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Alcohol expectancy cognitions: Psychophysiological perspective

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Alcohol Expectancy Cognitions:

Psychophysiological Perspective

by

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ABSTRACT

Considerable evidence indicates that the expectations individuals hold about the effects of alcohol determine, to a degree, the amount of alcohol they drink. However, the bulk of this evidence was acquired using verbally-based measures of expectancy. The present study sought to extend the validation network by utilizing an electrophysiological measure – the P300 component of the Event Related Potentials (ERPs) – which is thought to index fundamental neurophysiological processes sensitive to expectancy.

Previous research has demonstrated that, when presented with various outcomes of alcohol consumption, heavier drinkers endorse statements that assert positive and arousing effects of alcohol, while lighter drinkers endorse sedating and negative effects of alcohol. Given the sensitivity of the P300 to violation of subjective expectancies, it was hypothesized that P300 amplitude elicited by stimuli violating one's alcohol expectancies (e.g., statements describing sedating effects of alcohol for individuals with high positive expectancies) would be correlated with the participants' alcohol expectancies measured by traditional self-report measures.

Participants were presented with statements reflecting a wide range of alcohol outcome effects, which either violated or confirmed the participant's own set of alcohol expectancies, while the ERPs evoked by these stimuli were recorded. As predicted, the P300 amplitude elicited by negative alcohol expectancy stimuli was positively correlated

with the degree of endorsement of positive/arousing expectancies on the self-report measure. That is, the higher the individual's positive/arousing expectancies, the larger the P300 elicited by stimuli asserting the negative effects of alcohol. There was no significant correlation, however, between P300 amplitude elicited by positive alcohol expectancy stimuli and the degree of endorsement of negative/sedating expectancies on the self-report measure.

In sum, variations in the amplitude of the P300 were consistent with the model of Alcohol Expectancies: Namely, words imputing negative/sedating effects of alcohol elicited a large P300 in individuals with high but not low positive alcohol expectancies. By indexing the brain's electrophysiological response sensitive to expectancy violations, these findings demonstrate concordance between verbal measures of alcohol expectancies, which by their very nature are introspective, and a psychophysiological index of expectancy thought to operate automatically and to be independent of overt responding.

Introduction

As in many other domains of psychological research, there is a large individual variability in alcohol consumption phenomenon: different individuals drink differently both in terms of quantity and frequency. Moreover, there is no long-term typical pattern of drinking, as individuals drink differently at different times in their lives, with a peak drinking occurring at young adulthood (Grant, Dawson, & Stinson, 2004). Although the psychopharmacological effects of alcohol, as well as of other psychoactive drugs, have been linked to the reward via dopamine mesolimbic system, these rewarding properties alone (or along with other biological variables, such differences in ethanol metabolism rates or receptors structure), cannot explain why *some* individuals in similar circumstances drink significantly more than others. Furthermore, the reinforcing element is not necessarily gained directly from the psychoactive action of alcohol, as someone drinking beer with colleagues may be more motivated by the feeling of fellowship it brings than by the psychoactive effect of the ethanol. This effect of alcohol reinforcement has been extensively described in the literature and is widely attributed to the cognitive mechanisms that *mediate* the relationship between the pharmacological and behavioral effects of various substances of abuse.

Cognitive Mediation of Pharmacological Effects: Expectancy Theory

The cognitive framework applied to the field of substance use and abuse assumes that information pertaining to drinking alcohol (as well as other drug use) resides in associative networks of interconnected conceptual nodes, with the central one being alcohol, that represent the direct and vicarious experiences a person has had with alcohol as a consequence of both their individual biological characteristics and environmental exposures (see Goldman, 2002). These nodes may represent images, memories of sensorimotor and affective experiences, specific behavior patterns, as well as verbal representations of the central concept (i.e., alcohol), acquired from sources including family members, media, peer groups, and inherited biological reactions to alcohol. When primed, these networks are theorized to activate information related to drinking or drug use. Activation occurs in a predictable fashion, once the individual encounters stimuli that match previously encoded material relevant to drinking. Recent models and comprehensive accounts of alcohol consumption emphasize the central role that memory associations to the anticipated consequences of alcohol use (i.e., *alcohol expectancies*) play in the individual's decision to use alcohol (e.g., Goldman, 1999; Stacy, 1997). Tasks traditionally used by cognitive psychologists (e.g., Stroop task, false memory paradigm, free associates task, among others) have been successfully used to demonstrate that alcohol-related cues can activate relevant alcohol associations in memory (e.g., Kramer & Goldman, 2003; Reich, Goldman, & Noll, 2004; Wall, McKee, & Hinson, 2000). Furthermore, the amount of experience a person has with alcohol appears to be related to the particular memory content that is activated in the presence of relevant (i.e., alcohol-related) cues in the environment (e.g., Kramer & Goldman, 2003; Rather & Goldman, 1994).

More importantly, there is sound evidence indicating that these alcohol-related memory associations are strongly correlated with actual drinking patterns. For instance, Brown, Goldman, Inn, and Anderson (1980) surveyed 2,400 college students and found that drinking patterns could be predicted from participants' responses to a questionnaire measuring alcohol expectancies. Specifically, relatively heavy drinkers expressed stronger expectations that a moderate dose of alcohol would enhance their aggressive behavior and sexual performance. Christiansen, Smith, Roehling, and Goldman (1989) found that specific expectancies about the positive effects of alcohol (e.g., that alcohol enhances cognitive and motor functioning) held by 7th and 8th grade students accounted for over 25% of the variance in the level of drinking 12 months later. Rather and Sherman (1989) found that expectancies about the effects of alcohol were correlated with the length of sobriety among members of Alcohol Anonymous: Specifically, the longer a recovering individual has abstained from alcohol, the less likely he or she will have expectations of the reinforcing effects of alcohol (i.e., the lower his or her alcohol expectancy scores are). Similarly, Brown (1985) has shown that recovering alcoholics with higher expectancies, as measured at the time of treatment, are less likely to be abstinent at a one-year follow-up. Finally, Smith, Goldman, Greenbaum and Christiansen (1995) found that, at three-year follow up, an increase in alcohol consumption in a large sample of public school students at age 12-14 at the first assessment was significantly predicted by expectancies about alcohol's effects on social facilitation: The stronger the social expectancy at the first assessment, the greater the increase in drinking over time at the follow-up assessments. Similar findings were reported by Stacy and colleagues in a longitudinal study spanning over a 9-year period: They demonstrated that alcohol outcome expectancies measured in adolescence predicted drinking and drug use during early adulthood, above and beyond the level predicted by these same behaviors measured at the first time point (Stacy, Newcomb, & Bentler, 1991a). Overall, depending on measurement and analysis techniques used, alcohol outcome expectancies appear to account for as much as 50% of the variance in alcohol consumption, both concurrently and prospectively (Goldman, Darkes, & Del Boca, 1999).

