



Effects of a Glyconutritional Supplement on Brain Potentials Associated with Language Processing

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Supported in part by the Arkansas Children's Nutrition Center through USDA ARS CRIS # 6251-51000-002-03S and by Mannatech, Inc., Coppell, Texas

Presented at Federation Proceedings Experimental Biology Meeting, April 20-24, 2002, New Orleans, LA

ABSTRACT

The effects of a nutritional supplement on language processing were studied in 20 healthy 20-30 year-old males. The supplement (Ambrotose[®]) contained glucose and seven other basic saccharides the human body derives from glucose. Since glucose enhances level of arousal and cognitive processing, it was expected that major saccharides derived from glucose would act similarly and improve performance on a language processing task. Subjects were tested on two separate visits one week apart. On the first visit each subject received either supplement or placebo prior to testing. On the second visit subjects received the opposite treatment. During testing, subjects judged (agree or disagree) whether a word following a sentence was related to the sentence. Brain potentials were recorded during testing, averaged separately for conditions, and analyzed using SPSS repeated measures software. Relative to placebo, the supplement was associated with decreased reaction time and a significant amplitude increase of the ERP slow-wave response in the agree condition. The slow-wave response has been related to post-stimulus processing, i.e., preparation for the next stimulus and reflection on what has just transpired. These findings are consistent with a facilitatory effect of the nutritional supplement on information processing.

INTRODUCTION

Glucose has been shown to enhance cognitive processes such as memory and attention (Benton and Owens, 1993; Benton and Parker, 1998; Korol and Gold, 1998; Manning et al., 1998; Meisser et al., 1997). However, glucose is routinely metabolized into other important saccharides (sugars) which play an important role in nutrition, cell communication, and other biological functions (Stella et al., 2001). Although nutritional supplements that provide a loading of these sugars independent of that produced by glucose metabolism are in general use by the public, there is limited

knowledge regarding the effects of these compounds on behavior. The present investigation evaluated the effect of one of these nutritional supplements (Ambrotose[®]) on electrocortical activities of the brain [event-related potentials (ERPs)] generated during a language processing task in young adults.

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HYPOTHESES

The supplement will improve performance on a language-related task requiring discrimination regarding semantic congruity. Specifically, the supplement treatment condition will be associated with decreased response time to indicate agreement or disagreement regarding the semantic relationship of the target word to the preceding sentence, and enhancement of event-related potentials associated with phonological processing.

METHODOLOGY

Subjects

20 healthy male college students 20-30 yrs. old enrolled

Treatment

- On study days subjects were told to report to the laboratory at noon, not eat anything after breakfast, and that they would

receive \$50.00 for each visit.

- Two visits were scheduled, one week apart.
- Treatments [a placebo (methyl cellulose) or the supplement (see Table 1 for contents)] were counterbalanced across subjects, with equal numbers of subjects randomly assigned to the two conditions.

Procedures

- Upon arriving at the laboratory, subjects were given one tablespoon of either the supplement or the placebo mixed in 4 ounces of no-calorie, fruit- flavored water.
- The electrodes were then attached, and recordings began approximately 60 minutes after the consumption of the placebo or supplement, i.e., at the time when blood levels of orally administered glucose reach peak values (Anderson, 1998).
- Recordings were conducted in a dimly lighted electrostatic-sound-shielded room. During recordings subjects sat quietly in a comfortable chair and performed the following sentence-reading task:
 - 80 sentences (varying in length from 5-9 words) created with reading levels well below those of the education of college subjects were presented.
 - Words in sentences were presented serially at a comfortable intensity level on a computer monitor in white lower-case letters against a black background.
 - Words were presented one at a time with a fixed interval of 600 ms and a word duration of 300 ms.
 - Half of the sentences were followed by a semantically incongruous word with respect to the meaning of the sentence; the other half were followed by congruous words, e.g., The most often used utensil is a fork. xxx Goodyear (incongruous). Few musical instruments sound as brash as the saxophone. xxx jazz (congruous).
 - Subjects pressed one of two reaction time (RT) keys, depending on whether the ending word was or was not a match.
 - Failure to press was counted as an error.
 - At the end of the experiment, subjects were asked to answer questions about the relationship of words to the content of the sentences.

