Sodium Consumption,

Health and Food Palatability

Sodium Consumption,
Health and Food Palatability

Melinda Ferrier (B.A., Hon.)

A report submitted as a partial requirement
for the degree of Masters of Clinical Psychology
in the Department of Psychology,
University of Tasmania, 1998.

This thesis contains no material which has been accepted for the award of any other higher degree in any university and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except when due reference is made in the text of the thesis.

Signed..

Acknowledgments

I would like to thank all the people who in some way contributed to the completion of this thesis. I am especially grateful to my supervisor, Peter Ball, for his continual support, advice and encouragement. In addition I would like to thank Trevor Beard and David Woodward, for their generous time and insight in the analysis and presentation of this study, the staff of the Psychology Department for their assistance, knowledge and guidance, and participants in the study, including the staff at Department of Community and Health Services, and first year psychology students. I am also grateful to my work colleagues who kindly assisted in the collection and sterilisation of the film containers, my parents who travelled throughout Queensland collecting the journal articles I required, and finally, my friends Robyn, Linda, Lyndal, Karen, Louise and Malcolm for assisting in the soup kitchen.

Table of Contents

Journal Article

List of Tables

List of Figures

Sodium Intake and Health: Factors Affecting Food Choice and Salt Reduction

Melinda Ferrier (B.A., Hon.)

A report submitted as a partial requirement
for the degree of Masters of Clinical Psychology
in the Department of Psychology,
University of Tasmania, 1998.

Abstract

There is concern that humans consume sodium, mostly as salt (sodium chloride, NaCl) at levels that produce significant medical risks. The current review gives an appraisal of psychologically relevant research into concerns in relation to sodium intake. Determinants of food choice, including sensory preferences, familiarity and exposure, customary level of sodium in daily diet, attitudes, and personality traits (including food neophobia) are explored, and their impact on dietary sodium is also discussed. In addition, strategies for reducing salt levels are discussed, including a reduction in salt content in food products, and the use of alternative tastants to salt. The use of glutamate salts such as monosodium glutamate (MSG) and calcium diglutamate (CDG) as alternative tastants is discussed. Finally, there is a summary of the methodological issues of the research reviewed and recommendations for future research into the area of alternative tastants is provided.

Sodium Consumption

Since the early 1980's there has been growing concern that humans are consuming sodium, mostly as salt (sodium chloride, NaCl) in excess of known physiological needs, and at levels that produce significant medical risks. Governments, health organisations and nutritionists worldwide have urged a reduction in sodium intake. In support of these concerns, national and international dietary guidelines have been developed, recommending a reduction in sodium intake (National Health and Medical Research Council (NH&MRC), 1992; National Research Council, Committee on Nutrition and Health, 1989; World Health Organisation, 1990). Internationally, both the World Health Organisation and the United States National Research Council's Committee on Nutrition and Health advise that healthy adults should consume less than 100 mmol of sodium per day (6.0g NaCl). In Australia, the NH&MRC has set the Recommended Dietary Intake (RDI) for sodium at 40-100 mmol/day, and the need to reduce sodium intakes was acknowledged by the Health Targets and Implementation (Health for All) Committee (1988) who adopted national dietary targets for sodium intakes to be achieved by the year 2000. These targets include reductions in sodium intake to 100 mmol/day or less by the year 2000.

Nutrition intervention programs and education campaigns conducted by various health authorities throughout the country have focused on the messages included in the dietary guidelines (Crawford & Baghurst, 1990). This has been paralleled by increased media attention to food and nutrition issues, and increased efforts by the food industry to provide consumers with nutrition information.

There is some evidence that such efforts have been effective, as there appears to be a trend demonstrating that some sections of the public may be reducing their sodium intakes (Baghurst, Record, Syrette & Baghurst, 1989). Concerns remain however, that sodium intakes in the Australian diet remain too high, and this is evidenced by the findings of Beard, Woodward, Ball, Hornsby, von Witt and Dwyer (1997) who found excess sodium consumption, despite a high proportion of participants reporting a reduction in salt intake.

The aims of the current review are to provide an understanding of the concerns in relation to sodium intake, and to explore the determinants of food choice behaviour and their impact on dietary sodium. In addition, strategies for reducing salt intake will be provided and discussed in terms of their implications for future research into the reduction of dietary sodium. This includes an exploration of the merits of the use of glutamate salts as alternative tastants and recommendations for future investigations into the area of alternative tastants.

Impact of Sodium Intakes on Health

Many health problems are associated with the current sodium intake of people in Western societies (Antonios & MacGregor, 1995). Australian health authorities, in setting a national sodium-intake target, have acknowledged that excessive dietary sodium results in significant morbidity, mortality and economic costs to the community.

Dietary Salt: Effects On Cardiovascular Risk Factors and Disease

Cardiovascular disease (CVD) is the leading cause of death in Australia, responsible for 43.8% of all deaths in 1993 (National Heart Foundation of Australia, 1995). Cardiovascular risk factors (eg high blood pressure) and disease are significantly affected by diet. A considerable body of evidence has accumulated implicating sodium in the aetiology of high blood pressure (Elliott, 1991) and data from several studies indicate that a decrease in dietary sodium may favourably affect hypertension (Cutler, Follmann, & Allender, 1997; Elliott, Stamler, & Nichols, 1996; Intersalt Cooperative Research Group, 1988; Law, Frost & Wald, 1991; National High Blood Pressure Education Program Working Group, 1993).

In 1991 Law, Frost and Wald reported that a decrease in sodium intake to 100 mmol/24 hour has been associated with an average fall in systolic blood pressure ranging from 5 mm Hg at age 15-19 years to 10 mm Hg at age 60-69. Similarly, in a recent study Elliott et al (1996) showed that among adults aged 20-59 years, there were highly significant positive associations between average sodium intake (measured by 24 hour urinary excretion) and slopes of blood pressure with age in the 52 study populations; and between individual 24-hour urinary sodium excretion and blood pressure among the 10 000 or more study participants. Evidence also indicates that a decrease in dietary sodium may favourably affect cardiovascular morbidity and mortality (Law, Frost & Wald, 1991). These findings and consistent results from other clinical studies (Cutler et al, 1997) have led to independent expert groups recommending a reduced salt intake for hypertensive persons and for the general population.

Dietary Salt: Effects On Other Conditions

The consumption of food containing salt in preservative concentration expands the extracellular fluid volume, with a corresponding weight gain of about 2 kilograms (Freis, 1976). The consumption of salt-preserved food, and resultant volume expansion, aggravates all conditions associated with oedema, such as congestive heart failure, idiopathic oedema, premenstrual syndrome, Meniere's syndrome and carpal tunnel syndrome (Beard, 1990).

A salted diet also increases the obligatory loss of calcium in the urine, with significance for osteoporosis and recurrent calcium stone formation (Goulding, Everitt, Cooney & Spears, 1986), and experimental evidence as well as some epidemiological evidence also suggest that salt intake may have an adverse effect on stroke mortality which may be independent of its effect on blood pressure (Antonios & MacGregor, 1995). Salt in hypertonic concentrations has also been associated with chronic atrophic gastritis and stomach cancer (Joosens, 1980).

Strategies to reduce dietary sodium intakes in the community have the potential for reducing the population burden of CVD and associated community costs, and assisting in reducing a number of other medical conditions. However, whilst a low-salt diet may assist in the management of such medical conditions, this will be very difficult to implement unless methods can be found of modifying foods so as to provide less sodium with minimal loss of consumer acceptance.

Sodium Intakes in the Australian Diet

Sodium intake has been estimated by a variety of methods including a salt frequency questionnaire, diet collection, weighed food records, overnight, casual, single 24-hour and multiple 24-hour urinary sodium excretions. Questionnaires are advantageous for reasons of cost and efficiency, but they need to be validated before use if they are to give meaningful results (Shepherd & Farleigh, 1987). Duplicate diet collection leads to an underestimate of total food intake (Stockley, 1984), is very costly to perform and discretionary salt may not be accurately represented. Weighed food records give very poor estimates of sodium intake since salt added in cooking or at the table is rarely accounted for, although the contributions from these sources may be assessed separately using pre-weighed salt pots (Shepherd & Farleigh, 1989). Sodium excretion methods require motivated subjects to follow the necessary instructions, and are a more costly procedure than the other alternatives. However, procedures based on the 24-hour sodium excretion are considered the method of choice, having a relatively high degree of validity for the measurement of "usual" sodium intake (Elliott, 1991).

Dietary intakes of sodium in Australia are generally reported to be significantly higher than the national target of 100 mmol/day or less. A study in Sydney (Notowidjojo & Truswell, 1993) measured 24-hour urinary sodium excretions in three different groups (N=117) of healthy adult subjects. The lowest mean sodium excretion was for nutrition personnel (133mmol/ day); next lowest was for individuals following a western, traditional Australian diet (146mmol/ day), and the highest was for individuals following an Asian dietary pattern (168mmol/ day). Notowidjojo and Truswell report that their western diet group is the most representative of the majority of Australians, and that the values for this group are comparable to those values reported in a Tasmanian study by Beard, Eickhoff, Mejglo, Jones, Bennett and Dwyer

(1992) of 142 mmol/day. In a more recent study carried out by Beard et al. (1997) measures were taken of the 24-hour sodium excretion of 194 Hobart residents and the mean sodium intake was reported to be 170mmol for men and 118mmol for women. Both Beard et al. (1997) and Notowidjojo and Truswell (1993) found that only a small minority of subjects were within the recommended guidelines of 40 to 100 mmol/day for sodium excretion. These studies all provide evidence for the concerns that average sodium intakes in the Australian diet are substantially above the national target.

Results from the National Heart Foundation's Risk Factor Prevalence Study, 1980-1989 (Bennett & Magnus, 1994) indicate that there has been a decrease in the proportion of Australians who add salt during cooking or at the table. This is consistent with a population survey conducted in 1988 (Baghurst, 1989, unpublished data in Crawford and Baghurst, 1990) in which most of the participants who reported cutting back on the salt in their diet had done so by reducing salt used during cooking or added to their meals at the table, and with the findings of Beard et al. (1997) who reported that most of their participants claimed that they never or rarely added salt at the table, or never or rarely cooked with salt. Discretionary salt however, contributes only about 6 to 10% of total sodium in the diet, hence reducing it has only a marginal effect on overall intake. Approximately 10% of daily sodium intake comes from the natural sodium content of food, and the majority of salt consumed (at least 75%) comes from sodium compounds (mainly salt) added during processing (James, Ralph, & Sanchez-Castillo, 1987).

Role of Processed Foods

Evidence suggests that a salty taste appears to be extensively preferred (Beauchamp, Bertino & Moran, 1982; Kare, Fregly & Bernard, 1980). The main cause of excessive salt intake is no doubt that people's palates are adapted to salt in preservative concentration. This preference is due in part to the high levels of salt that consumer's have become used to in the popular foods bought ready to eat, particularly packet foods like cereals, biscuits and chips, and processed foods from fast-food outlets. The high sodium content of some foods from fast-food outlets is striking. An analysis of the sodium content of a wide variety of foodstuffs in common use in Australia, in particular 'convenience' foods, showed a large proportion with a very high sodium content of 150-600 mmol/kg (Dale, 1979).

Given the large quantity of salt consumed in processed foods, any programme for reducing the population's salt consumption will need to concentrate primarily on a reduction in the salt used during food processing. In recent years food manufacturers have responded by ensuring some low-salt processed foods are available and labelled in accordance with the food regulations. However, consumer's preference for the salty taste has to date ensured that many of these low-salt products on the market are unpalatable to a majority of consumers.

Influences on Food Choice

Food choice is a complex human behaviour. All food and fluid intake results from choices, and an understanding of the determinants of this behaviour has major implications for food producers, food consumers, and those interested in public health. Psychological research has contributed significantly to this area. Work on sensory preferences has demonstrated how physical characteristics of foods are related to individual food choices (Booth & Conner, 1990). Individual differences on sensory-affective grounds (e.g., liking or disliking lima beans) account for large variations in food preferences within a culture (Rozin & Vollmeche, 1986). However, whilst liking of a food is an important determinant of its selection and a large part of this liking relates to the sensory attributes of the food, it is important to note that other factors might be implicated in contributing to food choice, such as familiarity and exposure, preferences of others, personality traits, beliefs about nutritional quality and health effects.

Sensory Preferences

The sensory qualities of food plays an important part in determining whether they are selected for consumption. In food science, sensory evaluation is used to answer questions relating to differences between samples of foods, which might derive from different sources or different processes (Shepherd & Farleigh, 1989). The psychological measurement of sensory preference is often called palatability. Palatability is a hypothetical construct which is needed to account for the likeable aspects of the taste, smell, flavour, texture, etc of food. Palatability is determined by the result of the integration of orosensory and postingestive stimuli, and consequently it depends on the interaction of food and the organism (Rogers, 1990). The usual empirical definition of the palatability of a food or drink is its momentary sensory facilitation of an individual's disposition to ingest in a specified context. This disposition is measurable as relative amount or probability of intake. In humans, it can be expressed as a verbal degree of acceptance that is predictive of ingestion (Booth, 1994).

Measurement of Sensory Preferences. Perhaps the simplest sensory tests are those of whether there is a difference between samples. Although this has been a very popular method used in evaluating foods (Shepherd & Farleigh, 1989), its use is becoming less common because the information that is obtained is limited.

An extension from the idea of difference testing is that a scale can be devised which reflects equal psychological differences between stimuli by measuring how often stimuli are confused (Shepherd & Farleigh, 1989). This scale can be developed using the Just Noticeable Difference (JND). The JND is defined as the size of increment that must be added to a standard stimulus before a sensation is aroused which is different from the standard (Torgerson, 1958). Thus by measuring JND's it is possible to build up a scale based on the psychological continuum of interest (Thurstone, 1927). A number of scales have been developed using this sort of procedure and those scales commonly used in the sensory area include, 1) category, 2) unstructured and 3) magnitude estimation.

Category scales may be unipolar (eg labelled categories from 'no taste' to 'extremely strong"), or bipolar (ie have opposite adjectives at each end such as tough/tender). The most commonly used scale to index liking and acceptance is the hedonic scale. This type of scale measures the pleasantness experienced or the affect of a person, and tends to be used with untrained assessors. These scales are generally based on one developed by Peryam and Pilgrim (1957), and the usual form is a nine-category scale with category labels: like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much, dislike extremely. This type of scale has been widely used in studies where actual food samples are rated as a simple and direct index of the liking and/disliking for foods and /or its sensory attributes. Where samples are presented with a clearly varying attribute (such as salt or sugar concentration) the usual form of the response is an increase in liking for an increase in the attribute which reaches a maximum and then declines with further increases in the attribute. This maximum represents the most preferred level (or ideal) of that attribute for the individual (Shepherd & Farleigh, 1989). This scale is used widely throughout the world, but it does suffer from a number of well-known problems common to category scaling techniques. These problems include the fact that the end categories are underutilised, and that the neutral category reduces the efficiency of the scale (Moskowitz, 1980). Another criticism has been that the category labels do not constitute equal intervals, but investigation has revealed that increasing discriminability was found with more categories and although there was some departure from linearity, the extent of this would be unlikely to cause practical concerns (Jones, Peryam & Thurstone, 1955; Jones & Thurstone, 1955).

Unstructured linear analogue scales (eg, a line anchored at the ends with "none' and 'extremely strong') have become more widely used in sensory evaluation in recent years. With this type of scale the assessor marks the line at a point he or she feels is appropriate for the intensity. This type of scale lacks the coarseness which can be introduced by having too small a number of categories; the response is assumed to be a continuous function and to be linear with respect to sensation. However further investigation of the properties of such scales is required (Shepherd & Farleigh, 1989).

Another form of unstructured scale is to have the subjects rate the sample relative to their own ideal of the attribute in that particular food (Frijters & Rasmussen-Conrad, 1982; McBride, 1982) on an unstructured graphic scale with labels such as 'Not nearly sweet enough" at the left, "Just right" in the centre and "Much too sweet" at the right. The responses are linear with increasing log (concentration) and the point where the line crosses "Just Right' gives a measure of the individual's ideal concentration (Shepherd & Farleigh, 1989). The responses are similar to hedonic ratings but are unfolded about the mean (Shepherd, Smith & Farleigh, 1988b), and this scale gives good agreement with conventional hedonic ratings (Shepherd, Farleigh, Land & Franklin, 1985b). The advantage of this type of measure over conventional hedonic ratings is that its linear form allows easy assessment of an individual's ideal point, which is more difficult to calculate from the curvilinear hedonic function (Shepherd & Farleigh, 1989).

The third type of scale commonly used, magnitude estimation, adopts a different model for the relationship between stimulus and response (Stevens, 1956), with subjects providing numbers which relate to the magnitude of the sensory stimulus in a ratio manner. Giovanni and Pangborn (1983) compared this method with category scaling and found that it gave similar conclusions about taste intensity and liking of beverages, although more restricted ranges were used for magnitude estimation.

Research Problems. In addition to the problems outlined above there are a number of areas in sensory evaluation where more work and understanding are required. There are a number of experimental procedures that can influence the ratings obtained, for example, the ratings given to a sample are a function not only of the physical and chemical nature of that sample but also of the range of other stimuli presented and of the frequency with which other stimuli are presented. This can be explained using the range-frequency model developed by Parducci (1974). If a stimulus is presented along with a series of low concentrations then it will be rated higher than if the same stimulus is presented in a series of higher concentrations (Conner, Land & Booth, 1987; Shepherd, Farleigh & Land, 1984a). It has been suggested (Poulton, 1977) that such effects of bias can be overcome by presenting only one stimulus to each assessor. In most practical circumstances however, this is not possible. Booth, Thompson and Shahedian (1983) suggested that another method of overcoming the bias is to centre the stimulus range individually on each assessor's own ideal. This method has been used by a number of researchers and the estimate of the ideal concentration and unbiased estimate of the ideal have been found not to differ (Shepherd et al., 1984a).

Another potential source of variability in the assessment of likeability and food acceptance is the effect of swallowing versus expectorating samples (Cardello, 1996). The preference response is dependent on the time at which the subject chooses to assign a cognitive, internalised rating for the pleasantness/unpleasantness of the sample, however very little is known about the internal processes involved in making hedonic judgements of food or model stimuli. In addition, common sensory procedures do not define either the exact time or the internal process by which hedonic judgements are to be made (Cardello, 1996).

The effects of the environment on consumer assessment requires closer examination. Consumer preferences can be tested in fairly controlled conditions, for example in laboratory settings, with several small samples presented in coded containers for rating. This does not mimic the real eating situation however, where foods are eaten in combination with other foods, in realistic proportions rather than small samples, and in a social context. Ultimately it will be desirable to test foods in real life settings and relate this back to the sensory evaluation trials.

