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# A Pilot Study of the Acute Ingestion of No. 1 Rosemary Water: Evidence of Cognitive, Physiological and Subjective Effects in Healthy Adults

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## Abstract

This study investigated the potential impact of the acute ingestion of No. 1 Rosemary water—a commercially available carbonated water containing an extract of Rosemary (*Rosmarinus officinalis*). Twenty healthy adults were randomly allocated to consume either 330 ml of No. 1 Rosemary water or plain carbonated water. They then completed a series of subjective measures and cognitive tasks including a fifteen-minute session on a stress inducing multi-tasking framework, followed by a second completion of the subjective measures. Heart rate and blood pressure were monitored throughout the procedure. Given the pilot nature of the study, analysis of the data eschewed significance testing for the calculation of Cohen's d measure of effect sizes. These revealed a number of small enhancement effects on cognition, consistent with those found previously for the inhalation of the aroma of Rosemary essential oil, and oral administration of dried herb. Of particular interest here are the reduced subjective evaluations of stress, and the blunted physiological reactivity noted for heart rate and blood pressure, which represent novel findings in this area. Taken together the data suggest further investigation of this product is warranted with regard to its potential beneficial properties.

## Keywords

Rosemary Water, Memory, Heart Rate, Mood

## 1. Introduction

Rosemary (*Rosmarinus officinalis*) is a woody, perennial herb native to the

Mediterranean region. Historically it has been associated with memory and some studies suggest that this reputation may not be without substance. Completion of computerised tasks by healthy young adults in cubicles infused with Rosemary aroma have demonstrated enhancements on long term memory performance compared to no aroma [1]. More recently Rosemary aroma has been shown to deliver improvements in prospective memory [2], and visual and numerical memory [3]. A number of studies have combined objective performance measures with subjective evaluations and physiological measurements. Diego and colleagues [4] found Rosemary aroma improved aspects of performance, and produced feelings of increased alertness and reduced anxiety. Importantly, these were matched with electroencephalography (EEG) recordings that showed decreased frontal alpha and beta power, suggesting increased alertness. Supporting evidence of these phenomena has been provided in a study that also reported increases in heart rate, blood pressure and respiratory rate during exposure to Rosemary aroma [5]. However, participants undertook no assessment of cognitive performance in this study. Interestingly, in a study investigating mood and heart rate responses to an anxiety provoking task, Rosemary aroma reduced feelings of fatigue and inertia, but observed reductions in heart rate disappeared when pleasantness of aroma was employed as a covariate in the analysis. These latter studies suggest a potentially complex relationship between physiological responses, cognitive task demands and subjective evaluations under conditions of aroma exposure.

With regard to acute orally administered Rosemary, Laybourne and colleagues found similar effects on long term memory as those for the aroma when administering 1600 mg of dried herb in young participants [6], and improvements in memory retrieval speed have been reported in an elderly sample following a 750 mg dose [7], although high doses (6000 mg) produced negative effects. A recent chronic study [8] found that a 500 mg dose delivered twice daily for a month improved both prospective and retrospective memory compared to placebo in a student sample. In addition, the authors reported reduced anxiety and depression and improved sleep quality in the Rosemary condition. It is worth noting however, that all the measures in the latter study were subjective self-reports and no objective measures were taken.

The market for herbal-based products as life and wellbeing enhancers has grown exponentially in the last twenty years—irrespective of economic downturn and recession. The global market for products used as dietary supplements or phytomedicines, either in capsules, extracts or drinks was estimated at US\$ 60 billion in 2000, increasing dramatically to US\$ 107 billion by 2017 [9]. However, the efficacy of many of these products remains untested and claims unverified. Given the rapidly increasing value that is placed on herbal interventions by the general public it is becoming imperative that scientific assessment using well established measures and robust techniques is undertaken. To date, this is seriously lacking.

In the current pilot study, the potential impact of the acute consumption of No. 1 Rosemary Water™—a commercially available product containing an extract and hydrolat of Mediterranean Rosemary—is investigated. Measures of memory previously indicated as sensitive to Rosemary aroma, and a stressful experimental paradigm are coupled with subjective measures of mood and objective measures of physiological responses. Given previous findings considered above it might be predicted that Rosemary Water will have the potential to enhance measures of memory and aspects of mood. However, the inconsistent data on physiological responses, and a lack of data relating to stressful experimental paradigms in this area means that no predictions are made regarding these variables.