Although the majority of these studies demonstrating the relationship between self-reported alcohol expectancies and drinking patterns have been correlational (albeit longitudinal) in nature, more recent research has begun to address the issue of causality through direct manipulation of expectancies in *true* experiments. The results of such experiments indicate that, in the laboratory, alcohol expectancy manipulations have reliably led to short-term changes in alcohol consumption. Specifically, Roehrich and Goldman (1995) observed increase in drinking (in a fake beer-tasting session) following implicit priming of alcohol-related concepts, using a modified Stroop task. Similarly, Stein, Goldman, and Del Boca (2000) demonstrated that *cognitive* or memory priming, using a task of generating synonyms to alcohol expectancy vs. neutral words (as compared to just mood induction condition, consisting of listening to positive vs. neutral music), implicitly affected drinking in an ostensibly unrelated beer-tasting experiment. They found that men in the alcohol priming condition drank significantly more than men in each of the other conditions. Likewise, other research teams (Carter, McNair, Corbin, & Black, 1998; Sharkansky & Finn, 1998) demonstrated that individuals primed with positive expectancy-related cues increased their alcohol consumption, while individuals primed with negative cues decreased their consumption. Furthermore, a number of studies have attempted to directly manipulate alcohol expectancies to produce more lasting changes in cognition. For instance, in indirect expectancy challenge studies, which utilize a placebo beverage administration paradigm, participants are told that they are receiving an alcoholic beverage or placebo, after which they participate in a group activity. After completing the exercise, participants are asked to indicate which individuals in the group they believe consumed alcohol. The purpose of these manipulations is to *challenge* participants' expectancies by showing that the behavior they observe in themselves and others could be attributed to their expectancies about the effects of alcohol, rather than to alcohol's pharmacological effects. Such indirect expectancy challenges have been successful in reducing alcohol consumption at 6 weeks following the beverage/placebo administration intervention sessions (Darkes & Goldman, 1993, 1998)[*]. Together, the results obtained from these *true* experiments, where alcohol-related cognitions have been experimentally manipulated in order to examine their effect on subsequent drinking, provide compelling evidence that alcohol expectancies not only correlate with actual drinking behavior, but rather influence it (or serve as mediators in a statistical sense, between the so-called antecedent variables, or risk factors for drinking, and the outcome behavior of actual alcohol consumption).

In sum, a large body of research has demonstrated that expectations of alcohol's effects, referred to as *alcohol expectancies*, can explain a good portion of variance in such complex behavior as alcohol consumption. Yet, although alcohol expectancies have been proposed to exist in the form of a semantic network in long-term memory (Goldman et al., 1991; 1999; Rather, Goldman, Roehrich, & Brannick, 1992), the nature of this network, as well as the extent to which it affects behavior, is only beginning to be

[*] These findings led some to argue that manipulating expectancies might be a route to manipulating consumption for problem drinking prevention and treatment.

explored. Investigations founded in cognitive psychology appear to hold promise for developing a better understanding of how these memory networks operate. The utility of general network theories of memory, like that of spreading activation (Collins & Loftus, 1975) in which activation from a node in a semantic network spreads through that network, has made further theorizing about the structure of alcohol expectancy in memory possible. Rather and colleagues (1992) named several characteristics of semantic network models which make them appropriate for initial investigations of the structure of alcohol expectancies. First, these models are parsimonious, in that expectancy information is readily transferable into the network structure. Second, the spreading activation model emphasizes the process with which an outcome is generated, as opposed to using mathematical prediction. Next, the model fits relatively well with what is currently known about the operations of the nervous system. Fourth, semantic network models may fit well with other memory research, and may be readily applied to the study of expectancies. Finally, the comprehensiveness of this model allows for the integration of other theories and research areas, as proposed by the present investigation.

Additionally, by means of this information-processing framework, Goldman and colleagues have postulated that the cognitive structure or the organization of expectancy representations in memory varies in accordance with individual's reported drinking level (Rather, Goldman, Roehrich, & Brannick, 1992). Specifically, it has been demonstrated that heavy drinkers appear to associate primarily positive and arousing effects with drinking, whereas lighter drinkers associate alcohol with primarily negative and sedating effects (Goldman & Darkes, 2004; Rather & Goldman, 1994; Southwick, Steele, Marlatt, & Lindell, 1981). For instance, when asked to complete a sentence stem "Alcohol makes me...", heavier drinkers more often give positive and arousing adjectives, such as *happy* and *sociable*. On the other hand, nondrinkers and light drinkers more often respond with sedating and negative adjectives, such as *sick* and *drowsy*. Using multidimensional scaling (MDS), it has also been demonstrated that heavier drinkers tend to have more tightly packed networks of these positive-arousing effects, while light drinkers have looser associations between drinking and positive outcomes (Rather & Goldman, 1994). This suggests that heavier drinkers would have a number of positive expectancies immediately accessible when information pertaining to alcohol is activated in memory, and although they may at times associate drinking with negative consequences, these associations are much less readily available than positive alcohol outcome effects. Others (e.g., Stacy, 1997) have also found that alcohol-related information in general (rather than alcohol-related expectancies) appears to be more accessible among heavier drinkers, when compared to lighter drinkers, suggesting a stronger relationship between cues that signal a drinking opportunity and the alcohol concept among heavy drinkers. Specifically, Stacy and colleagues measured drinkers' responses to pictures or words that had more than one meaning (e.g., *pitcher* as associated with baseball or beer). The resulting associations showed that heavier drinkers associated alcohol-related meaning to ambiguous stimuli.