The way food tastes plays a food play a major role in determining whether a food is liked or not, and the liking of a food is an important factor in determining food choice. There are other factors, however, that may be implicated in determining food choice and preference and it is necessary to consider these in conjunction with sensory aspects.

Familiarity/Exposure

Experience plays a central role in the formation of food preference in humans and other animals. Social psychologists have shown that simple repeated exposure to previously unknown stimuli usually results in a more favourable attitude towards them - the mere exposure effect (Zajonc, 1968). Simple exposure enhances familiarity. Familiarity, it must be emphasised, is not an intrinsic characteristic of a food, but is a function of the individual's experience of that food. It is listed by many researchers as the single most important determiner of food preferences (Lyman, 1989). Consumer's tend to like those foods with which they are familiar and ignore or reject those that are not. Thus familiarity, which can be increased directly by means of exposure, enhances preferences, acceptance and level of liking.

In an experimental investigation of "the influence of familiarization on preference", conducted well before interest developed in the mere exposure phenomenon, Maslow (1937) served a particular type of biscuit to his subjects over eight sessions. In a subsequent session, when given a choice between the familiar and an unfamiliar biscuit, subjects chose the familiar one slightly (but not significantly) more often than non-familiarised control subjects.

The most common way in which foods become familiar is through exposure while growing up. Ordinarily, exposure takes place over an extended period of time, but experiments show that even short-term exposure to novel foods, for both adults and children, increases preference (Birch & Marlin, 1982; Pliner, 1982; Pliner, Pelchat, & Grabski, 1993; Sullivan & Birch, 1990). In addition, whilst the effects of exposure on foods have been primarily demonstrated in the development of liking for novel foods, the effects of exposure have also been shown to operate in the development of liking for different levels of tastants within familiar foods (Prescott & Khu, 1995).

To investigate the effects of taste exposure to novel foods, Pliner (1982) had subjects taste 35 small samples of tropical fruit juice in an initial exposure phase. Although subjects were led to believe that each of the 35 samples was different, in fact, there were only three different juices; one was presented 20 times, the second was presented 10 times, and the third was presented 5 times. After this initial exposure phase, subjects tasted and rated the three juices tasted in the exposure phase and one juice never tasted. The results showed a strong exposure effect such that the more frequently a juice had been tasted, the better it was liked. Unfortunately this study involved only two exposure sessions, and while the exposure effect was large for the first session, it was much smaller for the second session (a week later). It would have been beneficial to have had a larger number of exposure sessions, which would have provided more information on whether the effect persisted over time, and was lasting.

The limitation of the study by Pliner (1982) in respect of number of exposure sessions, was not an issue in the study by Birch and Marlin (1982), who conducted two experiments with two-year-old children to look at the effects of exposure of novel foods. In Experiment 1 each of the six children tasted five initially novel cheeses, and received 20 exposures to one cheese, 15 exposures to a second, 10 to a third, 5 exposures to a fourth, and 2 exposures to the fifth. In Experiment 2, eight children received 20, 15, 10, 5, and 0 exposures to five initially novel fruits. The schedule of exposure in Experiment 1 was accomplished through a series of 26 paired stimulus presentations, presented at a rate of one pair per day. In Experiment 2 exposures were completed in a series of 25 pairs, at a rate of one pair per day. The experimenter recorded tasting order, amount consumed, and any comments and consumption behaviours of the child. Following the exposure series the children were given a series of ten paired comparison choice trials comprising all possible pairs of the five foods. In these choice trials the child was asked to taste both foods and to choose one food to "eat more of". Thurstone scaling solutions were obtained for the series of choices: when the resulting scale values for the five stimuli were correlated with exposure frequency, values of r=0.95, p<0.02, r=0.97, p<0.01; and r=0.94, p<0.02 were obtained for the data of Experiments 1, 2, and the combined sample, respectively. These results clearly provide further evidence for the view that preference is an increasing function of exposure frequency.

In a recent study however, Roininen, Lahteenmaki and Tuorila (1996) failed to confirm previous research. The researchers investigated the effect of umami taste, monosodium glutamate (MSG) on pleasantness of low-salt soups during repeated testing, and found there was no main effect between pleasantness ratings at the beginning (session 1) and end (session 8) when all the soups (with and without umami) were included in the analysis. However, when separate analyses were undertaken the pleasantness ratings without umami decreased with tasting condition (beginning to end), whereas with umami the ratings were practically unchanged. The researchers concluded the overall exposure effect was probably not observed because the soups were probably not novel enough to cause an exposure effect. The researchers also distinguished their participants on the basis of salt preference and analyses revealed the low and high salt groups showed some differences in their responses over time. In the case of the high salt group, exposure tended to improve the palatability of low-salt soups with or without umami. Roininen et al. (1996) concluded that this is because low-salt soups were probably less familiar to the high-salt group than the low-salt group and hence may have caused a tentative exposure effect.

Whilst Roininen et al. (1996) suggest that exposure effects are not found with familiar foods, Prescott and Khu (1995) have specifically investigated this issue and reported a positive relationship. In their study Prescott and Khu (1995) investigated whether exposure effects could be demonstrated on liking for a different intensity of salt (familiar tastant) within pumpkin soup (a familiar Australian food). Sixteen subjects, previously assessed for their preferred salt level in soup, were allocated to either an experimental group that received soup samples with a salt level lower in intensity and less preferred, or to a control group that received soup with their most preferred salt level. Ten samples were presented at daily intervals. Compared to the control group, the experimental group increased their liking for the lower salt soup, with maximum change attained after five exposures. This study extended the scope of findings on mere exposure by demonstrating that it can occur for a familiar taste within a familiar context. In addition it also provided evidence that this effect can occur after a relatively brief period of exposure, in this instance five exposures. However, the small sample size in this study (N=16) does cast some doubt on the reliability of the results, and it may be that variations resulting from individual differences could have been exaggerated. Future research should aim to increase participant numbers and hence improve the reliability of the results.

These studies provide support for the view that the mere exposure effect plays a role in the acquisition of food preferences for novel foods and tastants. There is also some evidence that these effects are also seen with familiar foods and tastants, although given conflicting results, further research addressing exposure to familiar foods and to novel tastants within familiar foods is required. The study by Roininen et al. (1996) also highlights the need to consider other confounding factors, such as customary level of dietary sodium.

Customary Level of Sodium Intake in Daily Diet

In the case of food choice it appears that in addition to exposure during the experimental situation the effect of previous dietary behaviour prior to the experiment is very powerful in determining choice. Evidence suggests that the preferred level of salt in a familiar food is directly influenced by prior dietary experience (Beauchamp & Cowart, 1990; Bertino, Beauchamp & Engelman, 1982, 1986; Blais, Pangborn, Borhani, Ferrell, Prineas and Laing, 1986; Shepherd and Farleigh, 1986). Generally speaking, after a few weeks of increased dietary salt, adults show an increased preference for higher levels of salt in sampled food (Bertino et al., 1986).

An experiment examining the relationship between customary level of Na intake and preferred concentration of salt in a soup was carried out by Shepherd and Farleigh (1986). Twenty four hour urine samples of thirty-six participants were collected over a seven day period as measures of sodium intake. Over the same period the subjects were given pre-weighed salt pots, a table salt pot for use only by the subject, and a cooking salt pot, which was to be used for the ordinary family cooking. Estimates of the amount of salt consumed by the subject were then calculated. During the week (four sessions), subjects took part in taste tests of tomato soup, with seven concentrations of sodium chloride. The study found that participants with a low sodium intake had a preference for lower concentrations of salt in the particular food tested. This finding was true for both total intake and table salt use.

Similar results were reported by Beauchamp and Cowart (1990). They found that adult responses to questions such as a) Do you salt food before tasting it? and b) Do you use salt in cooking? were related to the salt preference results. Those adults with higher salt taste preferences were more likely to use salt in cooking, to salt their food before tasting it, or both. However, given that the majority of sodium consumed comes from sources other than that added by the individual in food preparation or at the table, these conclusions although they add support to previous research, are limited.

Studies such as these provide support for the view that prior dietary experience is an influencing factor in food preferences, and hence accordingly is a factor implicated in determining food choice.

Attitudes

Many of the influences on food choice are likely to be mediated by the attitudes and beliefs held by an individual and hence the study of the relationship between choice and the beliefs and attitudes held by a person offers one possible route towards a better understanding of the influence of different factors on food choice (Shepherd & Raats, 1996). Two models incorporating and relating the measures of belief, attitude and behavioural intention and behaviour are the Theory of Reasoned Action (Ajzen & Fishbein, 1980), and its extension the Theory of Planned Behaviour (Ajzen, 1985). These theories propose that the best predictor of an individual's behaviour is his/her conscious intention to perform behaviour. Behavioural intentions reflect an individual's commitment to act and are strongly predictive of actual behaviour (Fishbein, Ajzen & McArdle, 1980). These intentions are determined by three factors, 1) an individual's attitude toward the behaviour, 2) subjective norms (the individual's perception of how others expect him/her to behave combined with his/her motivation to comply with these expectations), and 3) perceived behavioural control (the individual's belief as to how easy or difficult performance of the behaviour is likely to be), specifically incorporated in the TPB model. These models have been widely applied in the area of social psychology and more recently have been applied to food choice issues in studies of food selection.

A study by Shepherd and Farleigh (1986) used the TRA model to investigate attitudes towards adding table salt to foods as a determinant of salt intake. The researchers found that behavioural intention was shown to be well predicted in a multiple regression by the attitude to the behaviour (r=.77) and subjective norm (r=.48), with the former showing greater prediction. Behavioural intention was found to relate to measured table salt use (r=.64). Likewise beliefs about behaviour predicted attitude to the behaviour (r=.54).

Few studies have incorporated the actual assessment of samples of food, along with attitude and belief responses in the Ajzen and Fishbein framework. The majority of studies have not involved the subjects tasting samples of the foods, but have merely been questionnaires which gather ratings on general beliefs and attitudes towards consuming the types of foods. To incorporate actual assessment of samples of foods, along with attitude and belief response Tuorila-Ollikainen, Lahteenmaki, and Salovaara (1986) measured consumer's hedonic responses to breads with normal and low levels of salt and related these hedonic responses to their 1) attitudes towards low-salt bread, 2) subjective norm (role of nutrition related recommendations, 3) intentions to buy low-salt bread, and 4) actual selection of breads during the experimental period. Significant relationships between individuals' hedonic responses and their attitudes (correlation coefficient of 0.36), subjective norm (0.46), buying intentions (0.61), and selection (0.50) were found. Tuorilla-Ollokinen et al. concluded that their results indicate there is a population group which may be willing to switch from normal salt bread to low salt bread, and that this change would depend on a person liking the low salt breads available, possessing a favourable attitude to the consequences of the low salt quality of bread in general, and having internalised the nutritional recommendations concerning sodium and bread. This research demonstrates the need to consider criteria which might differentiate subjects, and hence mask important differences. Consequently, in looking at consumers' level of liking for products with varying levels of salt, it would seem important to differentiate subjects on the basis of their attitudes towards salt and motivation to change their salt levels. This is an issue that has not been clearly addressed, and warrants further research.

The Ajzen and Fishbein (1980) model has provided a framework in which to examine the relationships between attitudes, beliefs and behaviour, and this model has been successfully used in a number of applications in the food choice area. The model also provides evidence for the view that there are a large number of factors which will influence food choice, and can be used to determine the relative importance of different factors in influencing food choice (Shepherd & Raats, 1996). However, further modifications and extensions to the model appear warranted in order to make it more food-specific, and Shepherd and Sparks (1994) suggest that factors for possible inclusion include role of perceived control, habit, and self-identity.

Personality Traits

Another factor to consider in examining food choice is personality traits. In their 1986 study Shepherd and Farleigh (1986) measured salt intake and then related this to preferences for salt levels in tomato soup, general food preferences, and personality. They found that certain personality factors from Cattell's Sixteen Personality Factor Questionnaire (16PF) related to both total salt intake and table salt use; anxiety was positively correlated with cooking salt use and total salt intake, and tough poise (decisive, resilient, given to rapid action and insufficient thought) was positively correlated with table and cooking salt use. In a further experiment Shepherd and Farleigh (1986a) found that extraversion was positively related to non-discretionary salt-intake, however this relationship was not significant for total salt intake. The finding for extraversion was expected, given that extraversion may be seen as seeking external stimulation (Eysenck, 1967).

Stone and Pangborn (1990) also examined the preference and intake measures of salt and their relation to personality traits. In their study thirty five personality traits were assessed using the Sixteen Personality Factor Questionnaire (16PF), the Jenkins Activity Survey, the Eysenck Personality Questionnaire, the Multidimensional Health Locus of Control to Scale, and the Sensation Seeking Scale. The study revealed that subjects with a high salt intake liked saltier broths, and further that subjects who believed they had control over their health and well-being liked lower levels of salt in broth, while those who believed that fate or others controlled their health liked higher levels. Unlike Shepherd and Farleigh (1986) these researchers failed to find an association with extraversion.

Another personality-like trait to consider is food neophobia, as it has been shown that individual differences in food preferences are related to fear of trying new and unusual foods (Pliner & Hobden, 1992).

Food Neophobia. In humans, common experience suggests that there are large individual differences in the extent of food neophobia, that is the propensity to avoid or approach novel foods (Pliner & Hobden, 1992). Pliner & Hobden indicate that given these individual differences, it might be useful to conceptualise neophobia as a personality trait, a continuum along which people can be located in terms of their stable propensity to approach or avoid novel foods. Those subjects who are highly neophobic are less willing to taste novel foods than subjects lower in neophobia. Not surprisingly, Pliner and Hobden found more highly neophobic subjects appear to have less experience with and/or less exposure to novel foods than do their less neophobic peers. However when this greater unfamiliarity was controlled for statistically, they were still less willing to taste novel foods than subjects lower in neophobia. They, however, also reported that on actually tasting food, the more highly neophobic subjects did not rate foods, novel or familiar, as less palatable, that is there were no correlations between neophobia and actual liking for foods tasted.

To examine the effect of "forced" exposure to novel foods on subsequent neophobia Pliner, Pelchat and Grabski (1993) had their subjects taste seven novel foods in an adaption phase while others tasted seven similar familiar foods; all subjects were then given the test task of selecting for tasting one member of each of 11 pairs of foods. The pairs comprised one novel and one familiar food (different from those used in the exposure to novelty manipulation). The number of novel choices was the measure of neophobia (with fewer choices indicative of greater neophobia). Pliner et al. (1993) found that subjects in the novel food adaption condition chose more novel foods than did those in the familiar food condition, and concluded that clearly exposure to novel foods reduced food neophobia in their young adult subjects. However, given that the study did not include any follow up measures, the research does not provide evidence of lasting effects, and this requires further investigation.

As outlined there are a number of factors involved in determining food choice and these factors are interrelated. As a means of measuring the relationship between food preference patterns and several psychological and sensory variables, the Food Attitudes Survey (FAS), has been developed by Frank and van der Klaauw (1994). Subjects respond to an extensive list (455 items) of foods, beverages and condiments using statements related to their liking for or willingness to try each food. Responses are then summed across fields to yield preference patterns characterised by food acceptance or rejection, and willingness or unwillingness to try a variety of foods. Frank and van der Klaauw (1994) and Raudenbush, van der Klaauw and Frank (1995), who used a modified version of the original FAS (217 items), concluded that personality and sensory factors contribute to patterns of responding on the FAS, and that FAS response patterns provide an index of both attitudes towards foods and general openness to experience and activities. The disadvantage of this questionnaire, despite the provision of a shortened version, remains its length.

It is evident from the research reviewed that there is a variety of factors implicated in human's dietary choices. The taste of a food plays a major role, and accordingly the liking of a salty taste is an important factor in determining food choice. Familiarity with the salty taste and exposure to certain foods (either salty or non-salty) also play a role in dietary choice. In addition, personality variables are also implicated in dietary preference for salty or non-salty foods. Therefore, if there is to be success in reducing consumer's dietary sodium, it is important that these factors be considered when examining food choice and when attempting to bring about change in consumer's level of sodium intake.

Intervention

There is widespread concern about sodium, yet it appears that educational messages and dietary campaigns regarding dietary sodium have not been effective. Whilst there have been some positive movements, such as a reported reduction in the use of table salt, generally the public are having difficulties in translating these concerns into effective action. In reporting on the results from the National Heart Foundation's Risk Factor Prevalence Study, 1980-1989, Bennett and Magnus (1994) conclude that mass reach intervention and education programs which have been previously attempted have not been effective for a variety of population groups. Given these circumstances it is of practical importance to find a way to reduce sodium intake without reducing the palatability of foods (Yamaguchi, 1987), and hence to look at alternative measures of reducing sodium intakes in addition to education and marketing campaigns.

Approaches To Reducing Salt Intake

The main source of dietary sodium (at least 75%) is processed foods, and a major reduction depends on changing their composition (National Heart Foundation of Australia, 1995). In America the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure (1993) and National High Blood Pressure Education Program Working Group (1993) have found that alterations in food preparation and product formulation in conjunction with other methods such as changes in diet can be effective in reducing sodium consumption. One method of reducing consumers' sodium intake is to simply reduce the levels of salt in food products, and a second method of reducing the sodium level is to replace salt with alternative tastants in the manufacturing process.

Reduction in Salt Content in Food Products. The majority of salt consumed comes from commercially prepared foods, in which sodium levels can be easily altered and large reductions of sodium can be achieved. Studies such as those by Bertino et al. (1982), Garey and Chan (1985) and Witschi, Ellison, Doane, Vorkink, Slack, and Stare (1985) have found that sodium levels can be reduced (by 30 to 50%) without affecting consumer acceptability. However, while salt in food can be lowered through reduction in sodium intake, given that the initial reduction causes a decrease in the palatability of foods this may require several if not many months (Bertino et al, 1982). An additional problem is that if sodium levels are restricted too severely, then as much as 20% of the sodium is added back as table salt (Beauchamp et al, 1987).

In a recent study, Adams, Maller and Cardello (1995) conducted two independent studies to assess the magnitude of reduction in sodium that could be made without significantly changing the perception of saltiness or decreasing the acceptability of the food items. In the first study consumers evaluated the saltiness and acceptability of a variety of "regular" and "low-sodium" military entrees containing a wide range of sodium concentrations. The study found that reductions of sodium by 50% or more are possible, but that perceptions of saltiness and acceptability are product specific, with the type of food used as a carrier influencing both the perception of saltiness and the acceptable concentration of sodium. In the second study laboratory prepared foods and commercially prepared food items with a broad range of sodium content (0.03% to 0.63% and 0.01% to 0.60% respectively) were rated to determine whether the sodium concentration in specific foods influenced both the perception of saltiness and the acceptable concentrations of sodium. For both laboratory and commercially prepared foods the perception of saltiness was confirmed to increase as the concentration of sodium increased. Acceptability for the foods varied considerably over a broad range of sodium concentrations, although this was dependent on the complexity of the food. For example the simpler the food (containing fewer ingredients, eg mashed potatoes), the greater the perceived saltiness, and the greater the acceptability level at a lower rate of sodium content. The research revealed that considerable reductions in sodium levels can be made in some foods and recipes without reducing acceptance significantly but they do limit generalisations regarding the relationship between acceptance and the level of sodium in foods.

