgments made on the first set of samples, before the experimenter had mentioned the analytical term. The analytical ratings from the second run through the samples were used in the discrimination modelling of the integrative ratings in the first run. These calculations test if levels of the analytical concept were used in those initial integrative judgments. The findings could identify any instance of covert self-presentation of the analytical concept to label the samples.

Analytical term as concept during initial integration. Although the analytical term had yet to be mentioned, the best explanation of the first ratings of preference was the later bitterness ratings in 31 (66%) of the 47 assessors modelled. In 23 (74%) of this 31, the second run's integration into preference was also driven by the analytical concept of bitterness. All but six of these consistently conceptual assessors increased or stayed the same in the variance accounted for in the integrative judgments during the second run; those who decreased did so only slightly (reductions in r^2 of 1% to 13%). These results indicate that many of the assessors were using their analytical concept in their integration before the word had been mentioned. Nevertheless, as would be expected, the concept's influence on integration was usually increased by the explicit introduction of the usual term for describing the stimulus.

Most of the other participants' initial integrative judgments were best accounted for by more complex processes involving the analytical concept (N = 15). The majority of this remaining group (11; 23% of the 47 modelled) decided their integrative ratings by a process of describing the stimulus (S/R). Two assessors used bitterness to conceptualise the description (S/R//R), perhaps the intention in the integrative decision. Two further assessors used description on the stimulus side of processing, to modulate stimulatory processing

(S//S/R). That is, they may have decided their preferences in accord with a sensation of the characteristic of the stimulus.

Just six of the 47 participants modelled used only the levels of the stimulus to decide their degree of preference for each sample coffee first time around (S model). The best of these stimulation processes had $r^2 = 0.69$ merely and the other five ranged from 0.32 to 0.06.

Analytical term as stimulus in first integration. When the later analytical ratings were used to estimate any influence of that concept as a stimulus to the first set of integrative ratings, combination of the manipulated stimulus and of the analytical concept as a stimulus was found in a similar majority of assessors (73%) to that with the second set of samples. A few assessors (5 out of the 47) discriminated some similarity between the material stimulus and the conceptual stimulus, either as the sole process (in 6%) or as one of the processes within a two-process model (in 4%). The proportions of the whole set of assessors having the different sorts of model did not differ noticeably between runs. On the other hand, this line of modelling did not often show consistency between the two runs within individual assessors.

The remaining assessors had best models of only the stimulus (12%, twice as many as when the concept was rated) or of only the concept (4%, half the number during analytical ratings). Hence the assessors who did not achieve any sort of integrative response were in general less distracted by attention to the analytical concept than when the word was in overt use and were more susceptible to disparities in the strength of gustatory stimulation by caffeine.

Stimulus processing among integrators: implicit* vs. *subconscious

The integrative discriminators showed great diversity in the best multiple discriminations model of their integrative judgments during the first run through the stimulus-varied samples of the object.

A majority (19 of the 28) made implicit use of the concept that they used in analytical judgments during the second run through the samples. However, in four of these assessors, this conceptual (R) model accounted for less than a quarter of the variance in the assessor's initial integrative judgments (r^2 between 0.12 and 0.19). For seven, nevertheless, r^2 was 0.7 or over. This left little or no reason to doubt that the analytical concept, made explicit later only, was controlling these assessors' initial stimulus-discriminating integration.

This implicit use of the analytical concept was further indicated by the fact that 13 assessors determined their preferences by the process of conceptualising bitterness in both runs through the coffee samples. Moreover, the variances accounted for by these models were highly correlated between runs. The correlation was kept down to $r = 0.56$ ($P < 0.05$) by two of the five assessors with the lowest variances accounted for in integrative judgments

during the first run (r^2 =< 0.30) having among the four strongest conceptual models in the second run (increasing r^2 from 0.19 to 0.87 and from 0.30 to 0.91). Excluding those two assessors, the correlation between variances accounted for by conceptual models of integration in the first and second runs was r = 0.88, P < 0.001, with r^2 ranging from 0.06 to 0.96, median 0.60. That is, these eleven assessors, each with a Weber fraction for initial integration better than the fraction for later analysis, were thinking with their analytical concept while making integrative judgments as clearly before the experimenter introduced the analytical term as they were afterwards.