Taken together, these findings provide a conceptual framework that emphasizes how different cognitive structures might facilitate drinking (or other drug use). This approach, focusing on how different individuals, or groups of individuals, display differential responses to the same stimulus/situation, may help explaining the wide variety of possible effects or outcomes of alcohol consumption not otherwise understood via pharmacological or physiological prism. To further illustrate this point, a given word, like *bat*, can elicit different associations depending on the context: within a sports context, one may get associations with baseball and pitcher, while within a Halloween context it may be associated with horror and/or costume. But more importantly, individuals act within their own internal context shaped up by their prior experience within any given domain, which, due to a multitude of factors, has made them more or less specialized in this particular domain (be it baseball or substance of abuse). As a result, his or her baseball- or alcohol-related memory network needs to be interpreted within the individually tailored, personalized context. This approach illustrates how an application of cognitive/information processing methods to the substance use domain can allow for more fine-tuned predictions regarding the alcohol effects across individuals. This conceptualization leads to the present investigation, as elaborated below.

Implicit, Automatic Nature of Cognitive Operations

Furthermore, the alcohol-related network activation is presumed to be an active system, operating by and large automatically, relatively free of the influence of conscious processes (Goldman, 1999). Several research teams have tested this assumption with specific cognitive tasks referred to as “implicit” tasks, including false memory or free associates paradigms, which are understood to be relatively free of the influence of conscious processes (Roediger, 1990). Such implicit tasks have proved useful in studying a wide range of psychological phenomena, including attitudes in social psychology, and traits in personality research. Within alcohol field, Stacy and colleagues (Stacy, 1997; Stacy, Leigh, & Weingardt, 1997) have shown differences between heavy and light drinkers in their associations to ambiguous stimuli, using priming tasks (as described in more details above). Weingardt, Stacy, and Leigh (1996), for example, used a semantic priming task to show that, among heavy drinkers, alcohol-related targets (e.g., *drink*, *booze*) can be automatically activated in memory when preceded by positive drinking outcome primes (e.g., "They had fun after they had the…"). Using a modified Stroop task, Kramer and Goldman (2003) found that after presentation of alcohol beverage prime, heavy drinkers showed greater Stroop interference effect, as measured by longer reaction times, when naming arousing alcohol expectancy words (e.g., *horny, wild*) than did light drinkers, who had greater interference when naming sedating expectancy words (e.g., *sleepy, dizzy*). Because interference in the Stroop task is presumed to be a function of implicit, automatic processes, these results supported the hypothesis that expectancy network activation is operating beyond our conscious control. Similarly, Jones and Schulze (2000) found Stroop interference on positive outcome expectancy words after participants had sipped actual alcohol, in comparison to placebo condition. Reich, Goldman and Noll (2004) tested false memory for expectancy target words in neutral and alcohol contexts. They asked participants to study a list of words composed of either alcohol expectancy or other adjectives, after which a memory recognition task was administered. Consistently with the alcohol expectancy theory, the results indicated that in the alcohol context (i.e., when both learning and testing took place in a setting resembling a drinking establishment – in a dimly lit bar, equipped with alcohol bottles, bar stools and a recycling bin filled with old beer bottles, to provide an olfactory cue) heavier drinkers showed more false memory for alcohol expectancy words than they did in a neutral context (i.e., when the experiment took place in a neutral setting of a typical conference room). These differences were not found for lighter drinkers. The results were interpreted as indicating that the bar context served as an implicit prime, or as an unequivocal cue for activation of the alcohol-related meanings of the test items among heavy drinkers.

Thus, these studies have demonstrated that stimuli or cues associated with alcohol can *implicitly* activate expectancies, which are typically assessed with primarily explicit, questionnaire-like, self-report methods. Moreover, implicit priming with expectancy-related words has also been shown by several research teams to facilitate subsequent alcohol consumption (Carter, McNair, Corbin, & Black, 1998; Roehrich & Goldman, 1995; Stein, Goldman, & Del Boca, 2000). For instance, Roehrich and Goldman (1995) led participants to believe that they were taking part in a memory experiment. Half of the participants watched an episode of the television program *Cheers*, while the other half watched an episode of *The Bob Newhart Show*. These episodes were as equivalent as possible (in both episodes, the main characters discussed a resemblance between a food item and a famous individual), with the exception of alcohol context in the episode of *Cheers*, which served as an implicit alcohol prime. As a distracter task, participants were asked to perform a Stroop color-naming task (i.e., say the color in which the word is printed), when half of the participants ink-named alcohol expectancies words while the other half ink-named control words (thus, the Stroop task served as an additional priming level). Participants were then told that they must wait for the next segment of the experiment or that in the meantime they could choose to participate in an ostensibly unrelated beer taste-testing survey, while they waited. During this faked taste-testing session, those participants who had been exposed to the *Cheers* episode and the alcohol expectancy words in the Stroop task drank the most beer. Those who had been exposed to the *Cheers* episode and control words consumed the next highest amount. Of the two groups who saw the *Newhart* episode, those who saw expectancy words in the Stroop task consumed more beer than did those in the control group. In other words, exposure to either word- or video-alcohol primes increased drinking over control primes, with exposure to both kinds of primes producing the greatest drinking. Hence, it appeared that priming carried out in a manner similar to that used in implicit memory studies activated expectancy processing that led to an increase in drinking.

By demonstrating the relationship between memory priming and alcohol consumption, these findings reinforce the notion that alcohol-related information processing can operate automatically and without deliberate decision making or awareness. This, in fact, is consistent with Tiffany's (1990) model of addictive behavior, which postulates that drinking without thoughtful planning or deliberation is a central element of problematic drinking. In particular, Tiffany suggested that experienced users are more automatic in their drug/alcohol use in that their use is less governed by cycles of conscious experiences and urges, followed by deliberation of plans to acquire substances, but rather is driven by automatized behavioral sequences that occur with little or no conscious thought. Thus, it is only logical to attempt to tap into these information-processing mechanisms, which are presumed to operate outside of one's awareness, using *implicit* tasks, or *cover*t rather than overt indices, as proposed in the current study[*].