Alternative Tastants To Salt. Compensation for the salty taste by adding other flavours, for example spices and herbs, is often mentioned as a practical way of overcoming the difficulty of reducing sodium intake (Tuorila et al., 1990), official dietary guidelines have recommended this course of action (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 1988) and entire cookbooks have been based on it (eg, Williams & Silverman, 1982). The identification of alternative tastants that can be added to processed foods and maintain palatability, is important. Among the candidates are the glutamate salts, which carry a distinct flavour named "umami".

Umami

Glutamate was first identified in 1908 by Ikeda (1909). He extracted glutamic acid from sea tangles and proposed naming the characteristic taste of its salts *umami*, which is derived from the Japanese word meaning "deliciousness". Glutamic acid is one of the most common amino acids found in nature. It is the main component of many proteins and peptides, and is present in most tissues. It is a natural component that is found in meat, fish, certain vegetables (eg, tomatoes, mushrooms, peas) and cheese. When present in its "free" form- not "bound" together with other amino acids in protein-glutamate it has a flavour enhancing effect in foods and hence plays a role in the palatability and acceptability of many foods (International Food Information Council Foundation, 1994). Westerners often describe this flavour as savoury, broth-like or meaty (Yamaguchi, 1987).

Since its discovery this unique taste has been studied by a number of researchers and experimental psychophysical data in humans suggest that umami is distinct from conventional taste categories such as sweet, sour, salty, or bitter (Yamaguchi & Kimizuka, 1979). Several umami substances, Monosodium L-glutamate (MSG), sodium 5'-inosinate [or inosine 5'-monophosphate (IMP)], and 5'-guanylate [or guanosine 5'-monophosphate (GMP)] are now widely available as flavour enhancers in many countries.

Monosodium Glutamate (MSG). MSG is the sodium salt of glutamic acid and is the most well known of the glutamate salts. In the early part of this century, MSG was extracted from seaweed and other plant sources. Today, MSG is produced in many countries around the world through a fermentation process of molasses from sugar cane or sugar beets, as well as starch and corn sugar (Fuke & Shimizu, 1993). The human body metabolises glutamate added to foods in the same manner it metabolises glutamate found naturally in many foods (Filer & Stegink, 1994). Importantly, MSG contains only one-third the amount of sodium compared with common salt, 13 percent as opposed to 40 percent (International Food Information Council Foundation, 1991).

MSG is widely used as a flavour enhancer to increase the palatability of foods. Its effects in enhancing the flavours of various foods have been extensively investigated (Yamaguchi & Kimizuka, 1979), and the commercial use of MSG to improve food palatability for humans is well documented (Naim, Ohara, Kare & Levinson, 1991).

To explore the use of MSG as a tastant Yamaguchi and Takahashi (1984) examined various concentrations in a clear soup, sumashi-jiri, and their effects on saltiness and palatability by a response-surface method. Nine clear soups with various concentrations of MSG and NaCl were prepared and each participant (N=90) evaluated four of the nine samples successively and at random. Participants scored each sample for saltiness and palatability. With regard to the palatability rating, the NaCl concentration giving maximum palatability was estimated as 0.92% at 0%

MSG, and 0.77% at 0.5% MSG. By either rating, increase in the level of MSG was necessary on lowering the NaCl concentration. This study found that to maintain a high palatability score with restricted sodium intake, the MSG concentration should be kept at an optimum and the NaCl concentration reduced. Hence Yamaguchi and Takahashi (1984) concluded that this is an effective way to reduce the total sodium intake without influencing the palatability of food. It should be noted however, that for most of the soups the palatability scores were low, indicating that the soups were relatively unpalatable.

In a further experiment to examine the functional relation between MSG and NaCl Yamaguchi (1987) examined the relationship between concentrations of umami substances and NaCl in foods and the effects on palatability. In all cases, a reduction of about 30% (or >30%) of added sodium with no addition of umami substances definitely lowered all the scores of saltiness, umami and palatability. The addition of umami substances at all NaCl levels studied in this experiment significantly increased the feeling of satisfaction for the taste of meals and the meals themselves, and decreased the desire for saltiness. Yamaguchi (1987) concluded that if an appropriate amount of umami substance is used, sodium intake can be reduced by about 30% without decreasing the palatability of foods or decreasing the degree of satisfaction for meals.

Not all investigators have observed that alternative tastants can be used to maintain palatability whilst reducing sodium. Tuorila, Hellemann and Matuszewska (1990) conducted two experiments to investigate what effect the addition of spicy/herbal flavouring (allspice, marjoram, onion) and MSG would have on the preferred level of saltiness in beef broth. They found that the added flavours did not bring the preferred sodium level of salted broth down to a lower concentration, and hence concluded that the results provide no support for the widely held belief that other flavours such as spice or herbs might compensate for lower saltiness of foods. These results may reflect differences in experimental design, eg the focusing on ratings of saltiness rather than overall pleasantness, and the relatively high concentrations of MSG used in the study of Yamaguchi and Takahashi (1984) as compared to the low MSG levels used by Tuorila et al. (1990).

In their recent study Roininen et al. (1996) studied the effect of umami taste on pleasantness of low-salt soups during repeated testing. The umami substances were monosodium glutamate (0.2%) and 5'-ribonucleotides (0.05%), and there were two groups of subjects, one with low salt preferences (0.3% NaCl) and the other with high salt preferences (0.5% NaCl). Participants attended eight sessions: session 1 and 8 were tasting sessions, and sessions 2 to 7 were lunch and tasting sessions. The low-salt and high salt-groups were each divided into two groups that three times consumed either leek-potato or minestrone soup with umami and three times the other soup without umami during six sessions over 5 weeks (sessions 2-7). Participants rated the soups for pleasantness (on a scale of "extremely unpleasant" to "extremely pleasant"), saltiness (on a 9-point relative-to-ideal scale anchored from "not nearly salty enough" to "much too salty"), and taste intensity (9 point scale of "weak" to "strong"). At sessions 1 and 8 the participants tasted all four soups with and without added umami (the salt level depended on the initial preference of the participant) and rated pleasantness, on the scale they had previously used. Analyses revealed that umami significantly increased the pleasantness, taste intensity, and increased the ideal saltiness ratings to near optimum. The effect was observed at the beginning of the study and it remained the same during the experiment. The soups with umami were initially rated better than those without, and the exposure period did not change the judgement of soups with umami. Hence the researchers concluded that umami has a lasting and favourable effect on pleasantness of the soups and that enhancing the overall flavour maintains the palatability of low-salt soups during the initial phase of salt reduction. This study provides support for the view that appropriate flavour additions play a potentially important role in the reduction of salt intake in humans, and more specifically provides support for the positive effect of MSG on food palatability during restricted sodium intake. The levels of umami used in this study were relatively low, and are comparable to those used by Tuorila et al. (1990). Roininen et al. (1996) suggest that a possible explanation for their positive findings, and the failure of Tuorila et al. (1990) to find a compensatory effect of umami was their (Roininen et al) use of a combination of MSG and 5'-ribonucleotides, which may have had a flavour-potentiating effect. However, it should be noted that the soups used by Roininen et al (1996) contained ingredients (eg mushrooms, tomatoes, and potatoes) that contain high levels of "free" glutamate. Accordingly, these ingredients would have contributed to a greater total umami component than that reported by the researchers.

There is extensive research suggesting that MSG is safe (American College of Allergy, Asthma and Immunology, 1991; Commission of the European Communities, 1991; Federation of American Societies for Experimental Biology, 1995; Joint Food and Agriculture Organization and World Health Organization Expert Committee on Food Additives, 1988). In 1991 a panel of the American College of Allergy and Immunology reviewed the literature on MSG and food allergy and safety and concluded that MSG is not an allergen and reaffirmed its safety as a food ingredient (American College of Allergy, Asthma and Immunology, 1991). The Federation of American Societies for Experimental Biology (FASEB) evaluation reaffirmed MSG's safety as a food ingredient for the public, finding no evidence linking MSG consumption to any serious long-term neurological problems in the general public, and noting the lack of scientific information reporting negative effects on MSG on human health in the general population (FASEB, 1995).

Despite these conclusions, adverse reactions to MSG have been reported, and these are problematic because it is difficult to link the reactions specifically to MSG. Most are cases in which people have had reactions after eating certain foods containing MSG and are not controlled studies (International Food Information Council Foundation, 1994). The sensory side effects possibly caused by ingesting MSG were examined by Tarasoff and Kelly (1993) in a randomised double-blind cross-over study. Seventy-one healthy participants were administered five different treatments, which included two placebos and three different doses of MSG (1.5, 3, and 3.15g) in a random order. Neither the researchers nor the subjects knew which or how much of the test material was being consumed. Two hours after ingestion participants were interviewed. Tarasoff and Kelly (1993) found that the small number of effects seen were not statistically significant and that MSG in food had no discernible effect for healthy individuals.

The amounts of additives found in foods are of concern to the public, and certain additives, such as MSG, have been publicised in a negative light. In a study by Prescott (1993) the preference of Australian subjects for foods with and without the addition of MSG was examined, and in this study "natural taste" was evaluated, as consumers often attribute artificial chemical tastes in food to "additives". MSG is often perceived by consumers as an "additive" and consumers believe it decreases the natural taste of food. The research by Prescott (1993) however, suggests that if consumers are not aware that MSG has been added to a food, then they do not rate a food as having decreased in natural taste.

Despite the evidence demonstrating that MSG is safe and palatable, there are limitations to community acceptability of MSG as an alternative tastant to salt. There remains widespread public concern as the result of the so called "chinese restaurant syndrome" which limits the acceptability of MSG. The "chinese restaurant syndrome" describes a collection of symptoms, including warmth, tingling or feeling of pressure in the chest and upper part of the body, which some people believe to be associated with MSG in Chinese food (International Food Information Council, 1994). Secondly, MSG does contain sodium, albeit less than common salt, and this is in sufficient quantity to alter the sodium classification of some low salt foods to which it has been added. Given these issues with MSG there remains a need to explore further tastants.

Calcium Diglutamate (CDG). Calcium diglutamate (CDG) is another of the glutamate salts. However CDG, unlike MSG, contains no sodium and hence cannot alter the sodium classification of any low salt foods to which it is added. This is therefore a major advantage when the search is on for a tastant that can be used as an alternative to salt. Hence it is surprising to find that the literature addressing calcium diglutamate as a tastant is extremely limited. A recent literature search has revealed only two experiments investigating the use of CDG as a tastant to increase the palatability of foods (Bellisle, Dartois & Boyer, 1992). In their first experiment, 45 children with chronic renal diseases (on low-sodium diets) participated in sensory evaluation tests at lunch time. For each food selected, three samples were prepared in small plastic cups, and contained 0%, 1.2% or 2.4% CDG. The children rated each sample using a three-point category scale. This study found that CDG improved the taste of foods in approximately 60% of cases. In their second the researchers investigated the free use of CDG compared with a placebo (maltodextrin), by 15 children over a two week period. The CDG and the placebo were presented in coded (A or B) bags. One bag was provided for each meal during the first two weeks of testing. At least one week was allowed without tests, then the alternative powder was provided for two weeks. The study revealed that CDG was used three times more often than the placebo by 8 children, and that the CDG users were older, taller, heavier, and they had longer experience of using salt. Bellisle et al. (1992) suggest that their findings indicate that CDG is likely to enhance palatability and stimulate food intake in an important proportion of patients with low appetite aggravated by a restrictive diet. They also propose that, given that those participants who have experienced normal (salty) foods for a longer time prefer foods containing CDG, perhaps CDG can be offered to adults on low-sodium and low-potassium diets (Bellisle et al, 1992).

A minor but additional nutritional advantage of calcium diglutamate is that it contains a calcium component. Calcium is an important component in children's diets to ensure healthy bone development, and is an essential component in the diet of adults to guard against osteoporosis. In addition, Levey, Manore, Vaughan, Carroll, vanHalderen and Felicetta (1995) report that persons with hypertension who consume a low-Na diet may be at risk for deficient Ca intake: "A typical 2-g Na diet limits milk and dairy products (good sources of dietary Ca) to two servings per day. Low dietary intake of Ca along with a possible defect in Ca metabolism may further increase the risk of high blood pressure in these persons." Clearly, there has been a lack of studies investigating the use of calcium diglutamate as an alternative tastant to salt, and the above factors would seem to indicate the need to explore the viability of CDG as a tastant.

Methodological Issues in Food Choice Studies

The issue of the human senses is important in food acceptance. Each sensory system exerts its influence on the acceptance of food, either through direct mechanisms of innate preference/rejection, through crossmodal interactions with other sensory systems, or through learned associations with the reinforcing properties of food (Cardello, 1996). Food manufacturers will require a better understanding of what contributes to the sensory acceptability of foods to ensure improved sensory quality. This will require a better understanding of how innate sensory preferences/aversions, especially neophobic responses, are changed by experience, culture, socialisation, and cognition (Cardello, 1996). The development of the FNS and the FAS are important contributions and will advance research on factors which initiate or restrict eating, and the extent to which sensory and psychological factors influence preference and the nature of the interactions among the relevant variables. Information provided by the FAS may be used in future research designed to investigate the development and expression of human food attitudes and preferences, but the length of the questionnaire does limit its practical use. Further research is also needed to extend the concept and measurement of reluctance to eat foods other than novel foods as many people are reluctant to eat foods that are familiar to them, and this probably represents a greater dietary impact (Meiselman, 1996). Accordingly, further investigation is required of the FNS with familiar foods with different levels of familiar and unfamiliar tastants.

The investigation of attitudes in relation to salt requires further attention. Currently scales measuring this are limited. Maller, Cardello, Sweeney and Shapiro (1982) devised a 20-item inventory to assess habits of salt and sugar usage (five questions each) and attitudes to the health effects of dietary salt and sugar (also five items each). Each question had a ten-category response choice for degree of self-attribution of the practice or opinion. A scale that measures attitude towards salt intake and motivation to reduce salt intake would be useful for researchers in determining what impact attitudes are having and areas that can be addressed when attempting to influence sodium intake.

Another issue to consider is how many exposure sessions are required to lead to an increased acceptance of that food, via the mere exposure effect. Sullivan and Birch (1990) state that in accord with previous research their results indicate that 8 to 15 exposures are necessary to see an effect. In their more recent study however, Prescott & Khu (1995) found that 5 exposures were sufficient to produce effects. The importance of determining the number of exposures required to achieve an increase in acceptability is apparent in food choice research and hence further exploration of exposure levels is required.

The investigation of alternative tastants to salt has been limited. This has perhaps been limited by consumers' reluctance to have additives in foods. Additives such as MSG have been criticised in a negative light, however research (Prescott, 1993) indicates that when consumers are not aware of the additives they do not perceive the food as having decreased in natural taste. The importance of further exploration of the perception of natural taste with foods containing additives/alternative tastants is therefore evident. In addition, the importance of exploring tastants such as CDG, which have some nutritional advantages over salt, is warranted.

Food studies investigating the ability of other flavourants to compensate for the salty taste in foods, have found contradictory findings and this appears to be partly due to differences in experimental design. Researchers have used various methods in determining the levels of tastants that are added to the foods, and those studies using relatively low levels of umami have failed to find a compensatory interaction. It is therefore important when studying food palatability, to determine and include the optimal (i.e., preferred) levels of the tastants MSG and CDG. Due to the limited research on CDG as a tastant, studies to investigate the preferred levels of CDG are required.

In addition, the optimum levels of tastants may differ depending on the ingredients of the food. For example, as Adams et al. (1995) found, the simpler the food, the greater the perceived saltiness and the greater the acceptability at a lower rate of sodium content. Soup is a suitable medium to use in salt studies given that it is a homogeneous product with a simple structure, and it is one of the foods in which it is especially difficult to achieve optimum palatability with a low salt content.

Many of the studies examining the use of umami as an alternative tastant have been conducted in Japan (eg Yamaguchi & Takahashi, 1984), and cultural variation in hedonic responses to MSG may also play a role (Tuorila et al., 1990). Familiarity with a taste is associated with an increase in preference, hence the higher Japanese preference ratings for umami quite possibly results from greater familiarity with this taste (Prescott, 1993). More studies of umami are therefore required with Western populations.

Conclusions

Research has been reviewed that supports concerns regarding the quantities of sodium consumed and illustrates that high sodium consumption is a major contributor to CVD and other diseases. In order to achieve the recommendations to reduce salt intake it is necessary to understand what determines people's choice of foods and what obstacles there might be to such changes. It is clear from the research that dietary choices are influenced by a wide range of factors, many of which are interrelated. Factors implicated in contributing to food choice include the sensory attributes of the food, familiarity and exposure, personality traits, and beliefs about nutritional quality and health effects. Understanding these factors and their integration is central to understanding dietary intake and is especially important for public health nutritionists seeking to produce dietary changes (Southgate, 1996).

Further, determining methods of reducing dietary sodium without reducing the palatability of food are vital. Education campaigns have had some success in reducing the use of discretionary salt, however the major source of dietary sodium comes from processed foods which are consumed in high quantities, thereby ensuring that dietary sodium still remains too high. Hence it appears more pro-active measures are required. There is a need to guide the consumer in the choice of an appropriate healthy diet and to encourage the food producers, retailers and catering industry to contribute to the process of bringing about dietary change through the development of modified or new products which would assist the consumer in the choice of an appropriate diet (Southgate, 1996). The use of umami as alternative tastant to salt has shown some initial success, and the merit of further research, particularly with CDG, is clearly valuable in terms of the benefits to human health.

References

Adams, S. O., Maller, O., & Cardello, A. V. (1995). Consumer acceptance of foods lower in sodium. *Journal of the American Dietetic Association, 95(4)*, 447-453.

Ajzen, I. (1985). From intentions to actions: A theory of planned action. In J. Kuhl & J. Beckman (Eds.), *Action control: From cognitive to behavior*. New York: Springer.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour.* New Jersey: Prentice-Hall.

American College of Allergy, Asthma and Immunology (ACAAI). (1991). *Position statement on monosodium glutamate*. ACAAI: Illinois.

Antonios, T. F. T., & MacGregor, G. A. (1995). Deleterious effects of salt intake other than effects on blood pressure. *Clinical and Experimental Pharmacology and Physiology, 22,* 180-184.