## 2. Method

### 2.1. Design

A one factor independent groups design was employed in this study. The independent variable was the water consumed by the participants and had two levels: Rosemary water or plain water. The dependent variables were categorized as cognitive, subjective and physiological and contained the following:

#### *Cognitive*

Immediate Word Recall, Delayed Word Recall, Prospective Memory Score, Multitasking framework total score and scores from the four components.

#### *Subjective*

Mood measures Alert, Content and Calm mood, and Positive/Negative Affect measured at the start and end of the testing session. Present Stress was measured at baseline and at eight time points through the testing procedure. The NASA Task load index was completed at the end of the testing period.

#### *Physiological*

Heart rate and Blood pressure were recorded continuously throughout, and change from baseline values calculated for eight time points in the testing procedure.

### 2.2. Treatment

330 ml bottles of carbonated No. 1 Rosemary Water (No1. Rosemary Water Ltd., 6 Burnsall Street, Chelsea, London, SW3 3ST) and plain carbonated mineral water were sourced from a local department store. Gas Chromatography Mass Spectrometry (GCMS) and High Performance Liquid Chromatography (HPLC) analyses of the extract and hydrolat used in the production of the Rosemary Water were undertaken by Blue Sky Botanicals, Castle Farm, Upton Bishop, Ross-on-Wye, HR9 7UW. These identified the presence of a number of terpenes predominantly 1,8-cineole, and also Rosmarinic acid. In addition quinnic acid and glucosamine-like compounds are detectable.

### 2.3. Blinding

Rosemary water has a distinctive taste. In order to try and blind participants to

condition, those in the Rosemary water condition were informed that we had produced a flavour-equivalent water that contained no potentially active compounds. Those in the plain water condition were told that the Rosemary water we were testing had had the flavour element reduced so as to be negligible. The researcher indicated that they were also blind to which condition participants were in. At the completion of testing participants were asked to guess which treatment they had actually been given. Chi square analysis revealed that the blinding had been successful  $\chi^2(1) = 1.818, p = 0.178$ .

## 2.4. Participants

Twenty participants were each paid £10 each for taking part in the study. The Rosemary water group consisted of seven females (mean age = 26.71 years, SD = 4.78) and three males (mean age = 24.33 years, SD = 3.05). The Control group consisted of seven females (mean age = 34.42 years, SD = 11.19) and three males (mean age = 25.00 years, SD = 3.60).

## 2.5. Materials/Equipment

### 2.5.1. Blood Pressure & Heart Rate

Systolic and Diastolic blood pressure, and heart rate were measured continuously via the Portapres ambulatory blood pressure monitoring (ABPM) system. Portapres offers proven and tested clinical technology based on 20 years of scientific research. Data is stored and retrieved using the BeatScope software. Values were split and averaged over the phases of the study.

### 2.5.2. Mood

Subjective self-report mood was assessed using the Bond-Lader visual analogue scales [10]. The 16 visual analogue scales of Bond-Lader were combined as recommended by the authors to form three mood factors: “alert”, “calm” and “content”. To calculate the impact of the testing procedure and the Rosemary water, difference scores were calculated by subtracting initial values (pre-) from final values (post-). Positive values therefore indicate an increase in the mood dimension over the test period whereas negative values indicate a decrease in the mood dimension over the testing period.

### 2.5.3. Present Stress Scale

A single item “How stressed do you feel right now?” was used to evaluate present stress. Single item measures may be preferable as they are quicker to complete at times when other activities are being undertaken, are potentially easier to understand and respond to, may have more face validity and be more flexible as opposed to more complex measures [11].

### 2.5.4. NASA Task Load Index

The NASA-TLX comprises a set of six scales anchored with “Low” and “High” at the extreme points. Mental Demand: How much mental and perceptual activity was required? Was the task easy or demanding, simple or complex? Physical

Demand: How much physical activity was required? Was the task easy or demanding, slack or strenuous? Temporal Demand: How much time pressure did you feel due to the pace at which the tasks or task elements occurred? Was the pace slow or rapid? Overall Performance: How successful were you in performing the task? How satisfied were you with your performance? Frustration Level: How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task? Effort: How hard did you have to work (mentally and physically) to accomplish your level of performance?

