Half Way to Scarborough Fair? The Cognitive and Mood Effects of Rosemary and Sage Aromas

Dr Mark Moss, Department of Psychology, Northumbria University,

Newcastle upon Tyne, NE1 8ST, UK

The application of aromas as therapeutic treatments and mood stabilisers/enhancers is widely recognised and practised. The possibility of their use as cognitive enhancers is less well known or researched. Received wisdom assumed that our cognitive functioning was optimal for the environment in which we have evolved. However, research has demonstrated that natural nutritional interventions can augment cognition. My research has investigated the possibility that natural aromatic compounds absorbed through inhalation might also exert beneficial effects. Orally administered Sage preparations have been shown to improve memory and here I present data that indicate that Sage aromas act in a similar manner. The dietary impact of Rosemary on cognition is less well researched. However, I provide evidence that the absorption of pharmacologically active compounds occurs during exposure to Rosemary aroma and that these are related to observed improvements in performance. With regard to impact on subjective mood state, the data are less illuminating but it would appear that mood effects are perhaps a response to the psychological qualia of the aromas rather than anything pharmacological. This independence in effects offers interesting opportunities for the future development of health promoting aroma based interventions.

Introduction

One focus of research into herbal preparations has been that of improving cognitive functioning (Mantle, et al 2000). The *Salvia* (Sage) genus, in particular *Salvia officinalis* (SO) and *Salvia lavandulaefolia* (SL) have received attention with research involving healthy

volunteers, in the belief that finding improvements may give a clear view of how Sage might be used as a potential preventative or treatment of age related cognitive decline (Perry et al, 2003).

Tildesley (2007) orally administered SO extract to healthy young volunteers and recorded a significant improvement in the quality of memory factor and the secondary memory sub-factor scores from a computerised assessment battery when compared to the placebo control. A similar study employing healthy aged participants also found significant improvements in the quality of memory scores. In addition, the quality of attention factor also displayed and enhancement. However, no effects were observed for subjective mood state. A separate study performed by Tildesley et al., in 2005 investigated the effects of oral administration of SL essential oil. Findings showed that there were significant improvements in both quality and speed of long term memory for SL essential oil when compared to the placebo group. Significant improvements in "calm", "content" and "alert" aspects of mood were also recorded.

Work with animals has demonstrated that the aromas of essential oils can have the same effects as oral administration. Kovar et al (1987) found significant increases in locomotor activity in rats following oral administration of rosemary. This was replicated following the inhalation of the rosemary aroma. Such findings might suggest that when *Salvia* aromas are inhaled similar enhancements in cognitive abilities could be seen to those reported above following oral ingestion of the herbs and essential oils.

A number of studies have investigated the effects of the aromas of plant essential oils on cognition and mood. Lavender and Rosemary aromas have been shown to exert opposing

influences on cognitive ability and mood in young adults (Moss et al., 2003). Impairments in the quality of memory factor were found for the Lavender aroma when compared to the Rosemary aroma condition. Similarly, significant enhancements were seen for the secondary memory factor in the Rosemary aroma group when compared to then Lavender and control groups. Mood assessments were also significantly affected, as the Rosemary group increased in alertness (compared to Lavender and control group) and contentedness (compared to the control group).

Here I report data from four studies that include the assessment of a range of cognitive variables and measures of mood for the possible impact of the aromas of both Rosemary and Sage.

Materials and Methods

Aromas

The essential oils used were *Salvia officinalis, Salvia lavandulaefolia and Rosmarinus officinalis.* Essential oils were obtained from the NHR organic essential oils, Brighton, UK. To diffuse the aroma a Tisserand Aroma Stream was used. Five drops of the appropriate essential oil placed on a diffuser pad and the device switched on for five minutes in the testing cubicle prior to testing each participant.

Testing Cubicles

Testing cubicles measured 2.4m long x 1.8m wide x 2.4m high and were maintained at a temperature of between 18 and 22 degrees Celsius throughout the testing sessions.

Computerised Cognitive Measures 1: CDR

The CDR system includes a number of measures that are specific to particular aspects of attention, working memory and long term memory, and has been shown to be sensitive to the effects of aromas (Moss et al, 2003, Moss et al 2008) and herbal extracts (Kennedy, et al 2001, Kennedy et al, 2000, Tildesley, 2007).