Baghurst, K. I., Record, S. J., Syrette, J. A., & Baghurst, P.A. (1989). *The South Australian Dietary Survey - 1988.* Social Nutrition and Epidemiology Program, CSIRO, Division of Human Nutrition, Adelaide.

Beard, T. C. (1990). *Salt in medical practice.* Hobart: Menzies Centre for Population Health Research.

Beard, T. C., Eickhoff, R., Mejglo, Z. A., Jones, M., Bennett, S. A., & Dwyer, T. (1992). Population-based survey of human sodium and potassium excretion. *Clinical and Experimental Pharmacology and Physiology, 19,* 327-330.

Beard, T. C., Woodward, D. R., Ball, P. J., Hornsby, H., von Witt, R. J., & Dwyer, T. (1997). The Hobart salt study 1995: a few meet national sodium intake target. *Medical Journal of Australia, 166,* 404-407.

Beauchamp, G. K., Bertino, M., & Engelman, K. (1987). Failure to compensate decreased dietary sodium with increased table salt usage. *Journal of the American Medical Association, 258*, 3275-3278.

Beauchamp, G. K., Bertino, M., & Moran, M. (1982). Sodium regulation: sensory aspects. *Journal of the American Dietetic Association, 80*, 40-45.

Beauchamp, G. K., & Cowart, B. J. (1990). Preference for high salt concentrations among children. *Developmental Psychology, 26(4)*, 539-545.

Bellisle, F., Dartois, A. M., & Broyer, M. (1992). Two studies on the acceptability of calcium glutamate as a potassium-free sodium substitute in children. *Journal of Renal Nutrition, 2(3),* 42-46.

Bennett, S. A., & Magnus, P. (1994). Trends in cardiovascular risk factors in Australia. *The Medical Journal of Australia, 161,* 519-527.

Bertino, M., Beauchamp, G. K., & Engelman, K. (1982). Long-term reduction in dietary sodium alters the taste of salt. *American Journal of Clinical Nutrition, 36*, 1134-1144.

Bertino, M., Beauchamp, G. K., & Engelman, K. (1986). Increasing dietary salt alters salt taste. *Physiology and Behaviour, 38*, 203-213.

Birch, L. L., & Marlin, D. W. (1982). I don't like it, I never tried it: Effects of exposure on two-year old children's food preferences. *Appetite, 3,* 353-360.

Blais, C. A., Pangborn, R. M., Borhani, N. O., Ferrell, M. F., Prineas, R. J., & Laing, B. (1986). Effect of dietary sodium restriction on taste responses to sodium chloride: a longtitudinal study. *American Journal of Clinical Nutrition, 44*, 232-243.

Booth, D.A. (1994). Palatability and the intake of foods and drinks. In M.S. Westerterp-Plantenga, E.W.H.M. Fredrix & A. B. Steffens (Eds.), *Food intake and energy expenditure* (pp. 47-54). Boca Raton: CRC Press.

Booth, D. A., and Conner, M. T. (1990). Characterisation and measurement of influences on food acceptability by analysis of choice differences: theory and practice. *Food Quality and Preference, 2*, 75-85.

Booth, D. A., Thompson, A., & Shahedian, B. (1983). A robust, brief measure of an individual's most preferred level of salt in an ordinary foodstuff. *Appetite, 4*, 301-312.

Cardello, A. V. (1996). The role of the human senses in food acceptance. In H.L. Meiselman & H.J.H. MacFie (Eds.), *Food choice, acceptance and consumption* (pp.1-82). London: Blackie Academic & Professional.

Commission of the European Communities. (1991). L-glutamic acid and its salts. Report of the Scientific Committee for Food: 25th Series, No. EUR 13416.

Conner, M. T., Land, D. G., & Booth, D. A. (1987). Effect of stimulus range on judgements of sweetness intensity in a lime drink. *British Journal of Psychology, 78*, 357-364.

Crawford, D. A., & Baghurst, K. I. (1990). Diet and health: a national survey of beliefs, behaviours and barriers to change in the community. *Australian Journal of Nutrition and Dietetics, 47(4)*, 97-104.

Cutler, J. A., Follman, D., & Allender, P. S. (1997). Randomized trials of sodium reduction:an overview. *American Journal of Clinical Nutrition, 65(2),* 643-651.

Dale, N. E. (1979). Sodium and potassium content of some Australian foods and beverages. *Medical Journal of Australia, 2,* 354-355.

Elliott, P. (1991). Sodium and blood pressure: A review of the evidence from controlled trials of sodium reduction and epidemiological studies. *Klin Wochenschr, 69 (Supplement XXV),* 3-10.

Elliott, P., Stamler, J., & Nichols, R. (1996). Intersalt revisited: further analyses of 24 hour sodium excretion and blood pressure within and across populations. *British Medical Journal, 312,* 1249-1253.

Eysenck, H. J. (1967). *The biological basis of personality.* Illinois:Thomas.

Federation of American Socities for Experimental Biology (FASEB). (1995). Analysis of Adverse Reactions to Monosodium Glutamate (MSG). Prepared by the Life Sciences Research Office, FASEB, for the Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration. Maryland: FASEB.

Filer, L. J, & Stegink, L. D. (1994). Report of the proceedings of the glutamate workshop. August 1991. *Critical Reviews in Food Science and Nutrition, 34(2),* 159-174.

Fishbein, M., Ajzen, I., & McCardle, J. (1980). Changing the behaviour of alcoholics:effects of persuasive communication. In I. Ajzen & M. Fishbein (Eds.), *Understanding attitudes and predicting social behaviour* (pp. 217-242). New Jersey: Prentice-Hall.

Frank, R. A., & van der Laauw, N. J. (1994). The relationship of sensory and personality factors to individual differences in reported food preferences. *Appetite, 22*, 101-123.

Freis, E. D. (1976). Salt volume and the prevention of hypertension. *Circulation, 53*, 589-595.

Frijters, J. E. R., & Rasmussen-Conrad, E. L. (1982). Sensory discrimination, intensity perception, and affective judgement of sucrose-sweetness in the overweight. *Journal of General Psychology, 107*, 233-247.

Fuke, S., & Shimizu, T., (1993). Sensory and preference aspects of umami. *Trends in Food Science & Technology, 4*, 246-251.

Garey, G., & Chan, M. M. (1985). Acceptance and consumption of reduced-sodium hot food menu items. *School Food Service Research Review, 9*, 35-39.

Giovanni, M. E., & Pangborn, R. M. (1983). Measurement of taste intensity and degree of liking of beverages by graphic scales and magnitude estimation. *Food Science, 48*, 1175-82.

Goulding, A., Everitt, H. E., Cooney, J. M., & Spears, G. F. S. (1986). Sodium and osteoporosis. In M. L. Wahlqvist & A. S. Truswell (Eds.), *Recent advances in clinical nutrition* (pp. 99-108). London: John Libbey.

Health Targets and Implementation (Health for All) Committee. (1988). *Health for All Australians.* Canberra: Australian Government Publishing Service.

Ikeda, K. (1909). On a new seasoning. *Journal Tokyo Chemical Society, 30*, 820-836.

International Food Information Council (1994). IFIC review on monosodium glutamate: examining the myths. [Online]. Available: http://www.social.com/health [1997, August 1].

Intersalt Cooperative Research Group. (1988). Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. *British Medical Journal, 297,* 319-328.

James, W. P. T., Ralph, A., Sanchez-Castillo, C. P. (1987). The dominance of salt in manufactured food in the sodium intake of affluent societies. *Lancet, 1*, 426-429.

Joint Food and Agriculture Organization and World Health Organization Expert Committee On Food Additives (1988). L-glutamic acid and its ammonium, calcium, monosodium and potassium salts. In *Toxicological Evaluation of Certain Food Additives and Contaminants, WHO Food Additives Series No 22.* New York: Cambridge University Press.

Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure. (1993). The fifth report of the Joint National Committee on detection, evaluation and treatment of high blood pressure (JNC V). *Archives of Internal Medicine, 153,* 154-183.

Jones, L. V., Peryam, D. R., & Thurstone, L. L. (1955). Development of a scale for measuring soldiers' food preferences. *Food Research, 20,* 512-520.

Jones, L. V., & Thurstone, L. L. (1955). The psychophysics of semantics: an experimental investigation. *Journal of Applied Psychology, 39,* 31-36.

Joosens, J. V. (1980). Strike, stomach cancer and salt: a possible clue to the prevention of hypertension. In H. Kesteloot & J. V. Joosens (Eds.), *Epidemiology of arterial blood pressure* (pp. 489-508). The Hague: Martinus Nijhoff.

Kare, M. R., Fregly, M. J., & Bernard, R. A. (1980). (Eds.) *Biological and behavioral aspects of salt intake.* New York: Academic Press.

Law, M. R., Frost, C. D., & Wald, N. J. (1991). By how much does dietary salt reduction lower blood pressure?III: Analysis of data from trials of salt reduction. *British Medical Journal, 302,* 819-824

Levey, W. A., Manore, M. M., Vaughan, L. A., Carroll, S. S., vanHalderen, L., & Felicetta, J. (1995). Blood pressure responses of white men with hypertension to two low-sodium metabolic diets with different levels of dietary calcium. *Journal of the American Dietetic Association, 95 (11),* 1280-1287.

Lyman, B. (1989). *A psychology of food: more than a matter of taste.* New York: Van Nostrand Reinhold Co.

Maller, O., Cardello, A., Sweeney, J., & Shapiro, D. (1982). Psychophysical and cognitive correlates of discretionary usage of table salt and sugar by humans. In J.E. Steiner & J.R. Ganchrow (Eds.), *Determination of behaviour by chemical stimuli* (pp. 205-216). London: IRL Press.

Maslow, A. (1937). The influence of familiarization on preference. *Journal of Experimental Psychology, 21,* 162-180.

McBride, R. L. (1982). Range bias in sensory evaluation. *Journal of Food Technology, 17,* 405-410.

Meisleman (1996). Food choice, acceptance and consumption. In H.L. Meiselman & H.J.H. MacFie (Eds.), *Food choice, acceptance and consumption* (pp. 346-364). London: Blackie Academic & Professional.

Moskowitz, H. R. (1980). Psychometric evaluation of food preferences. *Journal of Foodservice Systems, 1,* 149-167.

Naim, M., Ohara, I., Kare, M. R., & Levinson, M. (1991). Interaction of MSG taste with nutrition: perspectives in consummatory behaviour and digestion. *Physiology and Behaviour, 49(5)*, 1019-24.

National Health and Medical Research Council. (1992). *Dietary guidelines for Australians*. Canberra: AGPS.

National Heart Foundation of Australia. (1995). *Heart and Stroke Facts Report.* Canberra: National Heart Foundation of Australia.

National High Blood Pressure Education Program Working Group. (1993). National High Blood Pressure Education Program Working Group Report on Primary Prevention of Hypertension. *Archives of Internal Medicine, 153,* 186-208.

National Research Council. (1989). *Committee on diet and health. Implications for reducing chronic disease risk.* Washington DC: National Academy Press.

Notowidjojo, L., & Truswell, A. S. (1993). Urinary sodium and potassium in a sample of healthy adults in Sydney, Australia. *Asia Pacific Journal of Clinical Nutrition, 2,* 25-33.

Parducci, A. (1974). Contextual effects: a range-frequency analysis. In E. C. Carterette & M. P. Friedman (Eds.), *Handbook of perception, Vol.II. Psychophysical judgement and measurement.* New York:Academic Press.

Peryam, D. R., & Pilgram, F. J. (1957). Hedonic scale method of measuring food preferences. *Food Technology, 11(9),* 9-14.

Pliner, P. (1982). The effects of mere exposure on liking for edible substances. *Appetite, 3,* 283-290.

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120.

Pliner, P., Pelchat, M., & Grabski, M. (1993). Reduction of neophobia in humans by exposure to novel foods. *Appetite, 20,* 11-123.

Poulton, E. C. (1977). Quantitative subjective assessments are almost always biased, sometimes completely misleading. *British Journal of Psychology, 68*, 409-425.

Prescott, J. (1993). Taste Preference for Umami in Australia and Japan. Proceedings of the Umami International Symposium. Tokyo: Society for Research on Umami Taste.

Prescott, J., & Khu, B. (1995). Changes in liking for saltiness within soup as a function of exposure. *Appetite, 24*, 302.

Raudenbush, B., van der Klaauw, N. J., & Frank, R. A. (1995). The contribution of psychological and sensory factors to food preference patterns as measured by the Food Attitudes Survey (FAS), *Appetite, 25,* 1-15.

Rogers, P. J. (1990). Why a palatability construct is needed. *Appetite, 14,* 167-170.

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annual Review of Nutrition, 6*, 433-456.

Roininen, K., Lahteenmaki, L., & Tuorila, H. (1996). Effect of umami taste on pleasantness of low-salt soups during repeated testing. *Physiology & Behavior, 60 (3),* 953-958.

Shepherd, R., & Farleigh, C. A. (1986). Preferences, attitudes and personality as determinants of salt intake. *Human Nutrition: Applied Nutrition, 40A*, 195-208.

Shepherd, R., & Farleigh, C. A. (1986a). Attitudes and personality related to salt intake. *Appetite, 7(4),* 343-354.

Shepherd, R., & Farleigh, C. A. (1987). Salt intake assessment by questionnaire and urinary sodium excretion. *Nutrition Research, 7,* 557-568.

Shepherd, R., & Farleigh, C. A. (1989). Sensory assessment of foods and the role of sensory attributes in determining food choice. In R. Shepherd (Ed.), *Handbook of the psychophysiology of human eating* (pp. 25-56). Chichester: John Wiley & Sons Ltd.

Shepherd, R., Farleigh, C. A., & Land, D. G. (1984a). Effects of stimulus context on preference judgements for salt. *Perception, 13,* 739-742.

Shepherd, R., Farleigh, C. A., Land, D. G., & Franklin, J. G. (1985b). Validity of a relative-to-ideal rating procedure compared with hedonic rating. In J. Adda (Ed.), *Progress in flavour research 1984* (pp. 103-110). Amsterdam: Elsevier.

Shepherd, R., & Raats, M. M. (1996). Attitudes and beliefs in food habits. In H.L. Meiselman & H.J.H. MacFie (Eds.), *Food choice, acceptance and consumption* (pp. 346-364). London: Blackie Academic & Professional.

Shepherd, R., Smith, K., & Farleigh, C. A. (1988b). Relative-to-ideal ratings and their relationship with hedonic and intensity ratings. *Chemical Senses, 13,* 734.

Shepherd, R., & Sparks, P. (1994). Modelling food choice. In H.J.H. MacFie & D.M.H. Thomson (Eds.), *Measurement of food preferences* (pp. 202-226). London: Blackie Academic & Professional.

Southgate, D. A. T. (1996). Dietary change: changing patterns of eating. In H.L. Meiselman & H.J.H. MacFie (Eds.), *Food choice, acceptance and consumption* (pp. 365-391). London: Blackie Academic & Professional.

Stevens, S. S. (1956). The direct estimation of sensory magnitudes-loudness. *American Journal of Psychology, 69*, 1-25.

Stockley, , L. (1984). Direct measurements of intake. In *The dietary assessment of populations* (1-4). London: MRC Scientific Report No 4.

Stone, L. J., & Pangborn, R. M. (1990). Preferences and intake measures of salt and sugar, and their relation to personality traits. *Appetite, 15(1)*, 63-79.

Sullivan, S. A. & Birch, L. L. (1990). Pass the sugar, pass the salt: experience dictates preference. *Developmental Psychology, 26(4)*, 546-551.

Tarasoff, L., & Kelly, M. F. (1993). Monosodium L-glutamate: A double-blind study and review. *Food and Chemical Toxicology, 31*, 1019-1035.

Thurstone, L. L. (1927). Psychophysical analysis. *American Journal of Psychology, 38*, 369-389.

Torgerson, W. S. (1958). *Theory and methods of scaling.* New York: Wiley.

Tuorila, H., Hellemann, U., & Matuszewska, I. (1990). Can sodium contents of foods be reduced by adding flavours? Studies with beef broth. *Physiology & Behavior, 47*, 709-712.

Tuorila-Ollikainen, H., Lahteenmaki, L. & Salovaara, H. (1986). Attitudes, norms, intentions and hedonic responses to the selection of low salt bread in a longitudinal choice experiment. *Appetite, 7*, 127-139.

U.S. Department of Agriculture and U.S. Department of Health and Human Services. (1988). *The Surgeon General's report on nutrition and health (DHHS Publication No. PHS 88-50210).* Washington, DC: U.S. Government Printing Office.

Williams, J. B., & Silverman, G. (1982). *No salt no sugar no fat cookbook. An easy, delicious approach to good health.* Benicia: Nitty Gritty Cookbooks.

Witschi, J. C., Ellison, R. C., Doane, D. D., Vorkink, G. L., Slack, W. V., & Stare, F. J. (1985). Dietary sodium reduction among students: feasibility and acceptance. *Journal of American Dietetic Asssociation, 85(7),* 816-21.

World Health Organisation. (1990). *Diet, nutrition, and the prevention of chronic diseases.* WHO Technical Report No.797. Geneva: WHO, 61.

Yamaguchi, S. (1987). Fundamental properties of umami in human taste sensation. In Y. Kawamura & M.R. Kare (Eds.). *Umami: A basic taste* (41-73). New York: Marcel Dekker, Inc.

Yamaguchi, S., & Kimizuka, A. (1979). Psychometric studies on the taste of monosodium glutamate. In L .J. Filer, S.Garattini, M. R. Kare, W. A. Reynolds, and R. J. Wurtman (Eds.). *Glutamic Acid: Advances in Biochemistry and Physiology* (35-54). New York: Raven Press.

Yamaguchi, S., & Takahashi, C. (1984). Interactions of monosodium glutamate and sodium chloride on saltiness and palatability of a clear soup. *Journal of Food Science, 49*, 82-85.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*, 1-27.

The Effect of Calcium Diglutamate on the Palatability of Low-Salt Soup

Melinda Ferrier (B.A., Hon.)

Journal Article

A report submitted as a partial requirement
for the degree of Masters of Clinical Psychology
in the Department of Psychology,
University of Tasmania, 1998.

Abstract

This study examined the effects of calcium diglutamate on the palatability of low salt soup, and the effect of repeated exposure. Forty-eight participants attended six tasting sessions. At Session 1 and Session 6 participants were presented with nine soups containing differing levels of CDG (zero; intermediate, 0.44g/100ml; maximum, 0.88g/100ml) and NaCl (zero; intermediate, 0.15g/100ml; maximum, 0.30g/100ml), and they tasted and rated all nine soups for level of liking, flavour intensity, familiarity, natural taste, saltiness and richness. In between, participants were randomly assigned to nine soup groups and tasted and rated their assigned soup at Sessions 2 to 5. The hypothesis that palatability would be maintained at a lower sodium content when some of the salt was replaced by CDG was supported. The hypothesis that repeated exposure would increase level of liking was partially supported, with favourability ratings increasing significantly over the first five sessions, though the ratings decreased significantly at Session 6. The data indicate that the palatability of salt-reduced foods can be increased by the addition of an appropriate flavourant such as CDG.