#### **2.5.5. Positive and Negative Affect Scale (PANAS)**

The PANAS questionnaire consists of two 10-item scales to measure both positive and negative affect. Each item is rated on a Likert scale of 1 (not at all) to 5 (very much). Research has identified that the measure can be successfully utilized within clinical and non-clinical populations [12].

#### **2.5.6. Memory Tasks**

Immediate and Delayed word recall required participants to recall as many words as they could from a list of fifteen, presented sequentially at a rate of one per second at the start of testing. Prospective memory was assessed by asking participants to send a text message of their participant number at a specific time after the testing session finished. Deviation before or after the allotted time was taken as a measure of prospective memory error.

#### **2.5.7. Multitasking Framework**

The Multi-tasking Framework (MTF) computerised battery (Purple Research Solutions UK) was used to induce acute psychological stress. The computerised battery consists of four split screen tasks, which are displayed simultaneously. This allows for a multi-tasking environment to be created and the workload intensity can be increased by increasing the difficulty of the modules, to either low, medium or high. The cognitive and psychomotor tasks of the MTF have been found, to cause negative effects on mood and an increase in subjective stress [13] [14]. Performance is measured as scores for each of the modules and the total combined score. For the current study the highest task difficulty level was employed for a period of 15 minutes of testing.

### **2.6. Procedure**

Participants responded to posters advertising the study that were placed around the Department of Psychology. On recruitment, all participants completed a health screen questionnaire to ensure that no pre-existing conditions would rule them out from participation. No participant was excluded based on these criteria. All participants were tested between 9:00 and 17:00 and were asked to refrain from eating, smoking, or drinking caffeinated beverages for one hour prior to their arranged testing slot. On arrival at the lab they were randomly allocated to one of the two conditions using a sampling without replacement allocation to ensure two groups of equal size were formed. Drinks were then given dependent

on condition and baseline subjective measures taken and the physiological sensors applied. After a period of twenty minutes to allow for absorption of the drinks the word recall tasks and Multi-Tasking Framework were completed, with present stress recorded at set points. A final set of subjective measures were then recorded. Upon completion, participants were fully debriefed regarding the nature of the study and the condition that they had been in. The study received full ethical approval from the faculty of Health and Life Sciences ethics committee at Northumbria University, Newcastle, UK.

### 3. Results

#### 3.1. Cognition

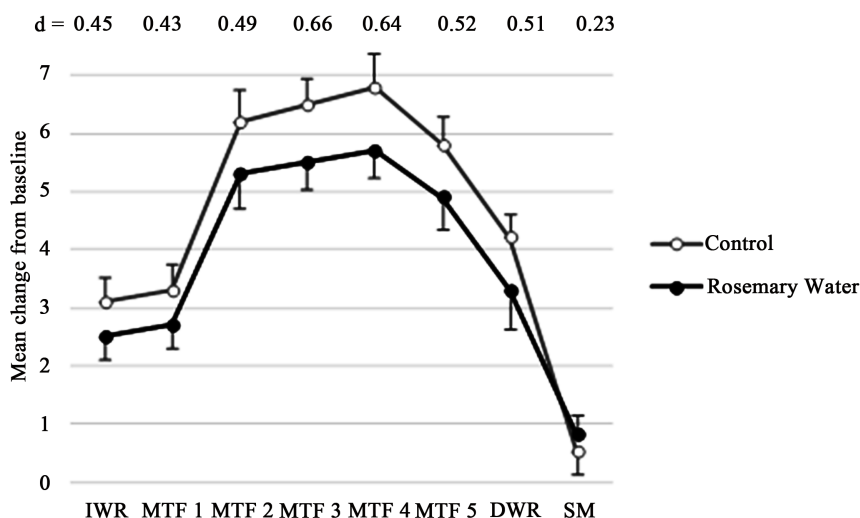
Descriptive statistics for both conditions and all cognitive dependent variables are presented along with calculated values for Cohen's *d* in **Table 1**. As can be seen, immediate and delayed word recall and prospective memory possessed small effects in favour of the Rosemary water condition. A very small effect exists for the overall multi-tasking framework (MTF) total that is largely a consequence of the difference in performance on the letter search task.