A substantial minority (seven) of the integrative discriminators made a deeper use of their analytical concept in their integrative ratings. Six used the concept to describe the stimulus (r^2 of an S/R model ranging from 0.97 down to 0.14). One used that description in her analytical conceptualistion of bitterness (S/R//R r^2 = 0.49).

In summary, even though the initial judgments of preference by these integrating discrminators were more differentially sensitive to the stimulus than were their analytical judgments of bitterness in the second run, nearly all of them (26 of the 28) put their analytical concept to implicit use in deciding this first set of integrative judgments.

Only the remaining two of the 28 assessors with better Weber fractions for integration than for analysis had their initial judgments of preference driven directly by levels of the gustatory stimulation by caffeine (S model r^2 of 0.69 or 0.32). In these participants it is possible that the integrative judgments of preference discriminated between levels of the stimulus outside of consciousness.

There was one further indication that each of these two assessors integrated by means of subconscious discrimination of the level of the stimulus from a personal norm. The Weber fractions for these two assessors' integrative judgments did not improve after the introduction of the analytical term by the experimenter. This contrasts with what was observed in many of the other assessors (reported above). We have seen that all the other better discriminators by integration than by analysis were aware of differences in the analytical intensity at some level during the initial run. If these two assessors were successfully discriminating subconsciously between levels of the stimulus, the descriptor conceptualising the stimulus might well have been of no use to them in that task, even when put to explicit use.

Finally, it should be mentioned that none of these perceivers of differences in stimulus levels in their first set of integrative judgments decided those initial preferences by variations in a sensation (an S//S/R model) consisting of a description of the gustatory stimulation by caffeine that relied on the word *bitter* to concepualise that stimulus. This weighs against the widespread assumption that psychophysical judgments measure subjective magnitudes.

Discussion

Normed discrimination approach to consciousness and cognition

The idea that subconscious processing enables fast decisions in life has become popular again recently (Gladwell, 2005). Nevertheless the evidence remains very thin. Common methods for addressing the issue are laborious to execute and coarse-grained in the structure of the data. The presupposition has been that it is impossible to measure ongoing performance in any detail because of diversity among individuals and instability within the individual. However, if a particular sort of situation is varied within a familiar range, the influences of inputs on outputs can be measured within an individual and rapidly as well (Conner, Land & Booth, 1987). Interactions among mediating mental processes can be characterised by use of normed discrimination as a common metric among both material and symbolic sources of information (Booth & Freeman, 1993). Now that this approach has been fully implemented computationally, the present paper illustrates its potential for advancing the understanding of subconscious perception in life.

Subconscious or implicit perception of differences?

Over half the participants in this experiment discriminated between levels of one of a familiar object's features better by their integrative judgments (i.e., preferences) on samples of the otherwise unvaried object than they did by judgments focused on the feature identified by its usual verbal label (i.e., bitterness). This finding can be taken to indicate that the feature had a higher discrimination 'threshold' than the whole object in those people under these circumstances. These participants might be considered to be differential subceivers.

However, the evidence also was that most of those apparently subconscious discriminators were using the verbal label or a related concept to judge overall before that label for the feature had been made explicit by the experimenter. Only about 7% of the seeming subceivers provided evidence that they might have been processing disparities in levels of the varied feature subconsciously with respect to the verbal label.

This result illustrates how individualised multiple discrimination scaling can address difficulties that have arisen during work using detection paradigms. It is far from obvious how to choose a criterion by which to identify perception that is subconscious in some absolute sense (Merikle *et al*., 2001). For example, the label applied to the perceived feature may not capture all that represents that feature in consciousness. That problem is reduced by the diagnosis of covert processing that is delivered by multiple discrimination scaling.