[*] Importantly, this does not imply that implicit and explicit measures tap into distinctive or separate memory "systems". The most likely scenario is that, like in most other life circumstances, an ongoing behavior is influenced by both controlled/conscious and automatic processes.

Summary of Information-Processing Approach to Alcohol Research

In sum, this collective body of research has shown that cognitive associations comprising the alcohol expectancy network play a critical role in determining alcohol consumption patterns. That is, drinking is not merely influenced by social factors or biological processes, but by intervening cognitive decision-making processes that include, but are not limited to, affective as well as automatic and non-conscious information processing. Perhaps the most striking aspect of this framework is that it allows integration of such numerous and varied outcomes that individuals anticipate to occur as a result of alcohol consumption. Expectations of changes in aggressive behaviors, sexual arousal and disinhibition, as well as changes in overall sociability, can only be explained applying these kinds of models, as these effects are in direct opposition to alcohol's pharmacological effects of inhibition and sedation.

Of course, this information-processing perspective is most useful when conceptualized within a web of other (causal) variables in etiological models of alcohol use and not simply as a static description. Put another way, although cognitive variables can explain a considerable proportion of most behavioral outcomes of substance use, this is not to say that cognitive factors alone will ever provide a complete account of the complex phenomenon of drinking. Nonetheless, cognitive processes represent a critical domain for understanding the genesis and maintenance of alcohol problems, as none of the biological, psychological, or environmental risk variables by themselves, or combined together, are enough to explain the likelihood of drinking. Instead, their influence is exerted by passing through the information-processing "buffer", which mediates the effects of these distal variables on eventual substance use. Thus, as research on the etiology of alcoholism becomes increasingly informed by exploring those distal risk (or, in some cases, protective) factors, including research on behavior genetics, social development, decision making, stress and coping, and behavioral pharmacology, the information-processing or expectancy mechanisms can be viewed as a filter through which these distinct biopsychosocial factors exert their influences on actual drinking behavior.

Yet, even within this information-processing framework, there remain some puzzles, which cannot be addressed by traditional cognitive psychology methods, be they explicit or implicit. For instance, traditional cognitive tasks are inferior in exploring basic information-processing *mechanisms*, which give rise to or activate the alcohol-associated memory networks. Thus, there is a need in utilizing measures that allow making inferences about the mechanisms behind the differential behavioral outcomes observed in heavier vs. lighter drinkers. Recent advances in cognitive neuroscience methodology are promising in providing further insight into the information-processing operations underlying the construct of alcohol expectancies. In particular, this investigation proposes applying the event-related potentials (ERPs) research paradigm to examine the cognitive processes associated with alcohol.

Event-Related Potentials (ERPs) as an Index of Information-Processing Mechanisms

Event-related potentials (ERPs) are aspects of electrical activity of the brain occurring in response to discrete external or internal events (e.g., sensory stimuli and/or cognitive events) and are regarded as manifestations of information processing activities (for review, see Fabiani, Gratton, & Coles, 2000). ERPs are extracted from the ongoing brain's electrical activity (as recorded by electroencephalogram, or EEG) by averaging the waveforms in response to a repeated occurrence of a particular event, to reduce the effect of nonevent-related, spontaneous EEG (i.e., background noise). That is, by averaging out the ongoing electrical activity (which is not assumed to have a temporal relationship to such events), the remaining ERP waveforms, time-locked to the specific event, are thought to reflect the effects of the particular information processing induced by the eliciting event (e.g., presentation of a stimulus or the occurrence of a response). Overall, the ERPs are smaller in voltage (a few microvolts) than the EEG (about 50 microvolts), which is another reason for averaging over many trials, allowing for the ERP patterns to be clearly seen. From the neurophysiological perspective, the ERPs are thought to represent summed postsynaptic potentials generated by large populations of neurons[*] acting (either in excitation or inhibition) in synchrony, in response to a given event that requires sensory or cognitive processing, so that they produce a potential recordable at the scalp. In general, these time-locked voltage changes in the EEG (i.e., positive and negative deflections of the ERP brainwaves in response to an event) are referred to as ERP components. An ERP component is assumed to have a functional significance, as changes in its amplitude are thought to reflect specific intracranial activity invoked to serve a specific information processing function (Donchin & Coles, 1988).

Basic sensory processing (e.g., visual or auditory), as well as some higher cognitive processes (e.g., visual attention), are associated with unique components in the

[*] Which of the more than 10 billion neurons in the human brain actually produce EEG has been long debated. There is some evidence to suggest that the EEG is generated by pyramidal cells in layers IV and V of the cortex.

event-related waveform. These components traditionally are labeled according to their polarity (positive peak or negative peak) and timing with respect to the eliciting event, either in order of appearance (e.g., P1, P2, P3) or in milliseconds (e.g., N200, P300). The average waveforms can be compared across multiple stimulus types or cognitive events, and/or across experimental groups or conditions, and then analyzed for changes in the amplitude or latency of these identified components, according to specific hypotheses.

Early ERP components, with a latency of less than 100 ms, reflect basic sensory processing, while later components reflect higher cognitive functions, such as attention, semantic processing, and error monitoring, among others. There are numerous reports in the literature that have employed both early sensory, and late event-related potentials in order to assess chronic and/or acute effects of alcohol, which will be briefly reviewed below. The present investigation, however, is restricted to the examination of those ERP components that have proved significant in the study of decision-making processes associated with alcohol use.

An important characteristic that makes the ERP methodology valuable in studying alcohol-related cognitions is that ERPs allow the on-line analysis of cognitive processing with a temporal resolution in the range of milliseconds. In other words, ERPs provide a very fine scale for determining the timing and temporal sequencing of particular neural events underlying cognitive processing[*]. Therefore, ERPs would be a useful probe of mechanism of expectancy as it evolves online. Moreover, several ERP components are

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[*] It is important to keep in mind that the scalp-recorded ERPs provide only superficial clues concerning where the neural activity underlying the information processing originated in the brain. This is referred to as the inverse problem: For any given distribution of EEG activity on the scalp, there are multiple, equally plausible combinations of neural sources superimposed on each other that might generate the same pattern of the scalp-recorded data.

known to be sensitive to expectancy and especially to deviations from the expected (i.e., expectancy violations). The P300 ERP component, in particular, is the most appropriate component for the present investigation as it is elicited in response to task-relevant, deviant stimuli that violate subjective expectancies.