#### 3.2. Subjective Variables

Subjective mood scores were calculated as described in the method section. Where change scores are indicated pre-test values are subtracted from post-test values such that a positive change score indicates an increase on that variable from the start to the end of the testing procedure. Descriptive statistics for both conditions and all subjective dependent variables (except the present stress scale for which see **Figure 1**) are presented along with calculated values for Cohen's *d* in **Table 2**. A medium effect size exists for change in Alertness with Rosemary

**Table 1.** Means (standard deviations) and Cohen's *d* measures of effect size for each of the cognitive variables and multi-tasking framework. Immediate and Delayed word recall scores represent number of correctly recalled words. Prospective memory scores indicate the amount of time (secs) the text message received deviated from the requested time. Scores on the multi-tasking framework are calculated by the software with speed and accuracy gaining points and errors or failures to respond losing points.

Variable	Rosemary Water	Control	Cohen's <i>d</i>
MTF Total	1312.20 (1054.76)	1213.5 (908.28)	0.10
Tracking	410.20 (350.78)	429.30 (386.83)	-0.05
Telephone	192.00 (230.45)	193.70 (158.50)	-0.01
Letter Search	178.00 (929.94)	64.30 (611.61)	0.14
Warning Signal	532.00 (92.71)	526.20 (63.19)	0.08
Immediate Word Recall	8.00 (2.31)	7.50 (1.26)	0.27
Delayed Word Recall	6.40 (2.79)	5.80 (1.62)	0.26
Prospective Memory	207.5 (265.68)	289.20 (307.43)	-0.29



**Figure 1.** Mean present stress scale change from baseline for both conditions over the testing period. Error bars represent standard errors and are presented in one direction only for each point to aid clarity of the figure. IWR = Immediate Word Recall; MTF 1 to MTF 5 represent the start of the multitasking framework and subsequent 3 minute windows up to the end of the framework task; DWR = Delayed Word Recall and SM = Subjective measure completion.

**Table 2.** Means (standard deviations) for the subjective variables. Those marked “change” represent the difference between ratings from pre to post testing with positive values indicating an increase in that element over the testing session. The six scales of the NASA-tlx were scored only at the end of testing and so represent absolute values.

Variable	Rosemary Water	Control	Cohen's d
Alert change	7.80 (5.05)	5.30 (5.49)	0.47
Calm change	10.00 (15.95)	10.00 (16.86)	0.00
Content change	-4.50 (15.24)	-9.50 (23.18)	0.25
Positive Affect change	1.40 (4.88)	0.20 (4.93)	0.24
Negative Affect change	-1.80 (5.11)	-0.90 (1.59)	-0.24
Mental Demand	75.00 (23.00)	78.00 (16.00)	-0.15
Physical Demand	31.00 (25.00)	22.50 (19.00)	0.38
Temporal Demand	85.00 (6.60)	85.00 (8.80)	0.00
Performance	56.00 (21.00)	62.00 (26.00)	-0.25
Frustration	81.00 (7.80)	80.00 (13.00)	0.09
Effort	58.00 (32.00)	59.00 (21.00)	-0.04

having the greater increase pre- to post-testing. There is a greater decrease in calmness in the control condition than in the Rosemary water condition, with a small effect size. Positive and Negative affect possess equal and opposite-signed small effects in favour of Rosemary Water. With regard to the NASA-tlx scale, participants in the Rosemary water condition found the testing session more physically demanding with a small to medium effect size, but less mentally de-



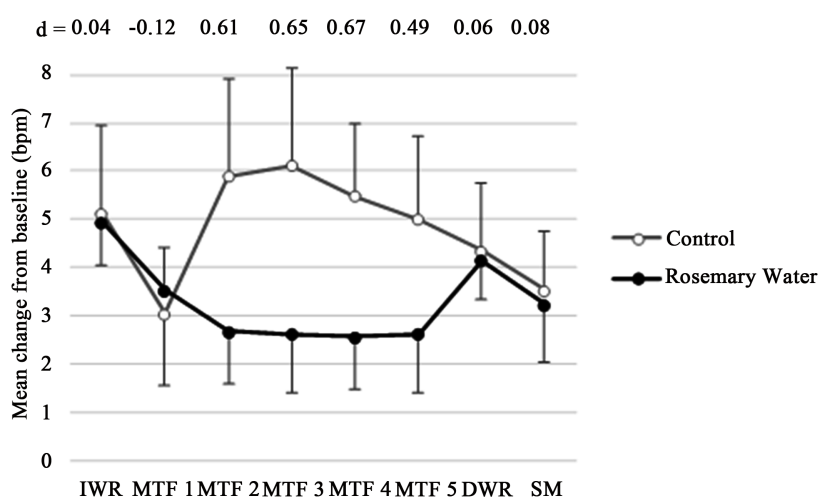
manding with a small effect. Participants in the control condition felt happier with their performance than those in the Rosemary water condition with a small effect size.