These measures produce four global outcome factors, and two sub-factors: *Quality of memory; Working memory sub-factor; Secondary memory sub-factor; Speed of memory; Speed of attention; Accuracy of attention.*

Computerised Cognitive Measures 2: COMPASS

Serial 3 & Serial 7 Subtraction Tasks: A starting number between 800 and 999 was displayed on the computer screen. The participant was asked to subtract three (or seven) from this number and enter their answer using the key pad. They were then required to subtract three from this answer and enter it likewise. They continue in the same way until the programme stopped after two minutes.

Rapid Visual Image Processing Task (RVIP): Participants were presented with a continuous series of digits in the centre of the screen and they were asked to detect sequences of any three consecutive odd digits or any three consecutive even digits by pressing the space bar. The task stopped automatically after three minutes.

Prospective Memory Measures 1: PRVP

Objective Prospective Memory (PM) was measured using the Prospective Remembering Video Procedure (PRVP). The PRVP involved presenting a list of 21 specific locations (e.g. "when you reach the store W.H. Smiths"), which were accompanied by a list of associated actions (e.g. "ask if there is a job available") which the respondent viewed for 1.5 minutes. This was immediately followed by a ten-minute video clip of a busy shopping area depicting

a range of shop fronts and passers-by that provided location cues during which the previously presented location-action combinations were recalled and recorded by writing them down.

Prospective Memory Measures 2: CAMPROMPT

The CAMPROMPT is a reliable and valid assessment tool for both time and event-based prospective memory. The test requires the participant to work on a number of 'background' distractor pencil and paper tasks such as a general knowledge quiz or word-finder puzzle for a 20 minute period. While they are doing this, and shortly after the 20-minute period is up, they carry out 6 prospective memory tasks. These tasks are cued in 2 ways: three are cued by time, three are cued by events. In all, the test takes about 25 minutes to administer. The type of prospective memory tasks that the participant is asked to do includes such tasks as remembering to change tasks at a certain time and reminding the researcher to do something (e.g. "do not forget your keys"). Three scores are obtained: prospective memory time-based score, event-based score and total score.

Subjective Mood Measure

The Bond-Lader visual analogue scales (Bond and Lader 1974). The 16 visual analogue scales of Bond-Lader were combined as recommended by the authors to form three mood factors: "alert", "calm" and "content".

Results

Study 1: Sage Computerised Assessment

Quality of Memory factor

Significant differences between groups were found when an independent groups Anova was carried out: $F(2,132) = 5.974$; $p=0.003$. Tukey post hoc comparisons revealed that the *Salvia officinalis* condition (mean = 373) scored significantly higher than the control condition (mean = 330) $p = 0.002$. No other significant results were found.

Secondary memory sub factor.

Significant differences between groups were found when an independent groups Anova was carried out: F(2, 132) = 5.662; p = 0.004. Tukey post hoc comparisons revealed that the *Salvia officinalis* condition (mean = 200) scored significantly higher than the control condition (mean = 165) p = 0.048. No other significant factors were found.

Alertness

Significant differences between groups were found when an independent groups Anova was carried out: F(2, 132) = 4.016; p = .020. Tukey post hoc comparisons revealed that both the *Salvia officinalis* condition (mean change = 4.75) and the *Salvia lavandulaefolia* condition (mean change = 5.29) increased in alertness, whereas the control condition possessed a fall in alertness (mean change = -3.99) p = .049 and .034 respectively.

Study 2: Sage & Prospective Memory

Prospective Remembering Video Procedure Total Score

The ANOVA identified significant differences between groups for the Total score on the PRVP F(2,132) = 8.433, p < .001, $\eta^2_{partial}$ = .113. Tukey post hoc comparisons revealed both *Salvia officinalis* aroma (mean = 15.8) and *Salvia lavandulaefolia* aroma (mean = 14.5) conditions produced higher scores than the no aroma condition (mean = 11.9); p <.001 and = .020 respectively. The two aroma conditions did not differ significantly p = .393.