P300 ERP Component as an Index of Expectancy Violation

In 1965, Sutton, Braren, Zubin and John were the first to report on a positive-going ERP component with a peak latency of approximately 300 ms after stimulus onset and with maximum amplitudes over centro-parietal scalp sites. A substantial amount of subsequent research elaborated on the conditions that modulate both the amplitude and latency of this "P300" component[*] (see Picton, 1992, for a review). It is commonly elicited using an "oddball" task in which two stimuli repeatedly occur with different (but complimentary) probabilities in a random order. The subject is asked to pay attention (by counting or responding in some other fashion) to the infrequent stimulus. The amplitude of the P300 response to the infrequent stimulus is thought to reflect the allocation of attentional resources toward the processing of the rare event. Briefly, the amplitude of the P300 tends to increase as a function of at least two variables: declining stimulus probability (e.g., Duncan-Johnson & Donchin, 1977) and increasing task relevance or value (e.g., Johnson, 1986).

More importantly for the present line of research, an extensive body of literature supports the earlier proposition (Horst, Johnson, & Donchin, 1980) that P300 amplitude is proportional to the *subjective*, and not objective, probability of an event (for reviews,

[*] Also sometimes referred to as the P3 component.

see Donchin & Coles, 1988; Dien, Spencer, & Donchin, 2003). Specifically, Horst et al. (1980) found that, when participants were asked to indicate how confident they were that their response on a given task was correct, the largest P300 was elicited when participants either believed they were wrong and turned out to be correct, or when they believed they were correct and turned out to be wrong. In other words, the individual's subjective probability associated with an event (i.e., *expectancy*) is as critical as the objective features of the event in eliciting P300. For example, a larger P300 is observed when a person unexpectedly hears his or her name, embedded among other words (Berlad & Pratt, 1995), suggesting that it is the stimulus' subjective relevance, rather than its objective frequency in lexicon (which was controlled for by using similar names of other people), that has an effect on P300 amplitude. These findings underscore that, having been "filtered by subjects' perceptual biases and tainted by an individual's predilections" (Horst et al., 1980; p. 484), the subjective probability or *expectancy* associated with an event needs not accurately reflect the objective probabilities with which this event occurs. But it is the former, rather than the latter, that is responsible for the changes in the P300 amplitude.

Hence, because P300 responds to subjective probabilities, it can be used to assess expectations specific to individuals. According to the context-updating hypothesis (Donchin, 1981; Donchin & Coles, 1988), unexpected events interrupt ongoing cognitive processing and cause the individual to revise the current model of the environment. Thus, P300 is thought to reflect a ubiquitous process by which working memory is updated: Events that require the most significant updating (low probability, meaningful events) are those that generate the largest P300. Moreover, as some events might be expected to take longer to integrate into working memory (e.g., more complex stimuli), the time course of the context update process is reflected in the latency of the P300.

It is just this relationship between unexpectedness within a given context and the P300 component that makes the P300 paradigm a useful tool for investigating actual expectancy operation as it evolves on-line. Moreover, it is one of the major theses of this investigation that both P300 and alcohol expectancy research face similar theoretical questions. Specifically, as articulated by Goldman (1999; 2002), expectancies, in a broad sense, represent patterns or templates of information regarding some systematic relationship between contextual cues and outcomes. This information is stored in memory and serves to help the organism to deal (usually) more efficiently with new situations that are similar to the ones previously experienced. As new information is perceived by the organism, it is constantly compared to existing information templates (i.e., expectancies). This comparison allows the organism to anticipate, organize, and interpret the upcoming events and adjust its behaviors accordingly. In other words, the brain, where these processes presumably take place, serves as an “anticipatory machine” (Dennett, 1991). This view is in almost perfect concert with Donchin’s context update hypothesis, according to which surprising or unexpected events interrupt ongoing cognitive processing and trigger an instantaneous revision of the current representation of the environment. In other words, the context update model of the P300 suggests that the human brain is sensitive to discrepant or deviant events that violate a person’s expectations based on the operating memory networks activated by a particular context. The key component in eliciting the P300 is establishing that context (either by experimental manipulations or by identifying an individual’s unique, ‘internal’ context based on his/her personalized experiences) and presenting events, which are deviant or unexpected within this established context. Similarly, as elaborated above, alcohol-consistent contexts have been shown to be integral in activating alcohol-related memories (including alcohol expectancies) and in driving actual consumption. This common theoretical ground strongly suggests applying the paradigm used for eliciting P300 to investigate alcohol expectancies as they evolve on-line. Thus, the present investigation set out to use the P300 research paradigm to examine individual differences in processing of the alcohol-related cues by indexing the brain's electrophysiological response to subjectively unexpected stimuli.

Previous Studies on P300 and Alcohol

Studies over the last few decades have found attenuation in the P300 amplitude in chronic alcoholics (Begleiter, Porjesz, Bihari & Kissin, 1987). More recent studies have indicated that low P300 amplitudes are not only present in male alcoholics, but are also apparent in female alcoholics, although not to the same extent as in males (Porjesz et al., 1996). Additionally, the P300 amplitude decrements in alcoholics appear to not recover with prolonged abstinence (Porjesz & Begleiter, 1985). Moreover, Begleiter, Porjesz, Bihari and Kissin (1984) reported that young boys at high risk of developing alcoholism (*CoAs*, or children of alcoholics) manifested significantly lower P300 voltages compared with matched low-risk boys coming from control families without first- or second-degree alcoholic relatives (see also review by Polich, Pollock, & Bloom, 1994).