**Figure 1** presents the change from baseline values for the present stress scale. Cohen's *d* values for the comparisons at each time point are presented above the figure. The participants in the Rosemary water condition consistently reported lower stress throughout the testing procedure, with a return to near baseline levels for both groups at the point when the second subjective measures are completed.

Figures two to four display the mean change from baseline for the three physiological variables recorded in the study: heart rate, systolic and diastolic blood pressure for both conditions. Cohen's *d* values for the comparisons at each time point are presented above each figure.

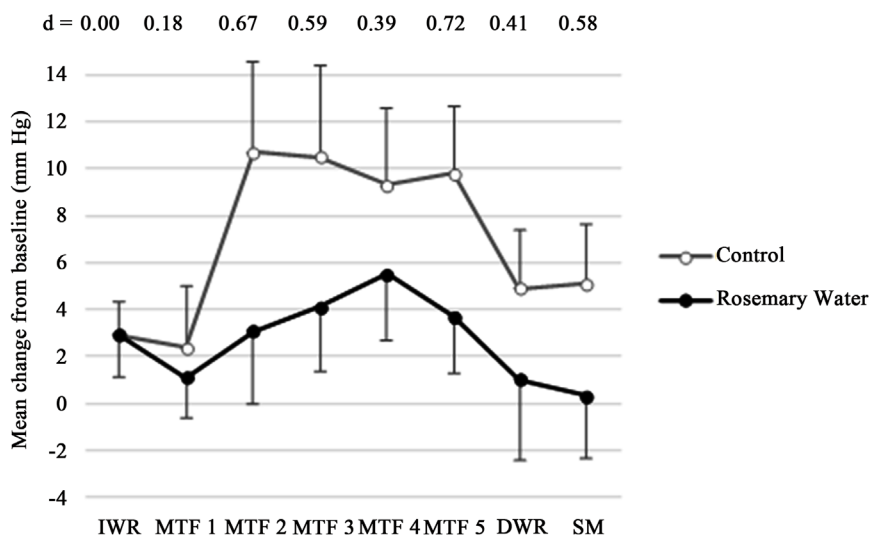
As can be seen in **Figure 2**, both conditions start the cognitive testing period with a noticeable increase in heart rate compared to baseline of five beats per minute. As testing progresses heart rate in the Rosemary water condition declines whereas that in the control condition is maintained at a higher level until the end of the testing when the two conditions are reconciled around three beats per minute above baseline. Medium sized effects are observed across the period that represents the completion of the multitasking framework.

The multi-tasking framework leads to a large increase in systolic blood pressure in the control condition (**Figure 3**). This is considerably blunted in the Rosemary water condition. Both conditions show a decline in systolic blood pressure at the end of the framework task although continues to be higher in the control condition with medium to large effects present over the testing period.