Prospective Remembering Video Procedure Event Score

The ANOVA identified significant differences between groups for the Event score on the PRVP F(2,132) = 13.441, p < .001, $\eta^2_{partial}$ = .169. Tukey post hoc comparisons revealed both *Salvia officinalis* aroma (mean = 9.4) and *Salvia lavandulaefolia* aroma (mean = 8.8) conditions produced higher scores than the no aroma condition (mean = 7.2); p <.001 and = .001 respectively. The two aroma conditions did not differ significantly p = .397.

Prospective Remembering Video Procedure Action Score

The ANOVA identified significant differences between groups for the Action score on the PRVP F(2,132) = 4.144, p = .018, $\eta^2_{partial}$ = .059. Tukey post hoc comparisons revealed that *Salvia officinalis* aroma (mean = 6.4) produced higher scores than the no aroma condition (mean = 4.6); p = .014. The *Salvia lavandulaefolia* aroma (mean = 5.7) conditions did not differ significantly to the SO or control condition, p = .484 and p = .206 respectively.

<u>Study 3: Rosemary, Performance and serum 1,8-cineole</u>

Serial Threes

A positive linear relationship was found between serum 1,8-cineole concentration and the number of correct answers on the Serial 3s subtraction task: r(18) = .469, p = .037; r^2 = .22.

A negative linear relationship was found between the reaction time of participants on the Serial 3s subtraction task and the serum 1,8-cineole concentration: r(18) = -.502, p = .024; r^2 = .25.

Serial Sevens

A positive linear relationship that approached but did not quite reach statistical significance was found between the number of correct answers on the Serial 7s subtraction task and serum 1,8-cineole concentration: $r(18) = .433$, $p = .056$; $r^2 = .19$.

A negative linear relationship was found between the reaction time of participants on the Serial 7s subtraction task and serum 1,8-cineole concentration: $r(18) = -.466$, $p=.038$; $r^2= .22$.

Rapid Visual Information Processing

No relationship was found between the number of correct responses on the RVIP task and serum 1,8-cineole concentration: $r(18)= .117$, $p =.624$; $r^2 = .01$.

A negative linear relationship was found between reaction time on the RVIP task and serum concentration of 1, 8-cineole: $r(18) = -.446$, $p = .049$; $r^2 = .19$.

Contentedness

A negative linear relationship was found between 1,8-cineole concentration and the change in contentedness: $r(18) = -.454$, $p = .044$; $r^2 = .21$.

<u>Study 4: Rosemary, Prospective Memory and serum 1,8-cineole</u>

CAMPROMPT

The total CAMPROMPT score was significantly higher in the rosemary aroma condition (mean = 31.21) than in the control condition (mean = 27.76) $t(64) = 2.654$, $p = .010$. Considering the two subscales Rosemary aroma was found to produce significantly better scores for both Time (mean = 15.88, $t(64 = 2.178$, $p = .033$) and Event (mean = 15.33, $t(64) = 2.334$ $p = .023$) based measures of prospective memory compared to controls (means of 14.36 and 13.39 for time and event measures respectively).

The plasma analysis revealed significantly greater amounts of 1,8-cineole were present in the plasma of participants in the rosemary condition than in the control condition $t(64) = 6.782$, $p < .001$. More importantly the levels of plasma 1,8-cineole in the rosemary condition correlated significantly with scores on the total PM variable $r(31) = .367$, $p = .036$, and on the event based PM scores $r(31) = .411$, $p = .018$. Scores on the time based PM did not correlate significantly with plasma 1,8-cineole levels $r(31) = .240$, $p = .178$.

The analysis of the mood factors provided a less striking pattern of results. Only the 'Calm' mood factor possessed a significant difference between groups from pre to post testing. Comparison of the means indicated that the control group became less calm over the testing period (mean change = -7.2) – a change that was attenuated by rosemary aroma (mean change = 1.0), $t(64) = 2.450$, $p = .017$. Pearson correlations indicated that none of the changes on any of the mood factors correlated significantly with the CAMPROMPT performance measures, or serum 1,8-cineole levels.