These findings were taken to mean that the decreased P300 amplitude was a phenotypic "trait" marker for alcoholism (for review, see Porjesz et al., 2005). The proponents of this view implicate that the reduced P300 in offspring at risk, prior to alcohol exposure, indicates inefficient allocation of resources during neural processing, which, in turn, may be involved in genetic predisposition toward the development of alcohol dependence and related disorders. In other words, the P300 is viewed as an index of cognitive inefficiency associated with alcohol abuse, and as such – as a marker of risk (Porjesz & Begleiter, 1996), and is further suggested to be used as an endophenotype for genetic studies (Porjesz et al., 2005). Yet, the review of the literature reveals much more scarce account of cognitive processes associated with alcohol consumption in a wider, non-pathological, population of so-called social drinkers, who represent a much larger part of the general population relative to individuals who develop alcohol-related disorders (SAMHSA, 2004). It is this normative, rather than pathological, drinking behavior that is focus of the present investigation. Moreover, the current project seeks to answer a question fundamentally different from the ones raised by the previous research in the field: namely, all previous applications of the P300 paradigm to the alcohol domain were done in the interest of empirically identifying "biological markers" of risk for developing alcoholism and its heritability, rather than in the interest of testing or probing a cognitive theory. The current investigation, however, is driven by testing a cognitive theory, namely alcohol expectancy theory, which makes predictions about the variance of the variety of variables (as reviewed above), one of which is the P300 amplitude.

Furthermore, although the ERP methodology, especially the P300 paradigm, is widely used in the field of alcohol research, virtually all of the existing ERP research in the alcohol field has focused on "cold cognition" tasks, that is, tasks that do not provide a context relevant to the behavioral phenomenon in question (i.e., alcohol use and/or misuse).[*] Virtually all previous P300 research in the alcohol domain has included simple (visual or auditory) stimuli evaluation, stimulus discrimination and target-selection tasks. The most frequently used task to this day in this field is a visual head-orientation task developed by Begleiter and colleagues (1984); this task consists of simple geometric drawings, where the participants are asked to discriminate between the less frequent stylized head-like figure (an oval with two attached triangles symbolizing the nose and one ear), rotated in different positions, and the more frequent plain oval (of the same size, with no triangles attached). From this "cold cognition" task, Begleiter and his colleagues induced that individuals with alcohol-related problems exhibit flattened P300 amplitude, which in turn was interpreted as a "marker" for alcohol-related problems. Several additional groups have repeatedly used this task (e.g., Bauer & Hesselbrock, 1999; Hill & Steinhauer, 1993; Malone, Iacono, & McGue, 2001). Other investigators have used yet other "cold" perceptual discrimination tasks, involving simple tones of different frequency (e.g., Marinkovic, Halgren, & Maltzman, 2001), light stimuli of different intensities (e.g., Polich, Haier, Buchsbaum, & Bloom, 1988), or lines of different orientation (e.g., Holguin, Porjesz, Chorlian, Polich, & Begleiter, 2001). It is evident that these experimental stimuli do not require involvement of affect-laden, motivationally

[*] An artificial, but useful for the present discussion purposes, distinction can be made between what is referred to as "cold" aspects of cognition and so-called "hot" cognitive processes. Cold cognition refers to the traditional subject of pure cognitive psychology research, namely to the information processing of relatively abstract, ecologically-irrelevant concepts or decontextualized problem-solving, which neuroanatomically is associated with dorsolateral prefrontal cortex. On the other hand, "hot" cognition refers to the kind of cognitive operations the humans employ when making their daily decisions in the real world, outside of the research laboratory (e.g., a decision to press on gas when the traffic light changes to red or a decision to have another drink at a party). Thus, the concept of "hot" cognition reflects the affective aspects of the human information-processing, involving decision making about the events that have emotionally significant consequences (i.e., meaningful rewards and/or losses), which in turn entails the regulation of affect. These aspects of cognition are typically associated with orbitofrontal cortex.

relevant processes (also referred to as *hot cognitions*) of the kind people employ when making their daily decisions, including the decision to have a drink, nor are these stimuli even remotely relevant or pertinent to the kind of information processing mechanisms addiction researchers are ultimately interested in.

Hence, relatively little research has focused on the processing of complex, real-life, socially-loaded information associated with alcohol. To place this hot cognition hypothesis in perspective, classical semantic priming studies have shown that behavioral responses to a target word are faster when that word is primed by related, associated concepts. Applications of this priming paradigm to the study of affective impact of stimuli demonstrated that words can automatically activate not only semantic, but also affective associations (e.g., Bargh, 1997). These findings allowed extending the affective priming paradigm into such "hot" areas of inquiry as social or political attitudes and emotional research. For instance, Cacioppo and colleagues (e.g., Cacioppo, Crites, Berntson, & Coles, 1993; Cacioppo, Crites, & Gardner, 1996) showed that evaluative inconsistency between a primed category and a stimulus word (e.g., a positive attitude word following a negative prime) elicits a large late positive ERP component approximately 300 to 600 ms post stimulus presentation. Osterhout, Bersick, and McLaughlin (1997) found that sentences with pronouns implying violations of gender stereotypes (e.g., "The doctor prepared *herself* for the operation") elicited a larger positive potential than sentences with stereotype-consistent pronouns. Furthermore, the positive wave elicited by stereotype violations persisted even when participants judged these sentences to be acceptable (which also attests to the automatic, non-deliberate nature of the information processing mechanisms indexed by the ERPs). However, this notion of applying ecologically valid and emotionally salient stimuli, which activate wide-spread, “real-life” semantic networks, to the inquiry of alcohol-related cognitions has not been fully embraced in the alcohol research field. The present study seeks to bridge this gap by using highly relevant (alcohol-related) and cognitively complex stimuli resembling the types of information that drinkers process in real-life drinking situations.

An additional problem of the descriptive approach to studying alcohol abuse populations using ERPs (as exemplified by the studies reviewed above) has been a general lack of specificity of the findings. In particular, the flatter amplitude profile of P300 in chronic alcoholics, children of alcoholics, or individuals with positive family history described by Begleiter and his colleagues has been also found in a wide spectrum of psychopathological populations such as adolescents with conduct and oppositional-defiant disorders (Bauer & Hesselbrock, 1999; Carlson, Katsanis, Iacono, & Mertz, 1999), individuals with antisocial personality disorder (Bauer, O’Connor, & Hesselbrock, 1994), cocaine and heroin abusers without history of alcohol dependence (Branchey, Buydens-Branchey, & Horvath, 1993), individuals with schizophrenia (Jeon & Polich, 2003), first degree relatives belonging to families with two or more bipolar patients (Pierson, Jouvent, Quintin, Perez-Diaz, & LeBoyer, 2000), long-term cigarette smokers in comparison to never-smokers (Anokhin et al., 2000), and even individuals with low IQ (McGarry-Roberts, Stelmack, & Campbell, 1992). Therefore, these findings indicate that many psychopathological disorders or conditions have been indiscriminately associated with a smaller (and/or later) P300, which makes the association between reduced ERP amplitudes and alcohol abuse non-specific. Such lack of specificity greatly hinders the interpretation of the attenuated P300 as a potential risk factor for alcohol-related disorder.