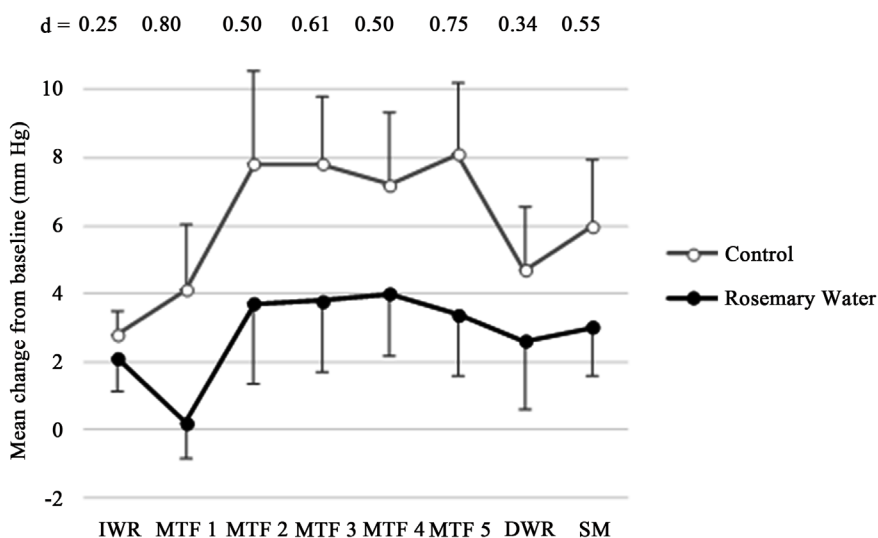


**Figure 2.** Mean heart rate change from baseline (bpm) for both conditions over the testing period. Error bars represent standard errors and are presented in one direction only for each point to aid clarity of the figure. IWR = Immediate Word Recall; MTF 1 to MTF 5 represent the start of the multitasking framework and subsequent 3 minute windows up to the end of the framework task; DWR = Delayed Word Recall and SM = Subjective measure completion.

Diastolic blood pressure is largely stable across the testing period in the Rosemary water condition, compared to a noticeable increase in the control condition, particularly during completion of the multi-tasking framework. Effect sizes are medium to large across the duration of testing (**Figure 4**).



**Figure 3.** Mean systolic blood pressure change from baseline (mm Hg) for both conditions over the testing period. Error bars represent standard errors and are presented in one direction only for each point to aid clarity of the figure. IWR = Immediate Word Recall; MTF 1 to MTF 5 represent the start of the multitasking framework and subsequent 3 minute windows up to the end of the framework task; DWR = Delayed Word Recall and SM = Subjective measure completion.



**Figure 4.** Mean diastolic blood pressure change from baseline (mm Hg) for both conditions over the testing period. Error bars represent standard errors and are presented in one direction only for each point to aid clarity of the figure. IWR = Immediate Word Recall; MTF 1 to MTF 5 represent the start of the multitasking framework and subsequent 3 minute windows up to the end of the framework task; DWR = Delayed Word Recall and SM = Subjective measure completion.

## 4. Discussion

The data collected in this pilot study reveal some interesting indications regarding the potential for carbonated No. 1 Rosemary Water to impact upon cognitive, subjective and physiological variables in healthy young adults. Due to the pilot nature of the study, tests of significance have been eschewed in favour of measures of effect size as defined by Cohen [15], and the discussion will be based around these. Considering the cognitive variables, it was predicted that aspects of memory previously identified as sensitive to Rosemary might benefit from the acute consumption of a Rosemary water product containing active ingredients. This was found to be the case with small effects present. Indeed the size of the effects observed are similar to those previously reported for both aroma [1] [2] and oral administration [6] [7] of Rosemary. Enhancement effects following oral administration help to shed some light on the potential mechanism underpinning the effects of Rosemary, as they rule out the likelihood of innervations from the olfactory bulb activating task sensitive areas of the brain—a widely purported possibility in the aroma research field [16]. In support of the alternate hypothesis that absorption of active compounds is the key that unlocks pharmacological mediated effects, is evidence from animal studies that demonstrate that 1,8-cineole is readily absorbed by the gut and impacts on behaviour [17] [18]. *In vitro* studies have previously demonstrated that 1,8-cineole has significant anti-cholinesterase properties [19], and given the primary role of the cholinergic system in memory it is possible that such a mechanism underpins the cognitive effects observed here and elsewhere. Although no bioavailability data exist for No. 1 Rosemary Water at this time, the data suggest that this may be the case, a proposal further supported by previous data showing that plasma levels of 1,8-cineole correlate with cognitive performance following exposure to Rosemary aroma [20].