Discussion

The findings for *Salvia officinalis* aroma compare favourably with those reported previously for oral administration of the herb in healthy young participants. Tildesley (2007) found a significant improvement in the quality of memory factor and more specifically the secondary memory sub-factor following a dose of herbal Sage extract when compared to a placebo control condition. Equally in keeping with the results reported here, no effect was found for the working memory sub factor. Interestingly, in a second study with a cohort of healthy elderly participants Tildesley reports much more striking effects. As well as the effect on memory, the elderly also displayed an enhancement on the accuracy of attention factor. No trend toward such an effect could be detected in the current data even though the level of

performance left headroom for improvement. The non-significant differences found here between the SL aroma condition and the control condition would not have been predicted based on previous research. Tildesley et al., (2003, 2005) reported significant improvements in word recall and the quality of memory factor scores following oral administration of SL herb and essential oil respectively.

When considering everyday prospective memory, both *Salvia officinalis* and *Salvia lavandulaefolia* aromas produced a significant enhancement effect for the total scores on the video based prospective memory task. A more fine grained analysis of the scores revealed that this enhancement was restricted to 'Event' based aspects of PM for *Salvia lavandulaefolia* aroma with no impact on action performance. In contrast, *Salvia officinalis* aroma significantly enhanced performance for both 'Event' and 'Action' based aspects of the task. The relationship between prospective memory and other forms of memory is something that engenders considerable debate (Kliegel et al., 2008), although there is some consensus that it may be seen as a separate and dissociable memory function (Salthouse et al., 2004). As such, these findings provide interesting comparisons for effects on aspects of memory reported above for both oral and aroma based administration of Sage species in healthy young participants.

With regard to the behavioural effects of exposure to Rosemary essential oil aroma, the results reported here support previous work indicating that Rosemary aroma can influence cognitive performance and mood (Moss et al., 2003). Here, serum levels of 1,8-cineole were correlated with the performance outcomes (number of correct responses and reaction times) for each subtraction task. Although it is wise to exercise caution when dealing with small samples, effect sizes (r^2) of between 0.1 and 0.3 (medium to large effects by Cohen's 1992

definitions) were found for all cognitive task variables except the accuracy of the RVIP task where no relationship was identified between 1,8-cineole and percentage correct hits. These effect sizes compare favourably to those found previously in our laboratory for the effect of Rosemary aroma on cognition. Moss et al., (2003) found R^2 values of .06 and .07 for the aspects of long term and working memory that were found to be enhanced by exposure to Rosemary aroma when compared to controls. The tasks employed in this first Rosemary study reported here were selected to tap into different cognitive processes: the RVIP task provides an assessment of sustained attention and central executive function compared to the continuous working memory, arithmetic processing and central executive composition of the serial subtractions tasks. Furthermore, the opportunity was taken to observe effects on tasks with discreet differences in cognitive load; with the serial sevens task being considerably more demanding than serial threes (Scholey & Kennedy 2002). Comparison of the relative relationships between plasma 1,8-cineole and performance on the serial subtraction tasks indicates that 1,8-cineole (or other active essential oil components) had a greater impact on the task with a lower cognitive load. Analysis of the difference between the correlation coefficients shows a stronger relationship between 1,8-cineole for both accuracy $t(15) = -3.27$, $p = .002$ and speed $t(15) = -6.06$, $p < .001$ for the serial threes task than for the serial sevens task. The finding that the strength of relationships differ between tasks implies that there may be an interaction with cognitive load, and that at some point task difficulty might be such that enhancement is not possible as a consequence of exposure to Rosemary aroma.

The findings from the second Rosemary (CAMPROMPT) study also support previous work indicating that the aroma of Rosemary essential oil can enhance cognitive functioning in healthy adults. This is however, the first time the effect has been shown for prospective memory and identifies that both time and event cued aspects of prospective memory are available for enhancement. Although the nature of the lab-based testing procedure means