Physiological Recordings

- Monopolar EEG [F3, F4, P3, P4, O1, O2, TPO1, TPO2, TCP1, TCP2 (Wernicke's area), FTC1, FTC2 (Broca's area) Fz, Cz and Pz:, all referenced to left mastoid placement and rereferenced offline to M1+ M2 mean value]
- Bipolar EOG (at the outer canthi and above and below one eye for recording horizontal and vertical eye movements, respectively)
- Resistance \leq 5K ohms for all recording combinations
- EEG signals were digitized (256 Hz) and stored for off-line analysis.

Analyses

Data processing

Artifact-free EEG recordings were averaged across trials and amplitude variations determined for two waveforms known to show variations in association with phonological processing, i.e., a negative going wave occurring ~400 msec after stimulus onset (N400), and a later slow wave (SW) beginning at ~500-600 msec (Osterhout and Holcomb, 1995; McPherson et al., 1998).

Data from three subjects were not included because of technical or procedural problems

Statistical

Repeated measures Analysis of Variance with post-hoc t-tests.

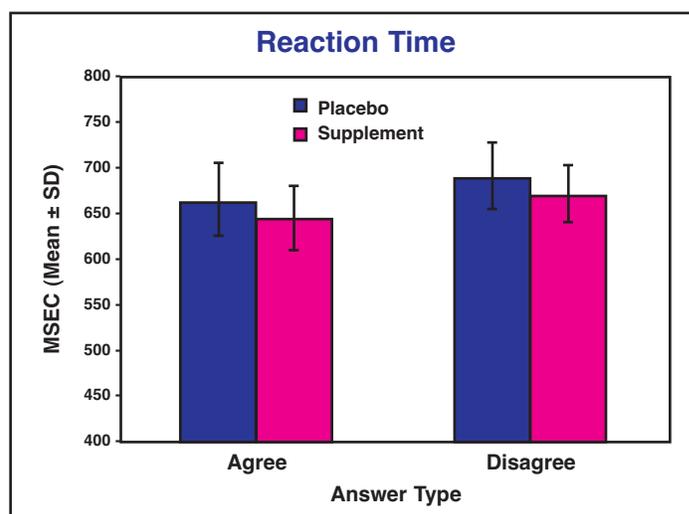
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RESULTS

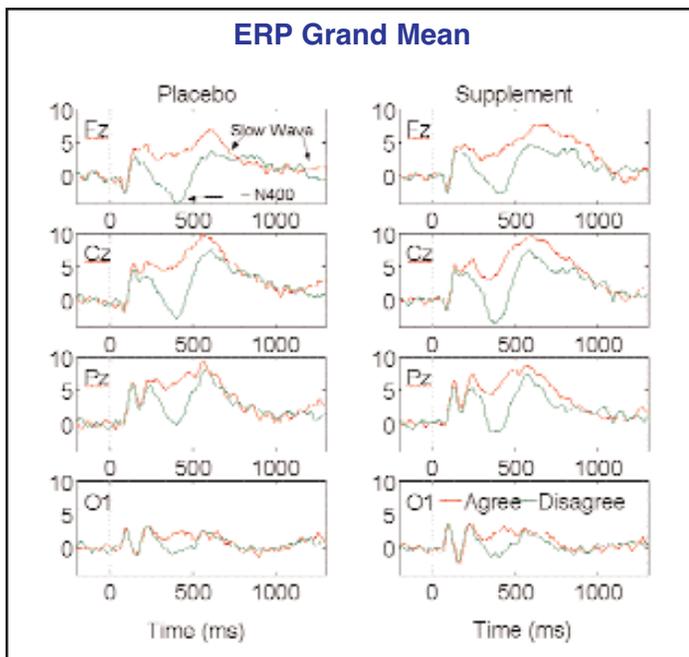
Table 1
Analysis of Hydrolized Alditol Acetates
by GCMS*