There is much less impact observed for scores gained on the multi-tasking framework, although this might not be too surprising. “*The multitasking framework is a performance-based, cognitively demanding stressor, representative of environments where individuals are required to attend and respond to several different stimuli simultaneously with varying levels of workload.*” [21]. As such, it is not designed to be a means of directly assessing cognition, and scores on the four modules are not equally weighted. It is designed to induce cognitive load and stress through competing demands for the attention of the participant. As a consequence, these parameters shall not be focused on here above the observation that condition did not appear to impact on performance. What is of greater importance is the impact of the multi-tasking framework on the physiological and subjective measures. Previous studies have consistently shown that the multi-tasking framework employed here can significantly increase heart rate and blood pressure from baseline levels [21] [22] [23]. The current study found responses of the same kind, but notably much greater in the control condition. Indeed, Rosemary water appeared to exert what might be seen as a protective effect

on these physiological variables with medium effect sizes across the board. This is of particular interest because no previous studies have identified Rosemary as possessing such properties when consumed orally, and in resting individuals the administration of Rosemary aroma has been associated with an increase in these variables [5]. However, intravenous injections of 1,8-cineole (the major active component in Rosemary essential oil) produces decreases in heart rate and blood pressure as a consequence of vascular relaxation in free-to-roam rats [24]. The possibilities suggested by the data reported here are intriguing, and worthy of further investigation. It may be that Rosemary possesses the properties to alleviate the physiological responses to acute stress through such a mechanism.

Consideration of the physiological markers of stress reactivity leads neatly on to the subjective psychological assessments. Here we find a medium effect for the increase in “alert” and a small effect for the decrease in “calm”; both in favour of Rosemary water. These are also interesting as they mirror findings reported elsewhere [4] [5] for Rosemary aroma. However, their observation here suggests that these effects are not a consequence of olfactory stimulation either. This is perhaps somewhat unexpected as previous studies have suggested that the mechanisms for influencing mood and cognition might be distinct; potentially one olfactory and one pharmacological; as correlations between the two variables have not been consistently present [6] [20]. The scales from the PANAS show similar small benefits as a consequence of drinking Rosemary Water. This is a novel finding, employing a scale widely used in Health research but not to the authors’ knowledge in connection with Rosemary. The small effects are in keeping with the “alert” and “calm” mood scales and support the general reputation of Rosemary as an uplifting herb [25]; even if in this study it is not a consequence of inhaling the aroma. It may be the case that the physiological effects on heart rate and blood pressure at a time of stress mediate the subjective mood effects. Such subjective effects have been reported in chronic patient treatment studies of high blood pressure [26], although persistent low blood pressure also has negative effects on mood [27]. Further work is warranted in order to clarify the relationship between physiological and subjective variables in healthy adults at times of stress and when subjected to interventions that might reduce perceived stress in the manner reported here. Finally, the NASA-tlx produced results that in some respect run counter to those previously reported here. A small to medium effect indicating that Rosemary water produced feelings of greater physical effort or exhaustion as a consequence of completing the study was identified. Whereas those in the control condition reported higher levels of satisfaction with their performance on the tasks—in spite of not performing as well. Why these effects should be observed is not clear, but it is possible that the cardiovascular response to stress is normative and the protective effect observed for Rosemary water might lead individuals to think they need to try harder as the “natural” response is not there? This might also relate to lower performance satisfaction as the tasks appeared harder? These latter points are of course purely speculative and do not seem to chime with better evaluations of

“alert” and “calm” reported above.

As a pilot, this study has provided some interesting data that certainly suggest there is value in greater investigation of the potential properties of No. 1 Rosemary Water. Possible benefits for memory, and in particular the cardiovascular responses to acute stress are exciting avenues to explore. Indeed, current work in our lab includes a large scale replication of this study, and investigations of the impact of chronic consumption of No. 1 Rosemary Water on a number of cognitive, psychological, cerebrovascular and EEG variables.

## 5. Conclusion

To conclude, Rosemary herb offers a number of interesting possible health promoting applications, from antioxidant and anti-microbial to hepatoprotective and antitumorigenic activity [28]. The current study adds to the growing evidence in support of the potential for enhancing memory-based aspects of cognitive functioning, improving mood especially in terms of subjective alertness and reduced stress, and perhaps even delivering cardiovascular benefits as well. Future research in this area would benefit from inclusion of bioavailability data regarding the absorption of identified active components in No. 1 Rosemary Water, in order to facilitate correlations with performance, mood and physiological data to be calculated.

## Conflicts of Interest

The authors declare that there are no conflicts of interests.

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