that extrapolation to real world prospective memory performance should be tentative, the size of the enhancement is of the same order of that found for other metabolic based interventions eg glucose on this kind of task. Furthermore, the serum data provides supporting evidence to that reported above that the influence of Rosemary aroma on cognition is mediated pharmacologically. 1,8-cineole has been shown to be a cholinergic agonist *in vitro*, the correlation between serum concentration and performance suggests that it may also be *in vivo*. The observation that none of the mood measures correlated with performance adds weight to the conclusion that performance is not influenced as a consequence of changes in subjective alertness or arousal. The data reported here broaden the base of knowledge regarding the mechanisms behind the effects of aromas on cognitive performance and suggests that future research based upon the potential benefits of aroma based treatments for behavioural memory problems is warranted. The effects on mood are not in line with those previously reported where alertness has been found to be affected but calmness not so. The reasons behind these discrepancies are unclear but two distinct possibilities suggest themselves. Firstly, the effects on mood might be a consequence of the subjective qualia associated with the aromas – something that might be prone to the effects of individual differences and preferences. Secondly, the differences might indicate fragility of the subjective nature of these measures, leading to them being less reliable than the objective tests of cognition. Certainly, the same measures have previously illustrated a degree of inconsistency in repeated measures design studies where many assessments are taken.

References.

Bond, A. Lader, M. (1974). The use of analogue scales in rating subjective feelings. *The British Journal of Psychology,* 47, 211-218.

Cohen, J. (1992). A power primer. *Psychological Bulletin,* 112: 155-159.

Kennedy, D.O., Scholey, A.B., Wesnes, K.A. (2000) The dose dependant cognitive effects of acute administration of Ginko biloba to health young volunteers. *Psychopharmacology, 151,* 416-423.

Kennedy, D.O., Scholey, A.B., Wesnes, K.A. (2001) Differential, dose dependant changes in cognitive performance and mood following acute administration of ginseng to healthy young volunteers. *Nutritional Neuroscience, 4,* 295 – 310

Kliegel, M., McDaniel M.A., & Einstein, G.O. (Eds) (2008) *Prospective memory: cognitive, neuroscience, developmental, and applied perspectives.* Lawrence Erlbaum Associates, New York.

Kovar, K.A., Gropper, B., Friess, D., Ammon, H.R.T. (1987) Blood levels of 1,8-cineole and locomotor activity of mice after inhalation and oral administration of rosemary oil. *Planta Med, 53,* 315-318.

Mantle, D., Pickering, A.T., Perry, E.K. (2000) Medical plant extracts for the treatments of dementia: a review of their pharmacology, efficacy and tolerability. *CNS Drugs, 13 (3),* 201-213.

Moss, M., Cook, J., Wesnes, K., Duckett, P. (2003) Aromas of rosemary and lavender essential oils differently affect cognition and mood in healthy adults. *International Journal of Neuroscience, 113*, 15-38.

Moss, M., Hewitt, S., Moss, L. (2008) Modulation of cognitive performance and mood by aromas of peppermint and ylang-ylang. *International Journal of Neuroscience, 118(1)*, 59-77.

Perry, N.S.L., Bollen, C., Perry, E.K., Bollard, C. (2003) Salvia for dementia therapy, review of pharmacological activity and pilot tolerability clinical trial. *Pharmacology, Biochemistry and Behaviour, 75*, 651-658.

Salthouse, T.A., Berish, D.E., & Siedlecki, K.L. (2004). Construct validity and age sensitivity of prospective memory. Memory & Cognition, 32, 1133-1148.

Scholey AB and Kennedy DO (2002) Acute, dose-dependent cognitive effects of Ginkgo biloba, Panax Ginseng and their combination in healthy young volunteers: differential interactions with cognitive demand. *Human Psychopharmacology - Clinical and Experimental* 17, 35-44.

Tildesley, N.T.J., Kennedy, D.O., Perry, E.K., Ballard, C.G., Savelev, S., Wesnes, K.A., Scholoey, A.B. (2003) Salvia lavandulaefolia (Spanish sage) enhances memory in health young volunteers. *Pharmacology, Biochemistry and Behaviour, 75*, 669-674.

Tildesley, N.T.J., Kennedy, E.K., Perry, C.G., Ballard, C.G., Wesnes, K.A., Scholey, A.B. (2005) Positive modulation of mood and cognitive performance following administration of

acute doses of Salvia lavandulaefolia essential oil to healthy young volunteers. *Physiology and Behaviour, 83,* 699-709.

Tildesley, N.T.J. (2007) The neurocogntive effects of Salvia (Sage) in health and disease. Unpublished PHD thesis, Department of Psychology, Northumbria University, Newcastle upon Tyne, England.