Salt (sodium chloride, NaCl) is commonly added to foods as a flavouring, flavour-enhancing agent, and a preservative. In recent years however, it has become clear that the sodium intakes of people in Western societies are associated with many health problems (Antonios & McGregor, 1995). Evidence from animal, epidemiological, intervention studies and treatment trials all clearly point to the important role that salt intake plays in determining blood pressure (BP). Experimental evidence and some epidemiological evidence also suggest that salt intake may have an adverse effect on stroke mortality which may be independent of its effect on blood pressure. In addition salt intake has also been associated with asthma, stomach and nasopharyngeal cancer, and it is likely that a high salt intake may be one of several factors aggravating osteoporosis (Antonios & MacGregor, 1995).

In response to the findings of harmful effects of excess sodium, initiatives to decrease sodium intake have included the recommendation of a lower salt content in processed foods, setting a national target for sodium intake of <=100mmol/day, and publishing the dietary guideline *Choose low salt foods and use sparingly* (National Health and Medical Research Council (NH&MRC), 1992). Food manufacturers have also responded by ensuring some low-salt processed foods are available and labelled in accordance with the food regulations. Consumer's preference for the salty taste however, has to date ensured that many of these low-salt products do not sell well on the market.

The major sources of salt in the diet are manufactured foods (e.g., bread, cereals, cheese, margarine). Given the large quantity of salt consumed in processed foods, any programme for reducing the population's salt consumption will need to concentrate primarily on a reduction in the salt used during food processing. The preferred level of salt in food can itself be lowered through reduction of sodium intake, however as Bertino, Beauchamp, and Engelman (1982) found, this may require several months as salt reduction initially causes a decrease in the palatability of foods. An additional problem is that if sodium levels are restricted too sharply, then as much as 20% is added back as table salt (Beauchamp, 1987).

An alternative approach to reducing sodium levels and one that can be applied during the manufacturing process, is to replace salt with another tastant. Some evidence exists that foods low in sodium are more palatable when alternative tastants are added. One of the more successful of the tastants has been the glutamate salts, which carry a distinct flavour named "umami". Several umami substances are available as flavour enhancers in many countries. In particular there is considerable research suggesting that the flavour enhancer, monosodium glutamate (MSG) can compensate for salt. Experiments examining the functional relation between MSG and NaCl (Roininen, Lahteenmaki & Tuorila, 1996; Yamaguchi, 1987; Yamaguchi & Takahashi, 1984) have revealed that if an appropriate amount of umami substance is used, sodium intake can be reduced without decreasing the palatability of foods or decreasing the degree of satisfaction for meals.

There are two major limitations however, to the acceptability of MSG as an alternative tastant to salt. Firstly, despite extensive research suggesting that MSG is safe (Commission of the European Communities, 1991; Joint Food and Agriculture Organization and World Health Organization Expert Committee on Food Additives, 1988) there remains widespread public concern as the result of the so called "chinese restaurant syndrome" which limits the acceptability of MSG. Secondly, MSG itself contains sodium, albeit less than common salt, but in sufficient quantity to alter the sodium classification of some low salt foods to which it has been added. These issues with MSG highlight the need to continue the search for further tastants.

Calcium diglutamate (CDG), another of the glutamate salts is worth consideration as a tastant. CDG unlike MSG, contains no sodium and hence does not alter the classification of any low salt foods to which it is added. It is surprising therefore, to find that the literature addressing calcium diglutamate as a tastant is extremely limited. There is only one published study (Bellisle, Dartois, & Boyer, 1992) investigating the use of CDG as a tastant, and this study found that CDG improved the palatability of foods for uremic children in approximately 60% of cases. There is accordingly a clear case for investigating whether CDG is effective as an alternative tastant to salt. This study therefore investigated how effectively CDG can be used to retain palatability at lower salt levels, with a simple soup as the food context. In addition it also aimed to explore the effect of repeated exposure. Social psychologists have shown that simple repeated exposure to previously unknown stimuli results in a more favourable attitude towards them - the mere exposure effect (Zajonc, 1968). Ordinarily, exposure takes place over an extended period of time, but research shows that even short-term exposure to novel foods, for both adults and children, increases preferences (Birch & Marlin, 1982; Pliner, 1982; Pliner, Pelchat, & Grabski, 1993; Sullivan & Birch, 1990). The effects of exposure on foods have mostly been demonstrated in the development of liking for novel foods, but there is some evidence that the effects of exposure also operate in the development of liking for different levels of tastants within familiar foods (Prescott & Khu, 1995).

Other factors that were considered given that they are implicated in determining food choice and hence may differentiate subjects included the level of food neophobia, customary level of sodium intake in daily diet and attitude and motivation towards reducing (or otherwise) sodium intake. With regard to food neophobia , that is the propensity to avoid or approach novel foods (Pliner & Hobden, 1992), it has been shown that individual differences in food preferences are related to fear of trying new and unusual foods (Pliner & Hobden, 1992). In humans, common experience suggests that there are large individual differences in neophobia, those who are highly neophobic being less willing to taste novel foods than those lower in neophobia. However, after tasting the food, more highly neophobic people have not rated foods, novel or familiar, as less palatable than those low in food neophobia (Pliner & Hobden, 1992).

In regard to customary level of sodium intake, evidence suggests that the preferred level of salt in a familiar food is directly influenced by prior dietary experience (Beauchamp & Cowart, 1990; Bertino et al, 1982, 1986; Blais, Pangborn, Borhani, Ferrell, Prineas and Laing, 1986; Maller, Cardello, Sweeney & Shapiro, 1982; Shepherd and Farleigh, 1986). Generally speaking, decreases in salt consumption are followed by decreases in the most preferred level of salt in food; the reverse is also the case. Influences on food choice are also likely to be mediated by the attitudes and beliefs held by an individual. Accordingly the study of the relationship between food choice and the beliefs and attitudes held by a person will provide a better understanding of the influence of different factors on food choice (Shepherd & Raats, 1996).

In the present study, 48 participants tasted and rated soups with differing levels of CDG and NaCl. In addition participants were exposed to a soup throughout the week so as to explore the effects of repeated exposure. So as to eliminate likely confounding variables, all participants completed a food neophobia checklist, salt-intake checklist and questions in relation to motivation and attitude towards reducing salt levels. The design permitted comparisons at individual sessions and across sessions, and consisted of ratings of level of liking, flavour intensity, familiarity, natural taste, saltiness, and richness. It was predicted that:

1. palatability would be maintained at a lower sodium content when some of the salt was replaced by CDG
2. following repeated exposure to low salt concentrations, and soups containing glutamate, the levels of liking and familiarity for those soups would increase
3. participants who scored highly on Millar and Beard's (1988) Sodium Intake Checklist (i.e., habitual high salt users) would favour the higher salt soups
4. low neophobics (as measured on Pliner and Hobden's, 1992, Food Neophobia Scale) would report greater willingness to taste soups than high neophobics, but following tasting, low and high neophobics would show no differences in liking
5. participants who were motivated to reduce salt intake (as measured by the questions relating to attitude and motivation to reduce salt) would favour the low salt component soup.

Method

Participants

Forty-eight university and community volunteers completed the study. The university participants included 22 staff and students (undergraduate and postgraduate psychology) from the University of Tasmania in Hobart (6 males, 15 females, 1 participant not recording gender). The undergraduate students participated in the study in partial fulfilment of psychology practical course requirements. The community participants were 26 employees (4 males and 21 females) recruited from the Tasmanian Department of Community and Health Services.

The 48 participants ranged in age from 18 to 54 years (M = 30.54, SD = 12.47). The ages of subjects of the university (M = 20.9 years, SD= 7.51) and the community participants (M = 38.7 years, SD = 9.69) were significantly different [$F(1,42) = 44.95$, $p < .001$). Smokers and any people who reported previous reactions to MSG were excluded. Participants were asked to refrain from eating for 1 hour prior to testing.

Apparatus and Materials

The instruments included (i) basic demographic data, (ii) the Sodium Intake Checklist (Millar & Beard, 1988), (iii) the Food Neophobia Scale (Pliner & Hobden, 1992), (iv) seven questions on attitude and motivation to reduce salt intake, and (v) questionnaires composed of rating scales, for each tasting session (see Appendices A-D).

The Sodium Intake Checklist (SICL). The SICL consists of 21 of the most heavily salted foods in the typical Australian diet and items are answered in relation to the previous three days' intake with a frequency rating range of "zero" to "eight or more times". The total sodium score is the sum of the ratings for all 21 items. In this study participants answered in relation to a frequency range of "one" to "eight or more times".

Results obtained in Millar and Beard's study (1988) suggest that the SICL is a reliable and accurate measure of the avoidance of food that contains added sodium. Scores on the checklist were internally reliable (Cronbach alpha/α = .75), the correlation between urinary sodium excretion and checklist scores was acceptable ($r = .70$), and discriminant validity has been indicated by the highly significant difference in scores obtained by two groups: college students who were eating their regular diet and individuals who were in the Canberra Blood Pressure Trial group. The SICL was chosen over a urinary test as the test was inexpensive, easy to administer and score, and reliable.

The Food Neophobia Scale (FNS). The FNS is a measure of the trait of food neophobia, ie the reluctance to eat and/or avoid novel foods. The test consists of 10 items, 5 positively worded and 5 negatively worded, and subjects indicate on a 7-point bipolar rating scale the extent of their agreement with each item (disagree strongly - agree strongly). Total scores are calculated and the potential range of scores on the scale is 10-70. A higher score is indicative of greater neophobia.

Results obtained by Pliner and Hobden (1992) suggest that the FNS has satisfactory test-retest reliability (r ranged from = 0.82 to 0.91) and internal consistency (alpha coefficient of 0.88). Pliner and Hobden (1992) found that subject's FNS scores were highly predictive of their behavioural response to the novel foods used in the experiment ($r(39) = 0.61, p < 0.001$).

Motivation/Attitude Towards Reducing Sodium Intake

An item analysis was conducted on the seven motivational/attitudinal items and found a Cronbach's alpha coefficient of .81. In theory scores on this scale could range from 7 to 35; in fact, they ranged from 11 to 35 with a mean of 23.96 and a SD of 6.08.

Soup. A chicken and vegetable broth was prepared by Lazenby's Restaurant, University of Tasmania. Ingredients selected for the soup contained only low levels of "free" glutamate (see Appendix E for recipe). Common salt (sodium chloride, NaCl) and calcium diglutamate (CDG) were added to the prepared soup by the author. CDG was obtained from Ajiinomoto Company, Tokyo. CDG is approved by Australian government authorities as food additive No. 623.

The soup was prepared in nine standard versions, with 3 levels of CDG combined with 3 levels of NaCl. In determining the levels of CDG the researcher was guided by the results of a pilot study which included 44 participants and 6 levels of CDG ranging from 0g/100ml to 1.32g/100ml, and which found the most preferred level of CDG was 0.88g/100ml. The three levels of CDG were 0g/100ml, intermediate (0.44g/100ml, being the midpoint), and the most preferred (0.88g/100ml).

In determining the levels of NaCl to use the author was guided by the levels of Na permitted in foods that are permitted to be labelled "low-salt" or "low-sodium" under Australian law, that is, no more than 120 mg Na/100 gms, which is equivalent to 0.30 g NaCl per 100 g. In this study the levels of NaCl used were 0g/100ml (zero), 0.30g/100 ml (maximum level consistent with "low-sodium" labelling), and 0.15g/100ml (half the "maximum level").

The samples were presented in coded plastic film containers, 30ml each, in a randomised order. A representative of Kodak was contacted regarding the use of film containers for food use and advised that the plastic conforms to Australian standards AS2070 Plastic Material for Food Contact Part 1. The containers were warmed in a bain-marie, at 40-50C.

Procedure

Main Study. Each participant attended six tasting sessions. At the first session (Friday) participants were initially given an information sheet and a consent form to complete (see Appendix F). A Food Neophobia Scale and a Sodium-Intake Checklist were also completed, as was basic demographic data, questions on attitude and motivation to reduce salt, and a question relating to willingness to taste soups.

Participants then tasted and rated the nine different soup samples, presented in random order for each participant. They rated each soup sample for level of liking (9 point scale from "dislike extremely" to "like extremely"), flavour intensity (5 point scale from "no flavour" to "extremely strong flavour"), familiarity (5 point scale from "not all familiar" to "extremely familiar"), natural taste (5 point scale from "not at all natural" to "extremely natural taste"), richness (5 point scale from "not at all rich" to "extremely rich taste") and saltiness (5 point scale from "not at all salty" to "extremely salty"). After each sample participants rinsed their mouths with water, and then waited an interstimulus interval of at least 1 minute before their next tasting. The session required approximately 30 to 40 minutes.

Participants were then randomly assigned to one of the nine soup groups and had repeated exposure with that one sample only. Participants attended four successive tasting sessions (Monday to Thursday) during the following week and at each of these sessions tasted and rated the one soup sample to which they had been randomly assigned. Ratings were the same as those recorded at the first session (ie liking, flavour intensity, familiarity, natural taste, saltiness, richness). The sessions required approximately 3 minutes each.

Subjects then attended a sixth tasting session (Friday) during the same week, and again tasted and rated all nine soup samples in a random order, rinsing their mouths between tasting and with an interstimulus interval of at least 1 minute. Ratings were the same as those recorded at previous sessions (ie liking, flavour intensity, familiarity, natural taste, saltiness, richness). The session required approximately 20 to 30 minutes. All participants were fully debriefed following the completion of the questionnaires and were given the opportunity to ask questions.

Results

A series of two-way analyses of variance (ANOVA'S) (Appendix G) was performed on the raw data from each of the six ratings (liking, flavour intensity, familiarity, natural taste, saltiness, richness) for Session 1 and for Session 6. The independent variables included in the analyses were CDG (zero, intermediate, maximum) and NaCl (zero, intermediate, maximum). Three-way analyses of variance were also carried out separately on the participants' ratings for the soup that they tasted at each of the six sessions (Appendix G). Alpha significance levels were $p<.01$ for all ANOVA's.

The findings from the ANOVA's are presented in six sections (Level of Liking, Flavour Intensity, Familiarity, Natural Taste, Saltiness, and Richness). In each section the analyses of the data from Session 1, Session 6, and Sessions 1 to 6 are reported and the consistency between the findings of these analyses is such that repetition is unavoidable. Other data (e.g., possible confounding variables, correlations), are reported separately.

In undertaking analysis of the data a MANOVA was considered, but after preliminary exploration of the data separate analyses were favoured given that a MANOVA would only have led on to individual ANOVA's in any case, and would itself have contributed nothing to the overall picture.

Groups Did Not Differ On Possible Confounding Variables

Participants were randomly allocated and exposed to nine soup groups during sessions 2 to 5. An analysis of variance revealed that these groups did not differ in level of food neophobia [$F(4, 38) = .62, p < .65$], level of sodium intake [$F(4, 38) = .68, p < .61$], or motivation/attitude [$F(4, 38) = .34, p < .85$].

Level of Liking

Session 1. The two-way ANOVA carried out on the level of liking ratings at Session 1 did not reveal a significant CDG by NaCl interaction [$F(4, 188) = .39, p < .82$]. There was however, a significant main effect for CDG [$F(2, 94) = 17.84, p < .0001$] and a main effect for NaCl [$F(2, 94) = 11.62, p < .0001$]. The Tukey HSD Test indicated that the soups containing the intermediate and maximum levels of CDG had significantly higher levels of liking than the soups containing no CDG, and the same pattern of results was found for NaCl at $p<.01$ (see Table 1). Figure 1 illustrates how the addition of an intermediate or maximum level of CDG to the soups containing no NaCl increased the level of liking, and that this level of liking was greater than for the soups with the maximum level of NaCl with no CDG. Figure 1 also illustrates how the addition of extra CDG (maximum level) did not increase level of liking significantly, from the intermediate level of CDG, and likewise the addition of extra NaCl (maximum level) did not increase level of liking significantly, from the intermediate level of NaCl (see also Table 1).

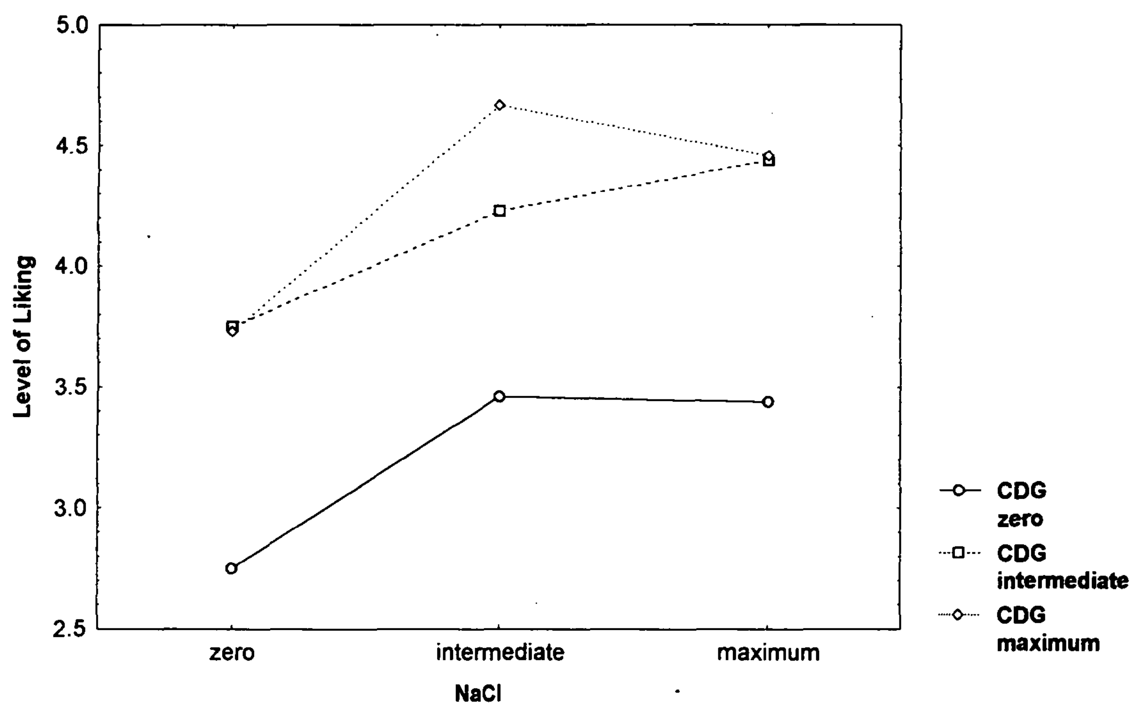

Figure 1. Mean level of liking for the nine different soups at Session 1.