The current investigation, on the other hand, sought to develop a task specific (and, optimistically, sensitive) to the alcohol-related cognitions, thought of as an information-processing "buffer" between the distal risk factors and ultimate drinking behavior, via carefully laying out the theoretical foundations for application of the P300 paradigm to the alcohol research, and by adjusting the stimuli to reflect "hot cognitions" relevant to the phenomenon of alcohol consumption.

Summary and Specific Predictions

The findings reviewed thus far suggest that the ERP methodology can be used to examine alcohol expectancies, which hitherto have been measured mostly through various self-report procedures. Such an investigation is an important step in elucidating the information processing operations underlying the concept of alcohol expectancies, which have been linked to the actual alcohol consumption patterns. As summarized above, there is strong evidence that individuals with differing drinking patterns also differ on the perceived effects of alcohol. Specifically, research to date suggests that heavier drinkers tend to endorse more positive and arousing effects of alcohol, while lighter drinkers tend to endorse more sedating and negative effects of alcohol. This study was set up to test the differential memory networks contents with ERP component known for its sensitivity to expectancy. Specifically, since the P300 component of the ERPs is sensitive to violation of *subjective* expectancies, it was hypothesized that the P300 amplitude elicited by stimuli describing various effects of alcohol would be inversely correlated with the degree to which an individual's subjective expectancies, as measured by self-report, matched the expectancies expressed by the stimuli presented in the P300 task. In other words, it was predicted that the arousing and positive effects of alcohol would elicit larger P300 in individuals who report low positive alcohol expectancies, while sedating and negative effects of alcohol would elicit larger P300 in individuals who report high positive alcohol expectancies.

The hypotheses were tested in a sample of typical, 4-year, college student population, which allows a glimpse into the age range which includes the lifetime drinking peak for many individuals (Schulenberg, O'Malley, Bachman, Wadsworth, & Johnston, 1996; Wechsler, Lee, Kuo, & Lee, 2000). Moreover, alcohol use trajectories for college students have been shown to differ dramatically during one year (Greenbaum, Del Boca, Darkers, Wang, & Goldman, 2005): for some individuals alcohol use patterns appear to be stable, for some it decreases, for others - accelerates, and yet for others the alcohol use depends on national, local and community events and holidays occurring during the calendar year. Hence, use of college-student sample offered a wide range of expectancies and corresponding drinking behaviors.

Method

Participants

Thirty participants were recruited from the University of South Florida. Students from all majors were allowed to participate in the study. Students recruited from psychology research pool (n = 25) were awarded 3 extra credit points in return for their participation. Students recruited from outside of the psychology department (n = 5) were paid $20 for their participation.

Only students who had some experience with alcohol were recruited. Individuals with no prior experience of alcohol consumption (i.e., with no subjective experience of alcohol effects) were excluded upon screening (n = 2). Based on the findings in the alcohol literature that expectancy level positively correlates with drinking level, it was expected that the heavier drinkers included in the study would exhibit higher (i.e., more positive and arousing) alcohol expectancies, while the lighter drinkers will exhibit lower (i.e., more negative and sedating) alcohol expectancies. Therefore, the recruitment was based on the participants' drinking level, although ultimately both expectancy and more accurate drinking data were collected at the time of the in-person assessment.

All participants were native English speakers, with normal or corrected-to-normal vision, with no known history of neurological disorder (e.g., seizure disorder or multiple sclerosis) or head injury (i.e., loss of consciousness > 5 min), which could affect the EEG quality. Also, participants were screened for any regular use of medications that might affect EEG signal (e.g., anxiolytics or neuroleptics), although none reported use of such medications.

Of the 30 participants, only 26 individuals had adequate electrophysiological data for the Expectancy Violation task, due to the stringent EEG artifact criteria described below (see *Offline EEG data preprocessing* section). Since the number of trials per condition was low (due to the limited number of existing psychometrically-tested alcohol expectancy stimuli), including individuals with large artifacts on more than two or three trials per condition would have rendered the averaged waveforms uninterpretable. As a result, four individuals were excluded from the analyses of electrophysiological data on the expectancy violation task. Thus, the analyses of all behavioral (i.e., self-report) and standard oddball task data included all 30 participants, while the only 26 individuals were included in all the analyses involving data on expectancy violation task.

Materials

Demographic information (Appendix A). All participants provided demographic information including age, gender, ethnicity, education, and health status, particularly history of head injury, neurological disease, and regular medication use.

ERP stimuli (Appendix B). Stimuli for the alcohol expectancy violation task consisted of 70 English sentences. The sentences represented statements describing various habits or activities pertinent to the college students, including studying, spending time with peers, partying, drinking, smoking, exercising, etc. Each statement was missing the last word, e.g., “On a Friday night, alcohol makes me....” The last word (e.g., “happy”), presented on a separate screen, was one of the 32 alcohol expectancy words, describing possible outcome effects of alcohol consumption. These 32 targets words were chosen from the Alcohol Expectancy Multiaxial Assessment scale (AEMax), which comprises of 132 most common alcohol expectancy words derived by various item selection procedures from a large pool of responses to the prompt "Alcohol makes one…" and subsequently normed in large college student samples, as described by Goldman and Darkes (2004). All in all, there were 16 sentences related to alcohol, each repeated twice: once with a negative/sedating ending and at another time – with a positive/arousing ending (e.g., "Alcohol makes me… happy" vs. "Alcohol makes me… sad"), in a semi-random order. Another 8 sentences were structurally similar statements, but related to smoking (e.g., "Smoking makes me…sick"), with 8 positive and 8 negative endings, thus making up 16 smoking items. These statements were borrowed from the Smoking Consequences Questionnaire (SCQ; Copeland, Brandon, & Quinn, 1995). Yet another 12 sentences were composed with other, non-alcohol or non-smoking content, such as exercising or studying (e.g., "After a workout at the gym, I always feel …exhausted"). Pilot data showed that these sentences generally elicited agreement and as such they served as fillers between the alcohol and smoking items. They were also intended as control/neutral condition for the ERP comparison. Finally, 10 classic N400-eliciting sentences (e.g., "I drink my coffee with sugar and…socks") were included in order to control for participants' attention to the task.[*] Based on the extensive literature (for review see Kutas, 1997), these 10 sentences were expected to invariably elicit N400