Another problem for research into the mental processes of consciousness is that the response used as the indicator of perception of the feature even if it were subconscious may not be captured by the same metric as that used on the feature in awareness. Discrimination

uses the same Thurstone (1927) Case V comparison formula as detection to provide an intensity spanning metric that is independent of physical units of measurement, the half-discriminated disparity (HDD). This unit of divergence between strengths of a material stimulus is the 'just-noticeable difference' interpreted objectively (Torgerson, 1958). Ernst and Banks (2002) used just the response variances to account for dominance of one sensory modality over another. That approach is less flexible than the scaling in HDDs, because these involve the slope as well as the mean square error of the psychophysical function. Scaling on the HDD also permits many other integration rules to be tested. Furthermore, the HDD can be used to scale any sort of stimulus, whether symbolic (like the word *bitter*) or material, like caffeine (Booth & Freeman, 1993; Conner *et al*., 1988; Freeman & Booth, 2010).

In addition, normed multiple discrimination has a more fundamental merit, providing a substantial improvement on multiple detection (Macmillan & Creelman, 2004). The characteristic features of objects are 'suprathreshold' in general, and indeed almost by definition. Hence, contrary to the presupposition of classical psychophysics, the psychological zero is not absence of the feature but its usual level in objects within a particular perceptual category. What needs to be detected is not the presence of the signal but a difference in signal strength from its norm. Once that step towards realism has been taken, then extraordinarily complex situations may become amenable to experimental analysis. These include not only familiar mixtures of tastants (Booth, Freeman, Konle, Wainwright & Sharpe, under review; Booth, Konle & Sharpe, 2008) but also mixtures of odorants simulating a natural aroma containing dozens of smelt compounds (Booth, Freeman & Kendal-Reed, 1995; Booth, Kendal-Read & Freeman, under review; Kendal-Read & Booth, 1992), the amplitudes and frequencies of microfracture patterns heard during the crushing of a material (Booth, Earl & Mobini, 2003) or of viscous arrays of fat droplets rubbing over tactile receptors (Richardson & Booth, 1993), and the conceptual attributes of pictured objects (Booth, Sharpe, Chechlasz *et al*., under review).

Traditional presuppositions in psychophysics make caffeine in water appear to be much simpler to investigate perceptually than caffeine in coffee. However, purity and precision of control come with artificiality. In contrast, consistently with many theories of perceptual learning, a familiar reality creates a 'template' and 'hidden variables'. The linear responding that has been acquired to valid affordances provides a powerful tool for dissecting out the mental processes that are operative during action on the complex reality.

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Footnote

[1] These interactions among elemental processes can be estimated without regard to type of process ('open' modelling) or each hypothesis can be confined to a single type of process ('closed' modelling). In the present data and in the variety of other types of data that we have analysed this way so far (papers under review or in preparation), the most predictive open models have generally accounted for very little more variance by their greater complexity than have the best closed models. Hence, to economise on space, only the results of closed modelling are presented here.

Caption to Figure

Figure 1. Proportion (%) of each subset of participants whose initial integration was more (left-hand bar) or less (right-hand bar) discriminative than their later analysis, split by age group, gender and the absence or presence of added material obscuring or countering the stimulus. Left side: age ranges in years (each N = 26). Middle: female (N = 32) or male (N = 20). Right side: plain coffee (unsweetened, unmilked: UU; N = 8); unsweetened coffee with milk (UM; N = 21); sweetened coffee with milk (SM; N = 18). *For UM, $\chi^2(2) = 6.03$, $P < 0.05$. Better discrimination of caffeine by preference might be induced by milk's blockade of receoptors for distractors in roast coffee flavour. Sweeteners on the other hand might counter all bitterness centrally including that of caffeine.

Figure 1