Session 6. The analysis conducted on the level of liking at Session 6 revealed a significant main effect of CDG [F(2, 94) = 36.28, $p < .0001$]. The main effect for NaCl did not reach significance [F(2, 94) = 4.47, $p < .014$]. The Tukey HSD Test indicated that the soups containing intermediate and maximum levels of CDG had significantly higher levels of liking than the soups containing no CDG, at $p<.01$ (see Table 1).

Table 1

Level of Liking for CDG and NaCl Differences at Session 1 and Session 6

	CDG			NaCl		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	3.22_b	4.14_a	4.28_a	3.41_b	4.12_a	4.11_a
Session 6	3.17_b	4.28_a	4.28_a	3.62	4.09	4.02

Note Mean values rounded to 2 decimal places

Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Means that have subscript *b* differ from the optimum group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Sessions 1 to 6. The level of liking for soups tasted over six sessions was analysed and revealed the main effect of CDG did not reach significance [F(2, 39) = 4.94, $p < .012$]. The main effect of NaCl was found not to be significant [F(2,39) = .75, $p < .48$]. There was a significant effect of Session [F(5, 195) = 7.67, $p < .0001$]. As Figure 2 illustrates there was an increase in level of liking from Session 1 to

Session 5 (post hoc tests reveal that this is significant at $p<.01$), then a significant decrease in level of liking from Session 5 to Session 6 at $p<.01$ (see also Table 7).

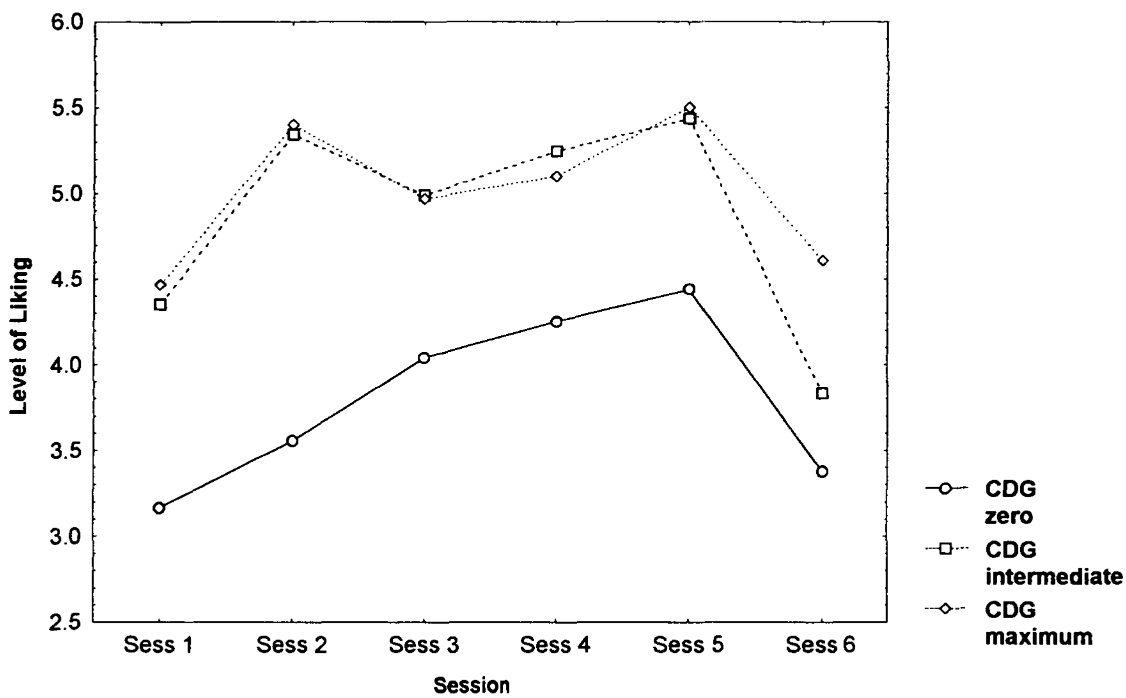

Figure 2. Mean level of liking for the nine different soups across 6 exposures.

Flavour Intensity

Session 1. The two-way analysis of variance carried out on the rating of flavour intensity at Session 1 failed to reveal a significant CDG by NaCl interaction [$F(4, 188) = .51, p < .73$]. There was however, a significant main effect for CDG [$F(2, 94) = 46.87, p < .0001$] and a main effect for NaCl [$F(2, 94) = 18.17, p < .0001$]. The Tukey HSD Test indicated that the soups containing intermediate and maximum levels of both CDG and NaCl had significantly higher levels of flavour intensity than the soups containing no CDG and NaCl respectively at $p<.01$ (see Table 2). Figure 3 illustrates how the addition of an intermediate or maximum level of CDG increased the flavour intensity of the soups at each level of NaCl.

Session 6. As for Session 1, the analysis of flavour intensity at Session 6 revealed a significant main effect of CDG [$F(2, 94) = 61.25, p < .0001$], and of NaCl [$F(2, 94) = 30.56, p < .0001$]. The Tukey HSD Test indicated that the intermediate and maximum levels of CDG had significantly higher levels of flavour intensity than the soups containing no CDG, and that the flavour intensity for each level of NaCl was significantly different, with flavour intensity rising with increasing NaCl at $p<.01$ (see Table 2).

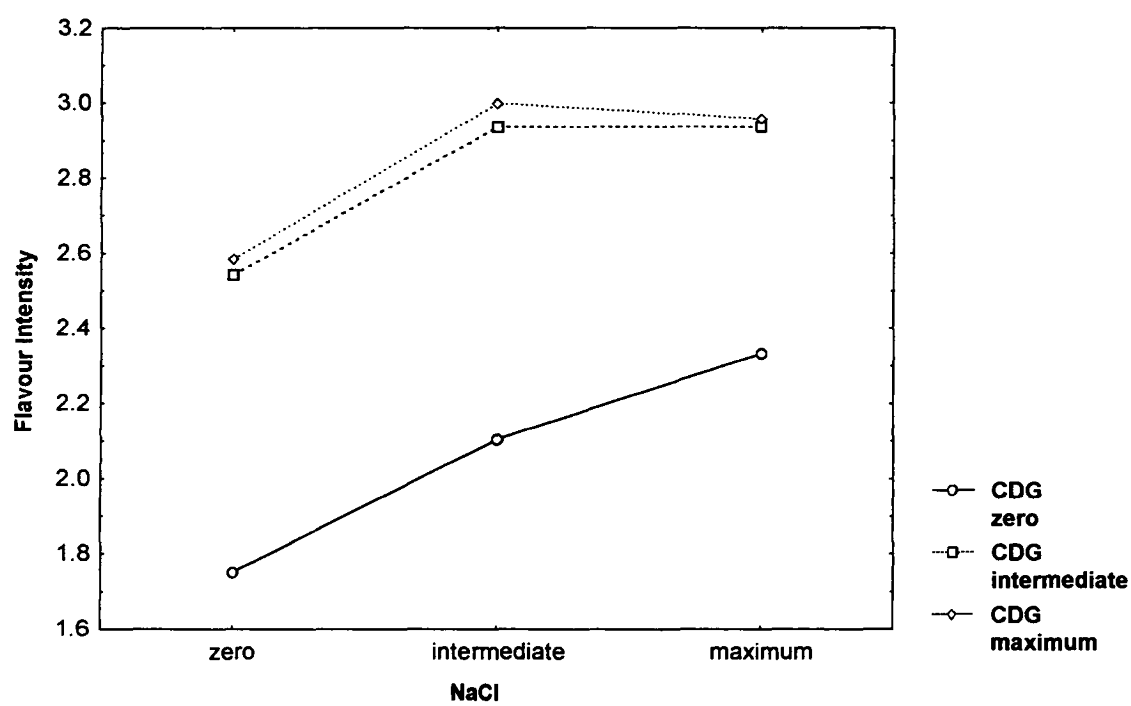

Figure 3. Mean level of flavour intensity for the nine different soups at Session 1.

Table 2

Level of Flavour Intensity for CDG and NaCl Differences at Session 1 and Session 6

	CDG			NaCl		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	2.06_b	2.81_a	2.85_a	2.29_b	2.68_a	2.74_a
Session 6	1.88_b	2.61_a	2.75_a	2.11_b	2.39_{ab}	2.74_a

Note Mean values rounded to 2 decimal places

Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Means that have subscript *b* differ from the optimum group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Sessions 1 to 6. The analysis of variance conducted on the flavour intensity for soups tasted over six sessions found the main effect of CDG reached significance [F(2, 39) = 11.96, $p < .0001$]. The Tukey HSD Test indicated that soups containing the intermediate and maximum level of CDG were found to be significantly more flavour intensive than those containing no CDG at $p<.01$. The main effect of NaCl was found not to be significant [F(2,39) = 1.30, $p < .28$]. There was no main effect found for Session [F(5, 195) = 2.07, $p < .07$].

Familiarity

Session 1. The two-way analysis of variance found the main effect of CDG reached significance [F(2, 94) = 13.01, $p < .0001$]. The Tukey HSD Test indicated that the maximum level of CDG was rated significantly more familiar than the zero level $p<.01$ (see Table 3). The main effect of NaCl was significant [F(2, 94) = 6.77, p < .002] with post-hoc tests revealing the soups containing no NaCl were significantly less familiar than the soups containing an intermediate level of NaCl at p<.01 (see Table 3).

Table 3

Level of Familiarity for CDG and NaCl Differences at Session 1 and Session 6

	CDG			NaCl		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	1.65_b	1.90_a	2.15_a	1.73	2.01_a	1.97
Session 6	1.60_b	2.10_a	2.06_a	1.81	1.96	1.99

Note Mean values rounded to 2 decimal places
Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.
Means that have subscript *b* differ from the optimum group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Session 6. The main effect of CDG reached significance [F(2, 94) = 30.37, p < .0001]. The main effect of NaCl did not reach significance [F(2, 94) = 3.54, p < .03]. The Tukey HSD Test indicated that soups containing no CDG were significantly less familiar than the soups containing an intermediate and maximum level of CDG at p<.01 (see Table 3).

Sessions 1 to 6. An analysis of variance was conducted on the level of familiarity for soups tasted over six sessions. There was a significant main effect of Session [F(5, 195) = 13.03, p < .0001]. The Tukey HSD Test indicated that the level of familiarity increased significantly from Session 1 to Session 5, with each session recording a familiarity rating that was significantly greater than at Session 1, however from Session 5 to Session 6 there was a significant decrease in familiarity, at $p<.01$ (see Table 7). There was no significant main effect of CDG [$F(2, 39) = 4.33, p < .0201$], or NaCl [$F(2,39) = .002, p < .997$].

Natural Taste

Session 1. The two-way ANOVA conducted on the rating of natural taste for Session 1 revealed there were no significant main effects of CDG [$F(2, 94) = .94, p < .39$], or NaCl [$F(2, 94) = 1.91, p < .15$].

Session 6. The analysis conducted on Session 6 found a significant main effect for CDG [$F(2, 92) = 8.46, p < .0001$]. The Tukey HSD Test indicated that soups containing an intermediate level of CDG were considered to have a significantly more natural taste than the soups containing no CDG at $p<.01$ (see Table 4).

Table 4

Level of Natural Taste for CDG and NaCl Differences at Session 1 and Session 6

	CDG			**NaCl**		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	1.94	2.03	2.08	2.02	2.11	1.92
Session 6	1.75	2.16_a	1.99	1.91	2.03	1.96

Note Mean values rounded to 2 decimal places
Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Sessions 1 to 6. An analysis of variance was conducted on the ratings of natural taste for the soups tasted over six sessions, and revealed there was no significant main effect of Session [$F(5, 195) = 3.04, p < .011$], NaCl [$F(2,39) = .35, p < .71$], or CDG [$F(2,39) = .49, p < .62$].

Saltiness

Session 1. The ANOVA carried out on the ratings of saltiness for Session 1 revealed significant main effects for CDG [$F(2, 94) = 41.65, p < .0001$], and for NaCl [$F(2, 94) = 17.20, p < .0001$]. The Tukey HSD Test indicated that those soups containing the intermediate and the maximum levels of CDG and NaCl were rated as significantly more salty than the soups containing no CDG and NaCl respectively at $p<.01$ (see Table 5).

Table 5

Level of Saltiness for CDG and NaCl Differences at Session 1 and Session 6

	CDG			NaCl		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	1.82_b	2.56_a	2.65_a	1.99_b	2.39_a	2.65_a
Session 6	1.76_b	2.36_a	2.49_a	1.83_b	2.15_{ab}	2.63_a

Note Mean values rounded to 2 decimal places
Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.
Means that have subscript *b* differ from the optimum group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Session 6. As for Session 1, the two-way ANOVA at session 6 revealed significant main effects for CDG [$F(2, 94) = 33.71$, $p < .0001$] and NaCl [$F(2, 94) = 32.44$, $p < .0001$]. The Tukey HSD Test indicated that the soups containing the intermediate and maximum levels of CDG were rated as significantly more salty than the soups containing no CDG at $p<.01$, and that with each increase in NaCl their was a significant increase in the rating of saltiness at $p<.01$ (see Table 5).

Sessions 1 to 6. An analysis of variance conducted on the rating of saltiness for soups tasted over six sessions found there was a significant main effect of NaCl [$F(2, 39) = 6.98$, $p < .003$], and CDG [$F(2, 39) = 7.24$, $p < .002$]. There was no significant effect for session [$F(5, 195) = 1.26$, $p < .28$].

Richness

Session 1. The two-way ANOVA revealed a significant main effect for CDG [$F(2, 92) = 28.21$, $p < .0001$], and NaCl [$F(2, 92) = 18.41$, $p < .0001$]. Post hoc tests indicated that for the intermediate and maximum levels of CDG the rating of richness was significantly higher than for the soups containing no CDG , and there was an equivalent pattern of results for NaCl, at $p<.01$ (see Table 6). Post hoc tests also revealed that increasing the level of CDG from intermediate to maximum did not increase richness significantly (see Table 6). As illustrated in Figure 4 the level of richness with an intermediate or maximum level of CDG was higher (although not significantly) than that for soups which contain the maximum level of NaCl and no CDG. Figure 4 also demonstrates that adding CDG at each level of NaCl increased the rating of richness.

Session 6. As for Session 1 the analysis at Session 6 revealed a significant main effect for CDG [$F(2, 94) = 42.46$, $p < .0001$], and for NaCl [$F(2, 94)= 16.95$, $p < .0001$]. The Tukey HSD Test indicated that soups containing an intermediate and maximum level of CDG were rated as richer than the soups containing no CDG at $p<.01$ (see Table 6). The same pattern of results was found for NaCl (see Table 6).

Table 6

Level of Richness for CDG and NaCl Differences at Session 1 and Session 6

	CDG			NaCl		
	0	**Intermed.**	**Maximum**	**0**	**Intermed.**	**Maximum**
Session 1	1.42_b	2.11_a	2.09_a	1.58_b	2.01_a	2.03_a
Session 6	1.51_b	2.20_a	2.26_a	1.74_b	2.02_a	2.21_a

Note Mean

Values rounded to 2 decimal places

Means that have subscript *a* differ from the zero group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Means that have subscript *b* differ from the optimum group in the same row for the same substance (ie CDG or NaCl) at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

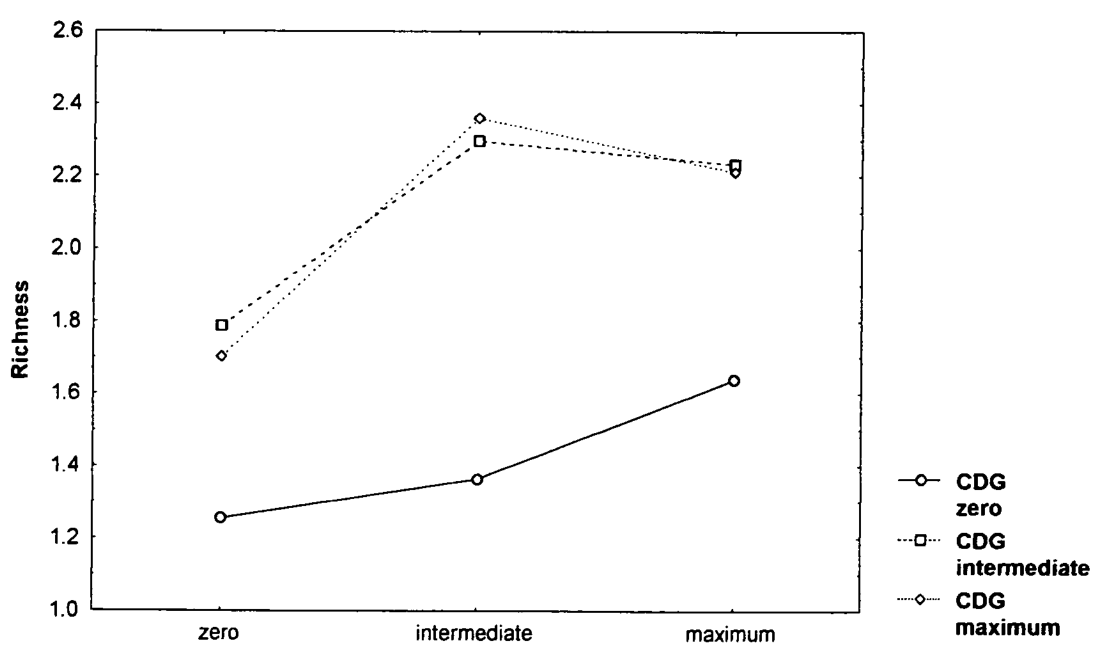

Figure 4. Mean level of richness for the nine different soups at Session 1.

Sessions 1 to 6. An analysis of variance was conducted on the rating of richness for soups tasted over six sessions. There was a significant main effect of CDG [$F(2, 39) = 7.65, p < .002$]. There was no significant effect for Session [$F(5, 195) = 1.86, p < .10$].

Table 7

Level of Liking, Flavour Intensity, Familiarity, Natural Taste, Saltiness, and Richness Over Six Sessions.

	Session					
	One	**Two**	**Three**	**Four**	**Five**	**Six**
Liking	3.99_b	4.77_{ac}	4.66_c	4.86_{ac}	5.12_{ac}	3.94_b
Flav. Int.	2.29_c	2.68_{ab}	2.74_{ab}	2.11_{bc}	2.39_c	2.74_{ab}
Famil.	1.82_b	2.39_{ac}	2.41_{ac}	2.48_{ac}	2.65_{ac}	1.95_b
Nat Taste	2.04	2.25	2.29	2.33	2.41_c	1.94_b
Saltiness	2.28	1.99	2.02	1.96	2.15	2.08
Richness	1.81	1.88	1.98	1.90	2.18	2.03

Note Mean values rounded to 2 decimal places

Means that have subscript *a* differ from the Session 1 mean in the same row at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Means that have subscript *b* differ from the Session 5 mean in the same row at $p < .01$ in the Tukey Significant Difference (HSD) comparison.