Ingredient	Assay ($\mu\text{g}/\text{mg}$)	Assay (%)	Per Tablespoon (mg)
Water	91.6	9.16	483.6
Rhamnose	2.3	0.23	12.1
Fucose	2.0	0.20	10.6
Ribose	not detected	-----	-----
Arabinose	92.7	9.27	489.5
Xylose	18.4	1.84	97.2
Mannose	39.3	3.93	207.5
Galactose	424.8	42.48	2242.9
Glucose	97.9	9.79	516.9
Glucosamine	62.7	6.27	331.1
Galactosamine	not detected	-----	-----
Total		83.17	4391.4

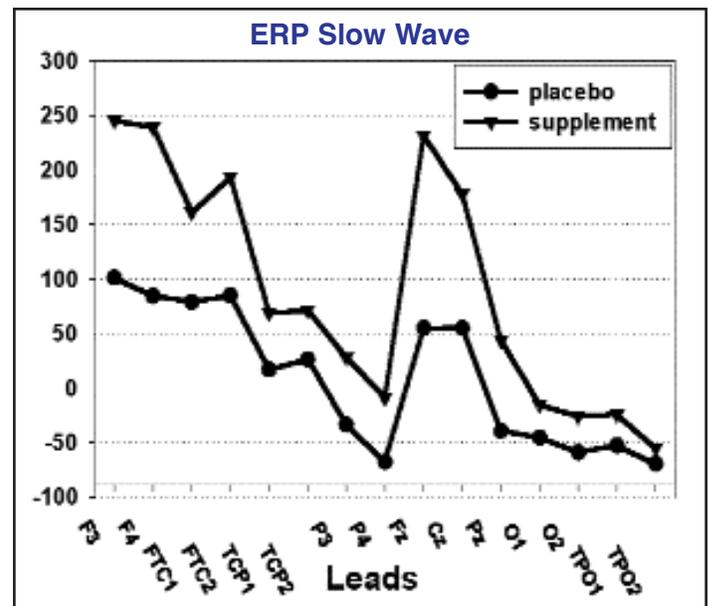
* The method of analysis is applicable only to neutral sugars and amino-sugars.



Reaction time values as a function of test and treatment conditions. Between-treatment comparisons were not statistically significant.



Grand mean ERP data comparing responses to Agree and Disagree stimuli under placebo and supplement conditions. The recording sites selected illustrate the anterior (frontal) to posterior (occipital) distribution of the waveforms of interest (N400 and Slow Wave) indicated in the upper left panel. N400 was significantly enhanced on Disagree trials ($p < .001$), particularly at language-related recording sites (F3, FTC1, FTC2, TCP1, P3, P4, Pz; all at $p < .039$). However, treatment effects were not statistically significant ($p < .095$).



Comparisons of group mean Slow Wave power spectral values as a function of recording site and treatment (collapsed across agree-disagree conditions). Graphed values are based on data points summed between 600-1200 msec. Significant treatment effects were present for the Agree condition ($>$ Slow Wave associated with the supplement: $p < .013$). This effect was present at multiple sites (Fz, F3, F4, FTC1, FTC2, Cz, P3, P4, O1, O2, TPO1; all at $p < .032$), but was most prominent frontally and centrally.

SUMMARY AND CONCLUSIONS

Although treatment-related reaction times were in the predicted direction, i.e., reduced in the supplement relative to the placebo condition, these differences were not statistically significant. Similarly, the N400 ERP was greater -- but not significantly -- following administration of supplement compared with placebo values. The late-occurring Slow Wave did discriminate between treatment conditions, showing a significant supplement-related amplitude increase in the Agree condition. This effect -- greatest at sites associated with executive functioning, alertness and emotion (i.e., frontally; Andreassi, 2000) -- has been related to post-decisional processing.

These findings are consistent with a facilitatory effect of the nutritional supplement on aspects of performance and information processing. It is important to note that the supplement did not have any side effects, and consequently these positive influences are not associated with other known supplement-related effects.

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