Means that have subscript *c* differ from the Session 6 mean in the same row at $p < .01$ in the Tukey Honestly Significant Difference (HSD) comparison.

Correlation of Food Neophobia, Sodium Intake, and Motivation/Attitude Towards Reducing Sodium Intake with Ratings of Liking, Flavour Intensity, Familiarity, Natural Taste, Saltiness and Richness

A series of separate 3 X 3 matrices of correlations were computed for Session 1 and Session 6 to examine food neophobia, sodium-intake and motivation/attitude towards salt as predictors of the ratings (liking, flavour intensity, familiarity, natural taste, saltiness, and richness) for each of the nine soups. The correlational analyses did not show a consistent pattern, and hence are not presented here (see Appendix H).

Correlation Between Food Neophobia and Willingness

Scores on the Food Neophobia Scale were correlated with the item regarding willingness to taste soups, and the correlation coefficient of .17 was not significant at $p < .05$.

Correlation Between Motivation/Attitude and Salt-Intake

The scores on the Motivation/Attitude Scale and the scores on the Salt-Intake Checklist were correlated and the r was found to be -.33, which was significant at $p < .05$. This indicated that those participants who are motivated to reduce their sodium intake have a diet that is lower in sodium than those participants who are not motivated to reduce their sodium intake.

Discussion

Findings supported Hypothesis 1, as soup palatability was clearly maintained at a lower sodium content when CDG was present, indicating that some salt can be replaced by CDG. When CDG at either the intermediate or maximum level was added to the no-salt soup, the rating of liking, flavour intensity, and richness increased significantly. Similarly, other researchers (Prescott, 1993; Roininen et al, 1996; Yamaguchi & Takahashi, 1984) have found the addition of MSG to low-salt soup has increased palatability and richness. The findings are also consistent with Bellisle et al.'s (1992) finding that CDG improved the taste of foods for some uremic children. The findings of the current study provide specific support for the positive effect of CDG on food palatability and richness under conditions of restricted sodium intake. Accordingly the results of this study indicate that alternative tastants can be used to reduce salt intake in humans.

It must be noted though, that the soup used in this study was of only low to moderate palatability, as is reflected in participant mean ratings. Similarly however, Yamaguchi and Takahashi (1984) also had soups that were rated of fair palatability.

The maximum level of CDG used in this study (.88%) was similar to that used by Prescott (1993) of .8% MSG, although it is considerably higher than the .38% MSG used by Yamaguchi and Takahashi (1984). The intermediate level of CDG used in this study (.44%) is however more equivalent to the level used by Yamaguchi & Takahashi (1984), and the findings of this study that there was little difference between the intermediate and maximum levels, suggest a lower level may be sufficient to maintain palatability in salt-reduced soups. This also supports the notion of Yamaguchi and Takahashi (1984) that NaCl can be reduced and the flavour intensity maintained by slightly increasing the added MSG level, but that one soon reaches a point where further MSG additions make little or no contribution to increasing taste intensity. An underlying explanation is probably that, as the intermediate level in this study is logarithmically closer to the maximum level than to the zero level, and that as subjective tasting is logarithmically related to objective saturation, the subjective ratings for the upper two levels were less separated than for the lower two levels. Further research using intermediate levels spaced on a logarithmic basis between the upper and lower levels would determine more clearly what levels of CDG are required to ensure maximum palatability in salt-reduced soups.

Hypothesis 2, that repeated exposure to low-salt soups and soups containing glutamate would increase liking and familiarity for those soups, was only partially supported. There was a significant main effect of session and CDG for the ratings of level of liking and familiarity. From Session 1 to Session 5 there was a steady increase in the level of familiarity and liking for soups and this provides support for the notion that the mere exposure effect plays a role in the acquisition of food preferences for novel tastants within familiar foods (Prescott & Khu, 1995). At Session 6 however, there was a significant decrease in both level of liking and familiarity. As previously indicated the soups were not overly palatable and it appears possible that participants were put off by the prospect of having to taste all nine soups again on the final day, causing a decline in ratings. Leaving aside the problem of Session 6, these findings do also demonstrate that exposure effects can be seen after relatively brief periods of exposure, which is in agreement with Prescott & Khu's (1995) finding that the effect can be seen after five exposures.

Level of customary salt has emerged as influential in the studies of food choice (Bertino et al, 1982,1986; Blais et al, 1986; Shepherd & Farleigh, 1986). In the present study the findings failed to support hypothesis 3 that high habitual salt users would favour the high salt component soups and low habitual salt users the low salt component soups, with the correlations found between salt intake and the ratings being only isolated and occasional. A possible explanation for the failure to find a strong relationship may have been the exclusive reliance upon self-report (SICL) to determine customary sodium intake. Participants may have answered questions carelessly, inaccurately, or untruthfully (Beard, 1990). The results of this study are consistent however with the recent findings of Drewnowski, Henderson, Driscoll and Rolls (1996), who found that hedonic response profiles for salt in soup were not related to daily sodium intakes as assessed by diet records. These researchers suggest that the relationship is not present due to food choices and food consumption being determined by sociocultural factors, including concern about nutrition and health, and that these effects are likely to outweigh sensory factors in their effect on adults.

Those participants who were highly neophobic did not differ from those low in food neophobia in their willingness to taste the soups, contrary to expectations (Hypothesis 4). This provides some encouragement to think that participants are willing to eat familiar foods with different levels of tastants, regardless of their level of food neophobia. The finding may be due however, to the fact that all participants were volunteers, and were aware prior to signing up for participation, that they would be tasting a variety of soups. In addition, or perhaps because of this, there were very few participants who could be considered as highly neophobic, in fact only two participants scored above 40 (the possible range of the FNS being 10 to 70). Once soups had been tasted the correlations between food neophobia and the ratings were extremely limited, consistent with the finding of Pliner and Hobden (1992) that on tasting foods highly neophobic participants do not rate foods as less palatable than those low in food neophobia. An alternative explanation could be that participants' range of scores on the FNS was not sufficient to generate significant correlations between food neophobia and the ratings. Hence further research would ideally ensure that the participant group contained a greater diversity in FNS scores.

The seven questions formulated to address attitudes towards salt and motivation to reduce (or otherwise) salt intake appeared to form a reliable and acceptable scale with the Cronbach's coefficient alpha (which is a measure of homogeneity of the test) of .81, indicating acceptable internal reliability for the check-list. Given this finding, and the important role of attitudes in influencing dietary choice (Shephard & Raats, 1996), further research into the validity of the scale and examination of consumers' attitudes to salt may be useful in determining what impact attitudes are having and areas that can be addressed when attempting to influence sodium intake.

The results did not support Hypothesis 5, that participants who were motivated to decrease salt intake would favour the low component soup, the significant correlations between motivation to reduce salt and the ratings being isolated and occasional. Although the finding of a correlation between motivation to reduce salt and the SICL scores suggests that those motivated to reduce salt levels are actually consuming less salt in their diet, this correlation however is reliant on two self-report measures, and hence the limitations of such measures must be borne in mind. Further research correlating a 24-hour urine measure of sodium intake and scores on the motivation scale is needed to confirm the findings.

The study confirmed that as the level of salt was increased participants not surprisingly rated the soups as saltier. What was perhaps surprising, however, was that as the level of CDG increased the ratings of saltiness also increased, hence participants perceived CDG as imparting a salty taste. CDG does not contain a sodium component, and hence the finding that it is perceived as having a salty taste provides further promise for the future use of CDG as alternative tastant to NaCl. In broad support of this, Bellisle et al. (1992) in their study of the acceptability of CDG as a sodium substitute in uremic children, found that the older children who had experienced salty foods for a longer time than nonusers, preferred foods with CDG added, indicating that CDG may impart a subjectively salty taste. An alternative explanation to the findings of the current study however, may be that the participants equated "nice" with "salty" in savoury foods, and hence inferred, rather than perceived, saltiness. Further research is needed to clearly distinguish participants' perception of saltiness as opposed to the inference of a salty taste.

Consumers often attribute artificial tastes in food to "additives". MSG is often perceived as just another additive, and is believed to decrease the natural taste of food, and hence it is probable that this perception would also exist for CDG. The findings of this study show however that there were no main effects for natural taste at session one, suggesting that soups containing CDG were considered as being no more unnatural than those containing no CDG. At session six there was a main effect of CDG which showed that as the levels of CDG increased participants rated the soups as tasting more natural. These findings suggest that the CDG flavour is perceived by participant's as natural. Similarly Prescott (1993) found if consumers are not aware that MSG has been added to a food, then they do not rate that food as having decreased natural taste.

This study was conducted on an Australian population and the finding that palatability can be maintained at a lower sodium content when some of the salt was replaced by CDG, provides support for the notion that umami can be used to increase palatability of foods for Australian consumers and be accepted by an Australian population as a tastant. This supports Prescott's (1993) finding that even where differences did occur for umami tastes between Australians and Japanese, that these were a matter of degree (higher Japanese preference ratings for umami most likely results from greater familiarity with this taste), not different response patterns. In addition, the study by Bellisle et al. (1992) conducted in France, also lends support to the notion that the umami taste is accepted by populations other than the Japanese, and to Prescott's (1993) notion that preferences for basic tastes may differ very little from country to country.

Current sodium intakes are associated with many health problems (e.g., blood pressure and strokes) and hence reduced sodium intakes are needed in order to assist in the management of such conditions. One method of modifying foods so as to provide less sodium with minimal loss of consumer acceptance is to replace salt with alternative tastants. Research into the viability of alternative tastants is clearly showing that tastants such as glutamates have the potential to improve the palatability of salt reduced foods. Further, the findings of this study suggest that CDG is capable of increasing the palatability of salt-reduced foods, and maintaining a taste that is perceived as natural. Given the importance of finding conditions where the total amount of NaCl can be restricted and foods remain fairly palatable, appropriate flavour additions such as MSG or CDG may play a potentially important role in the reduction of salt intake in humans. Given the advantages in community acceptability of CDG over MSG, further research in to CDG is needed to determine its validity as a tastant.

It would be important for future research to use a more palatable soup, with varying levels of CDG that were both objectively and subjectively different, and spaced on a logarithmic basis. This would assist in determining more clearly what level of CDG is needed to ensure the maintenance of palatability in salt-reduced soups. In addition future research should explore the viability of CDG as a tastant in foods of a more complex nature. Adams, Maller, and Cardello (1995) in a study looking at consumer acceptance of foods lower in sodium, found that acceptability for foods varied considerably over a broad range of sodium concentrations, and that this was dependent on the complexity of the food. The simpler the food (containing fewer ingredients) the greater the acceptability level at a lower rate of sodium content. Given these findings, it is likely that optimal levels of CDG will differ depending on the ingredients and complexity of the food, and this needs to be explored.

Further investigation is needed of the existing self-report instruments for assessing salt intake (eg SICL). Additional studies are required to validate the SICL against 24 hour urine measures and improve this questionnaire, so that there is one questionnaire that can be trusted as a self report measure of salt intake. Further research could also be undertaken of the motivation to reduce salt questionnaire, given it's acceptable alpha level and given the important role that motivation to reduce salt intake will take in attempting to reduce consumers' sodium levels. In addition, future research will be needed to examine whether CDG actually imparts a salty taste, or whether a salty taste is merely inferred.

In conclusion, the main findings of this study strongly suggest that CDG is capable of enhancing the palatability of reduced salt soup. The identification of tastants that can maintain the palatability of foods low in sodium will play an important role in the reduction of human sodium intake, and consequently will have benefits to human health.

References

Adams, S. O., Maller, O., & Cardello, A. V. (1995). Consumer acceptance of foods lower in sodium. *Journal of the American Dietetic Association, 95(4)*, 447-453.

Antonios, T. F. T., & MacGregor, G. A. (1995). Deleterious effects of salt intake other than effects on blood pressure. *Clinical and Experimental Pharmacology and Physiology, 22*, 180-184.

Beard, T. C. (1990). *Salt in medical practice.* Hobart: Menzies Centre for Population Health Research.

Beauchamp, G. K., Bertino, M., & Engelman, K. (1987). Failure to compensate decreased dietary sodium with increased table salt usage. *Journal of the American Medical Association, 258*, 3275-3278.

Beauchamp, G. K., & Cowart, B. J. (1990). Preference for high salt concentrations among children. *Developmental Psychology, 26(4)*, 539-545.

Bellisle, F., Dartois, A. M., & Broyer, M. (1992). Two studies on the acceptability of calcium glutamate as a potassium-free sodium substitute in children. *Journal of Renal Nutrition, 2(3)*, 42-46.

Bertino, M., Beauchamp, G. K., & Engelman, K. (1982). Long-term reduction in dietary sodium alters the taste of salt. *American Journal of Clinical Nutrition, 36*, 1134-1144.

Bertino, M., Beauchamp, G. K., & Engelman, K. (1986). Increasing dietary salt alters salt taste. *Physiology and Behaviour, 38*, 203-213.

Birch, L. L., & Marlin, D. W. (1982). I don't like it, I never tried it: Effects of exposure on two-year old children's food preferences. *Appetite, 3*, 353-360.

Blais, C. A., Pangborn, R. M., Borhani, N. O., Ferrell, M. F., Prineas, R. J., & Laing, B. (1986). Effect of dietary sodium restriction on taste responses to sodium chloride: a longtitudinal study. *American Journal of Clinical Nutrition, 44*, 232-243.

Commission of the European Communities. (1991). L-glutamic acid and its salts. Report of the Scientific Committee for Food: 25th Series, No. EUR 13416.

Drewnowski, A., Henderson, S. A., Driscoll, A., & Rolls, B. J. (1996). Salt taste perceptions and preferences are unrelated to sodium consumption in healthy older adults. *Journal of Dietetic Association, 96,* 471-474.

Joint Food and Agriculture Organization and World Health Organization Expert Committee On Food Additives (1988). L-glutamic acid and its ammonium, calcium, monosodium and potassium salts. In *Toxicological Evaluation of Certain Food Additives and Contaminants, WHO Food Additives Series No 22.* New York: Cambridge University Press.

Maller, O., Cardello, A., Sweeney, J., & Shapiro, D. (1982). Psychophysical and cognitive correlates of discretionary usage of table salt and sugar by humans. In J.E. Steiner & J.R. Ganchrow (Eds.), *Determination of behaviour by chemical stimuli* (205-216). London: IRL Press.

Millar, B. D. & Beard, T. C. (1988). Avoidance of dietary sodium- a simple questionnaire. *The Medical Journal of Australia, 149*, 190-192.

National Health and Medical Research Council. (1992). *Dietary guidelines for Australians*. Canberra: AGPS.

Pliner, P. (1982). The effects of mere exposure on liking for edible substances. *Appetite, 3*, 283-290.

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120.

Pliner, P., Pelchat, M., & Grabski, M. (1993). Reduction of neophobia in humans by exposure to novel foods. *Appetite, 20,* 11-123.

Prescott, J. (1993). Taste Preference for Umami in Australia and Japan. Proceedings of the Umami International Symposium. Tokyo: Society for Research on Umami Taste.

Prescott, J., & Khu, B. (1995). Changes in liking for saltiness within soup as a function of exposure. *Appetite, 24*, 302.

Roininen, K., Lahteenmaki, L., & Tuorila, H. (1996). Effect of umami taste on pleasantness of low-salt soups during repeated testing. *Physiology & Behavior, 6(3),* 953-958.

Shepherd, R., & Farleigh, C. A. (1986). Preferences, attitudes and personality as determinants of salt intake. *Human Nutrition: Applied Nutrition, 40A*, 195-208.

Shepherd, R., & Raats, M. M. (1996). Attitudes and beliefs in food habits. In H.L. Meiselman & H.J.H. MacFie (Eds.), *Food choice, acceptance and consumption* (pp. 346-364). London: Blackie Academic & Professional.

Sullivan, S. A. & Birch, L. L. (1990). Pass the sugar, pass the salt: experience dictates preference. *Developmental Psychology, 26(4)*, 546-551.

Yamaguchi, S. (1987). Fundamental properties of umami in human taste sensation. In Y. Kawamura & M.R. Kare (Eds.), *Umami: A basic taste* (pp. 41-73). New York: Marcel Dekker, Inc.

Yamaguchi, S., & Takahashi, C. (1984). Interactions of monosodium glutamate and sodium chloride on saltiness and palatability of a clear soup. *Journal of Food Science, 49*, 82-85.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*, 1-27.

Appendices

Appendix A Sodium Intake Checklist (SICL).

Appendix B Food Neophobia Scale (FNS).

Appendix C Questions on attitude and motivation to reduce salt intake.

Appendix D Rating scales used at each tasting session.

Appendix E Soup recipe.

Appendix F Participant Information and Consent form.

Appendix G ANOVAs on raw data.

Appendix H Correlation matrices.

Appendix A

Sodium Intake Checklist (SICL).

SODIUM INTAKE CHECKLIST (SICL).

Please circle the number of times that you have eaten the following foods in the past *three* days, not counting today.

It is important that you fill in the questionnaire as accurately as possible, indicating *every* time that you have eaten *any* of the foods mentioned.

We count the occasions, not the amounts (for example, three slices of bread score 1, if eaten on one occasion).

1. *Food with salt added in cooking*

   1 2 3 4 5 6 7 8 or more

2. *Food with salt added at the table*

   1 2 3 4 5 6 7 8 or more

3. *Cured meats such as ham, bacon, sausages or luncheon-meats*

   1 2 3 4 5 6 7 8 or more

4. *Corned/canned meats, salami, meat pastes*

   1 2 3 4 5 6 7 8 or more

5. *Pies, pasties or sausage-rolls*

   1 2 3 4 5 6 7 8 or more

6. *Smoked or canned fish, fish-pastes (salted)*

   1 2 3 4 5 6 7 8 or more

7. *Mature cheese (other than salted or low salt*)*

1 2 3 4 5 6 7 8 or more

*Low-salt cheese has a total sodium content of not more than 120 mg/100g. There are several unsalted (no-added salt) cheeses in this category, but McMahon's low-salt cheddar is the only *salted* cheese meeting this requirement.

8. *Processed cheese, cheese spreads*

1 2 3 4 5 6 7 8 or more

9. *Yeast vegetable extract such as Vegemite, Promite or Marmite*

1 2 3 4 5 6 7 8 or more

10. *Olives, salted nuts, crackers, potato crisps*

1 2 3 4 5 6 7 8 or more

11. *Canned vegetables, canned soups (other than unsalted)*

1 2 3 4 5 6 7 8 or more

12. *Packet soups, beef/chicken cubes*

1 2 3 4 5 6 7 8 or more

13. *Dressings, sauces, pickles (other than unsalted)*

1 2 3 4 5 6 7 8 or more

14. *Ordinary (salted) bread*

1 2 3 4 5 6 7 8 or more

15. *Ordinary (salted) breakfast cereals*

1 2 3 4 5 6 7 8 or more

16. *Cakes, pastries, biscuits (other than low-sodium/salt)*

1 2 3 4 5 6 7 8 or more

17. *Ordinary (salted) butter or margarine*

1 2 3 4 5 6 7 8 or more

18. *Chocolate or confectionary (salted)*

1 2 3 4 5 6 7 8 or more

19. *More than 300ml (half pint) of milk per serve*

1 2 3 4 5 6 7 8 or more

20. *Pharmaceutical goods containing sodium, for example, soluble painkillers*, effervescent vitamins and minerals, some health drinks, indigestion remedies and laxatives*

1 2 3 4 5 6 7 8 or more

21. *Any salt-containing food that is not mentioned above (e.g. soy sauce)*

1 2 3 4 5 6 7 8 or more

Compared to my normal diet over the past month, the amount of salted food that I have eaten in the past three days has been:

Much more A little more About the same A little less Much less

(Please circle one only)

Appendix B

Food Neophobia Scale (FNS).

NEW AND UNUSUAL FOODS

Indicate the extent to which you agree or disagree with the following.

	disagree strongly					agree strongly	
I am constantly sampling new and different foods.	1	2	3	4	5	6	7
I don't trust new foods.	1	2	3	4	5	6	7
If I don't know what is in a food, I won't try it.	1	2	3	4	5	6	7
I like foods from different countries.	1	2	3	4	5	6	7
Ethnic food looks too weird to eat.	1	2	3	4	5	6	7
At parties, I will try a new food.	1	2	3	4	5	6	7
I am afraid to eat things I have never had before.	1	2	3	4	5	6	7
I am very particular about the foods I will eat.	1	2	3	4	5	6	7
I will eat almost anything.	1	2	3	4	5	6	7
I like to try ethnic restaurants.	1	2	3	4	5	6	7

Appendix C

Questions on attitude and motivation to reduce salt intake.

Question 1. I would like to reduce my salt intake. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 2. I am trying to reduce my salt intake. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 3. I buy "low-salt" foods. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 4. I add salt while cooking food. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 5. I add salt to food at the table. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 6. I check food product labels for salt content. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Question 7. I like the taste of low-salt products. (Circle)

|_________|_________|_________|_________|

strongly disagree	neither agree nor disagree	strongly agree

Appendix D

Rating scales used at each tasting session for each soup tasted.

a) How much do you like this soup sample? (Circle)

dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

b) How would you rate the flavour intensity of this soup? (Circle)

no flavour	slight flavour	moderate flavour	very strong flavour	extremely strong flavour

c) How familiar is this soup to you?

not at all familiar	slightly familiar	moderately familiar	very familiar	extremely familiar

d) How natural does this soup taste to you?

not at all natural	slightly natural taste	moderately natural taste	very natural taste	extremely natural taste

e) How salty does this soup taste to you?

not at all salty	slightly salty	moderately salty	very salty	extremely salty

f) How rich does this soup taste to you?

not at all rich	slightly rich taste	moderately rich taste	very rich taste	extremely rich taste

Appendix E

Soup recipe.

Soup Recipe

onion

carrot

parsley

celery

egg white

bay leaf

pepper

thyme

small amount of chicken

water

Appendix F

Participant Information and Consent form.

University of Tasmania — Department of Psychology

Health & Social Cognition Laboratory

Participant Information & Consent Form
for subjects in soup palatability research

(Please retain a copy of this sheet)

This research is concerned with the effects of common salt and calcium diglutamate on the palatability of soup and its success depends to a considerable extent on the assistance of volunteers such as yourself. We are therefore grateful for your participation in this experiment. The project has received ethical approval from the University of Tasmania Ethics Committee (Human Experimentation) and complies with Tasmanian law. Calcium diglutamate is approved by government authorities as food additive No.623 in Australia.

It is important for you to be aware that in psychological research, some details of the experiments often cannot be explained to participants until after they have completed their role in it. This is because that information may change the participants' performance and consequently invalidate the experiment itself. For example, if a researcher were to tell participants beforehand that his or her experiment was about how caffeine improves peripheral vision, they might decide to have a couple of strong coffees before coming to the laboratory and they would almost certainly be attending with extra care to objects in the periphery of their visual field. *(Please note, this is just a hypothetical example; we are aware of no evidence whether caffeine actually affects vision in any way.)*

Thus, whenever you participate in a psychological experiment, there may well be aspects of the experiment which you will learn about only in the debriefing at the end of your final laboratory session. There is nothing ulterior or conspiratorial about this; it is just an inescapable necessity of conducting psychological research.

However, please be assured that in the research for which you have volunteered there will be no painful or distressing experiences, that you will receive as full a debriefing as you desire when you have completed the experimental tasks, and that in the debriefing all your questions will be answered honestly and to the best of our ability. No intimate or sensitive information will be required from you, but in any case all the information you do provide, including the taste judgements you make and any other data recorded, will be held under conditions of strict confidentiality.

In some research, participants receive a small payment for their inconvenience and time, but payments large enough to constitute a positive inducement to participate are not permitted under NH&MRC rules. Unless the experimenter mentions payment, you should assume that none will be involved, but do feel free to ask for clarification on this issue if you feel that there is any uncertainty that you would like resolved.

If you have any concerns of an ethical nature, or complaints about the manner in which this project is conducted, you may contact the Chair or the Executive Officer of the University's Ethics Committee (Human Experimentation). The present Chair is Dr Margaret Otlowski [phone (03) 6226 7569] and the Executive Officer is Ms Chris Hooper [phone (03) 6226 2763]. If you are a student at the University of Tasmania, you may also choose to discuss any ethical concerns confidentially with a University Student Counsellor.

Contact person. If you wish to know more about this research, either before deciding to participate or at any later stage, please ring the Chief Investigator, Mr Peter Ball on (03) 6226 2237.

Informed Consent Declaration

Please sign and date this form after carefully reading the following:

I agree to participate in an experiment being conducted by Mr Peter Ball and Ms Melinda Ferrier as part of Ms Ferrier's MPsych degree programme, which includes some or all of the following procedures: completion of questionnaires, provision of basic demographic information and participation in a total of six tasting sessions in which I will sample and record my judgements of a number of soup mixtures containing different quantities of common salt and calcium diglutamate.

The nature and any possible effects of the experiment have been explained to me and I understand that there is nothing about this research which is expected to be distressing or harmful to me. I have been advised that, although there is no reason for either calcium diglutamate or common salt to have adverse effects in the quantities used in this research, persons who have previously experienced adverse reactions to any glutamate salt (eg, monosodium glutamate) are ineligible to participate in the experiment, as are smokers.

I have been informed that at the end of my involvement in the experiment, I shall receive a complete debriefing and full answers to any questions I then wish to ask. I also understand that I am entitled to be informed about the results of this study when they are known if I so wish, and that in the event of the experiment revealing anything of direct relevance to the health and welfare of participants all reasonable steps will be taken to advise me.

I have read the information provided on this printed sheet and any questions I have asked relevant to my decision to participate have been answered to my satisfaction. I understand that I may withdraw at any stage of the experiment without prejudice to my academic standing, and that in the event of any such withdrawal I will still be entitled to a full debriefing.

I agree that my research data obtained for this study may be published, provided that I cannot be identified as a subject, and I undertake not to convey to any likely future participant in this research information which could undermine the value of that person's participation.

Signature of participant .... **Date** ..../........../1997

Name of participant ....

I have explained this project and the implications of participation in it to this volunteer. I believe that the above consent is informed and that he or she understands the implications of participation.

Signature of investigator .... **Date** ..../........../1997

Name of investigator ....

Appendix G

ANOVAs on raw data.

Analysis of Variance

Level of Liking at Session 1

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	48.43287*	94*	2.714194*	17.84429*	.000000*
2	2*	23.84954*	94*	2.052847*	11.61779*	.000031*
12	4	.77315	188	1.990642	.38839	.816788

Level of Liking at Session 6

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	59.63194*	94*	1.643765*	36.27766*	.000000*
2	2*	9.36111*	94*	2.096336*	4.46546*	.014040
12	4	.84722	188	1.486702	.56987	.684820

Liking Over 6 Sessions

STAT. Summary of all Effects; design:
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	5.99286	39	7.984829	.750530	.478812
2	2*	39.47355*	39*	7.984829*	4.943568*	.012203
3	5*	11.00372*	195*	1.434573*	7.670379*	.000001*
12	4	14.16881	39	7.984829	1.774467	.153573
13	10	1.73159	195	1.434573	1.207040	.288458
23	10	1.08969	195	1.434573	.759592	.667522
123	20	1.23112	195	1.434573	.858180	.640154

Flavour Intensity at Session 1

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	28.07176*	94*	.598946*	46.86860*	.000000*
2	2*	8.61343*	94*	.473946*	18.17385*	.000000*
12	4	.28356	188	.555432	.51053	.728057

Flavour Intensity at Session 6

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	31.30787*	94*	.511180*	61.24627*	.000000*
2	2*	14.44676*	94*	.472764*	30.55808*	.000000*
12	4	.82523	188	.347690	2.37347	.053782

Flavour Intensity Over 6 Sessions

STAT. Summary of all Effects; design:
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	1.54528	39	1.192379	1.29596	.285157
2	2*	14.25865*	39*	1.192379*	11.95816*	.000089*
3	5	.74555	195	.360071	2.07056	.070709
12	4	.30934	39	1.192379	.25943	.902117
13	10	.43015	195	.360071	1.19463	.296587
23	10	.43849	195	.360071	1.21777	.281559
123	20	.42832	195	.360071	1.18954	.266570

Level of Familiarity at Session 1.

STAT. Summary of all Effects
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	9.252315*	94*	.710944*	13.01413*	.000010*
2	2*	3.231482*	94*	.477344*	6.76971*	.001792*
12	4	.276620	188	.412554	.67051	.613212

Level of Familiarity at Session 6

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	10.94676*	94*	.360471*	30.36795*	.000000*
2	2*	1.32176*	94*	.373769*	3.53630*	.033055
12	4	.48843	188	.324123	1.50691	.201820

Familiarity Over 6 Sessions

STAT. Summary of all Effects; design:
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	.00500	39	2.330342	.00215	.997856
2	2*	10.08747*	39*	2.330342*	4.32875*	.020054
3	5*	4.95862*	195*	.380427*	13.03434*	.000000*
12	4	2.71874	39	2.330342	1.16667	.340364
13	10	.56067	195	.380427	1.47379	.151556
23	10	.36711	195	.380427	.96500	.475322
123	20*	.62812*	195*	.380427*	1.65109*	.044559

Natural Taste at Session 1

STAT. Summary of all Effects; design:
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	.793981	94	.843627	.941152	.393823
2	2	1.266204	94	.663367	1.908753	.153968
12	4	.745370	188	.553881	1.345723	.254585

Natural Taste at Session 6

STAT. Summary of all Effects; design:
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	5.832151*	92*	.689639*	8.456815*	.000425*
2	2	.583924	92	.426920	1.367762	.259806
12	4	.516548	184	.312442	1.653261	.162780

Natural Taste Over 6 Sessions

STAT. Summary of all Effects; design:
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	.711743	39	2.044801	.348075	.708217
2	2	1.001776	39	2.044801	.489914	.616399
3	5*	1.565464*	195*	.515570*	3.036376*	.011574
12	4	1.334257	39	2.044801	.652512	.628588
13	10	.384769	195	.515570	.746299	.680189
23	10	.302562	195	.515570	.586849	.823624
123	20	.386841	195	.515570	.750318	.769843

Saltiness at Session 1

STAT. Summary of all Effects; design:
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	29.80787*	94*	.715672*	41.65020*	.000000*
2	2*	15.57176*	94*	.905093*	17.20460*	.000000*
12	4	.23843	188	.656866	.36298	.834759

Saltiness at Session 6

STAT. Summary of all Effects; design:
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	22.18287*	94*	.658048*	33.71012*	.000000*
2	2*	23.32176*	94*	.718922*	32.43988*	.000000*
12	4	1.18287	188	.548119	2.15806	.075358

Saltiness Over 6 Sessions

STAT. Summary of all Effects; design
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	10.03640*	39*	1.437678*	6.980982*	.002561*
2	2*	10.40622*	39*	1.437678*	7.238214*	.002121*
3	5	.66594	195	.529815	1.256927	.284221
12	4	1.79380	39	1.437678	1.247706	.306913
13	10	.81848	195	.529815	1.544833	.126041
23	10	.67713	195	.529815	1.278048	.245076
123	20	.56049	195	.529815	1.057900	.397264

Richness at Session 1

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	21.79433*	92*	.772587*	28.20954*	.000000*
2	2*	8.95745*	92*	.486432*	18.41458*	.000000*
12	4*	1.07092*	184*	.400632*	2.67308*	.033503*

Richness at Session 6

STAT. Summary of all Effects; design
GENERAL 1-CDG, 2-NACL

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2*	25.41898*	94*	.598651*	42.46047*	.000000*
2	2*	8.36343*	94*	.493450*	16.94890*	.000001*
12	4	.79745	188	.338825	2.35359	.055492

Level of Richness Over 6 Sessions

STAT. Summary of all Effects; design:
GENERAL 1-SALT, 2-GLUTAMAT, 3-DAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	1.10138	39	2.089316	.527148	.594432
2	2*	15.97399*	39*	2.089316*	7.645561*	.001580*
3	5	.83482	195	.448803	1.860106	.103041
12	4	1.44230	39	2.089316	.690322	.603090
13	10	.60569	195	.448803	1.349560	.206646
23	10	.21243	195	.448803	.473331	.905877
123	20	.39361	195	.448803	.877010	.616479

Appendix H

Correlation matrices

Food Neophobia

Liking Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.01	-.03	.07
	Int	-.26	-.13	.12
	Opt	-.37*	.06	.08

Liking Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.16	-.06	-.03
	Int	-.08	-.13	.03
	Opt	-.02	.08	.07

Flav Int Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.02	-.01	.07
	Int	.16	.14	.10
	Opt	.19	-.08	.01

Flav Int Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.08	.13	-.11
	Int	-.13	-.09	.03
	Opt	-.20	-.00	-.26

Famil. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.12	-.06	.08
	Int	.04	-.26	.18
	Opt	.01	.13	.13

Famil. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.07	.13	-.02
	Int	-.17	-.23	.06
	Opt	-.23	-.15	-.01

Nat. T. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	-.00	.16	.12
	Int	-.19	-.13	.18
	Opt	-.30*	.21	.16

Nat. T. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.18	-.03	-.07
	Int	-.24	-.08	.14
	Opt	.00	.09	-.01

Saltin. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.07	-.02	.05
	Int	.06	-.03	-.14
	Opt	.10	.02	.16

Saltin. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.00	.04	.02
	Int	.01	-.03	.13
	Opt	-.14	.06	-.16

Rich.. Sess 1			NaCl	
		0	Inter	Opt
CDG	0	.20	.13	.21
	Int	.06	-.11	.05
	Opt	-.00	.11	.04

Rich. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.07	.23	.04
	Int	.08	-.07	.08
	Opt	-.13	.01	-.08

Salt Intake

Liking Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.12	-.02	.04
	Int	-.04	-.10	-.08
	Opt	.08	-.06	.03

Liking Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	.06	.04	.20
	Int	-.01	-.06	.13
	Opt	-.04	.06	.01

Flav Int Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	.06	-.10	-.02
	Int	-.04	.09	-.06
	Opt	.07	-.34*	-.10

Flav Int Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.14	-.16	-.09
	Int	-.15	-.17	-.19
	Opt	-.22	-.43*	-.36*

Famil. Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.31*	-.20	-.22
	Int	-.37	-.18	-.27
	Opt	-.10	-.07	.03

Famil. Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.36*	-.10	-.29*
	Int	-.39*	-.21	-.13
	Opt	-.38*	-.26	-.30*

Nat. T. Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.14	.07	-.09
	Int	-.19	-.15	-.16
	Opt	.19	-.12	.04

Nat. T. Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.01	-.04	-.00
	Int	-.20	-.20	-.13
	Opt	-.21	-.09	-.11

Saltin. Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	.39*	-.19	.00
	Int	.05	.06	.10
	Opt	.09	.01	.21

Saltin. Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	-.07	.06	-.10
	Int	-.09	-.21	-.05
	Opt	.17	-.03	-.16

Rich.. Sess 1		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	.22	-.15	-.02
	Int	-.06	-.04	-.12
	Opt	.01	-.15	-.08

Rich. Sess 6		NaCl 0	NaCl Inter	NaCl Opt
CDG	0	.12	.01	.05
	Int	-.18	-.24	-.18
	Opt	-.11	-.28	-.18

Motivation

Liking Sess 1		NaCl		
		0	Inter	Opt
CDG	0	-.10	-.09	-.22
	Int	-.22	-.24	-.17
	Opt	-.43*	-.17	-.15

Liking Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.41*	-.14	-.25
	Int	-.09	-.14	-.20
	Opt	-.08	-.32*	-.17

Flav Int Sess 1		NaCl		
		0	Inter	Opt
CDG	0	-.07	.18	-.08
	Int	-.02	-.16	-.14
	Opt	-.21	-.00	.02

Flav Int Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.02	-.09	-.09
	Int	.05	-.01	-.03
	Opt	-.08	-.21	.03

Famil. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.04	.27	.04
	Int	-.08	.01	.14
	Opt	-.12	-.08	.08

Famil. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	-.31*	.15	.21
	Int	.22	.10	.17
	Opt	.14	.23	.18

Nat. T. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.12	.22	-.07
	Int	.14	.16	.32*
	Opt	-.19	.09	.15

Nat. T. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.08	.16	.06
	Int	.17	.12	.20
	Opt	.30*	.19	.17

Saltin. Sess 1		NaCl		
		0	Inter	Opt
CDG	0	.12	.25	.17
	Int	.28	.21	.21
	Opt	.16	.28	.22

Saltin. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.21	.12	-.10
	Int	.10	.28	.06
	Opt	.04	.14	.26

Rich.. Sess 1			NaCl	
		0	Inter	Opt
CDG	0	-.00	.16	.07
	Int	-.00	-.04	-.05
	Opt	-.22	-.09	-.00

Rich. Sess 6		NaCl		
		0	Inter	Opt
CDG	0	.02	-.00	-.14
	Int	.17	.07	.02
	Opt	-.16	-.08	-.18