[*] The N400 component, originally described by Kutas and Hillyard in 1980, is a relative negativity which occurs approximately 400 ms after the onset of a word that is incongruent with the semantic context of the sentence (e.g., "I drink my coffee with sugar and…*socks*").

in all (attentive to the task) participants. As such, they served as an individual control for the students' full participation in the task.

In sum, the 70 sentences made up 6 experimental conditions: Alcohol-Positive/Arousing, Alcohol-Negative/Sedating, Smoking/Positive, Smoking/Negative, Incongruent, and Other – a baseline condition compiled of 12 neutral sentences, against which the remaining 5 conditions were compared (see Appendix B). As follows from the preceding description of the breakup of the sentences by condition, the number of trials per condition was not equal. The two main conditions of interest – Alcohol-Positive/Arousing and Alcohol-Negative/Sedating – had the largest number of items (16 in each) to assure a sufficient number of trials for a proper signal-to-noise ratio, while other conditions had between 8 to 12 items, which was still an adequate number of trials for averaging (given the very few motion and/or ocular artifacts achieved through thorough training of the participants during practice trials to sit still and withhold blinking for the duration of the target word presentation). A P300 amplitude elicited by Alcohol-Positive/Arousing and Alcohol-Negative/Sedating stimuli served as the main outcome measure.

Alcohol Expectancy Questionnaire (*AEQ; Appendix C*). The AEQ (Brown, Goldman, Inn, & Anderson, 1980; Brown, Christiansen & Goldman, 1987) is a 68-item forced choice (True/False format) questionnaire designed to measure individuals' beliefs about outcomes of alcohol use, including alcohol effects in social, physical and sexual domains. Reliability and predictive validity of the AEQ are well established (Goldman et al., 1991; Goldman, Greenbaum & Darkes, 1997); the AEQ has been consistently among the strongest predictors of alcohol use (both frequency and quantity), alcohol abuse and other, non-consumptive behaviors while drinking. The AEQ produces a general second-order alcohol expectancy factor and six unique factors (subscales): Global Positive Changes, Sexual Enhancement, Social/Physical Pleasure, Social Assertiveness, Relaxation, and Arousal/Aggression (Goldman, et al., 1997). Among the unique factors, Global Positive Changes and Social/Physical Pleasure are the strongest predictors of alcohol use for college student drinkers. Thus, the scores on these two subscales were calculated and served as predictors.

Alcohol Expectancy Multi-Axial Assessment (*AEMax; Appendix D*). AEMax (Goldman & Darkes, 2004) utilizes a comprehensive list of expectancy words with the intent to capture the entire range of alcohol expectancies*. The expectancy terms were originally generated in a study where college student drinkers and alcoholics in treatment completed the open-ended sentence "Alcohol makes one…" (Rather, Goldman, Roehrich & Brannick, 1992). Applying various data reduction techniques, a total of 132 items were selected out of 805 items collected (primarily adjectives). These 132 words represent a multidimensional network of alcohol expectancies, falling in a circular pattern around arousal and valence axes. Factor analysis on these items revealed three second-order distinct factors, namely Positive/Arousing, Sedating and Negative (Goldman & Darkes, 2004). Among these three higher-order factors, the Positive/Arousing factor most strongly predicted alcohol use one year later, using a structural equation modeling, accounting for 45% of the variance in drinking. The shortened version of this measure, employed in this study, includes 24 expectancy items, eight from each of the three

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* Notably, the AEQ items encompass mostly the positive/arousing dimension of the alcohol expectancies; thus, the AEMax was added as a second paper-and-pencil measure of alcohol expectancies because it assesses a broader range of alcohol effect expectations, namely both positive and negative outcomes of alcohol use.

second-order factors. Participants are asked to rate the frequency with which they expect drinking alcohol to result in each of the 24 alcohol effects, using a 7-point Likert scale ranging from 0 = never to 6 = always. The scores on the three aforementioned factors were calculated and served as predictors.

Pattern of alcohol use (Appendix E). Participants were asked to report the frequency and quantity of their typical alcohol use as well as the number of occasions on which they become drunk from alcohol, in the past year. These three items were used to create a composite score of Total Alcohol Involvement (sum of the 3 items). Regarding the veracity of self-reports, when inquiries are made about sensitive personal information such as alcohol consumption (especially in participants under the legal age of 21), reviews of the relevant literature indicate that verbal reports can provide reliable and valid information, especially under circumstances in which there are no obvious incentives to under- or over-report (see Babor, Brown, & Del Boca, 1990; Del Boca & Noll, 2000).

30-day Timeline Follow-Back (TLFB). This calendar-based interview (Sobell & Sobell, 1992) was designed to obtain a thorough assessment of past alcohol consumption (both quantity and frequency). Participants were asked to provide retrospective estimates of their drinking (in number of standard drinks) consumed on each day over the previous month (i.e., in the 30 days preceding the assessment day). Several memory aids were used to facilitate recall (e.g., customized calendar with key dates serving as anchors for reporting drinking, such as sporting events, important college dates, national holidays, as well as local festivals and events) and a standard drink conversion table was available during the interview. Although exact day-by-day precision cannot be assumed, the TLFB summary data (the total 30-days score) has been shown to have good psychometric characteristics with a variety of drinker groups (Sobell & Sobell, 1995; Tonigan, Miller, & Brown, 1997). Past research using this instrument has shown that individuals can provide reasonably accurate information about past drinking as far back as 3 months (e.g., Sobell, Sobell, Klajner, Pavan, & Basian, 1986), and high test-retest reliability has been demonstrated using the 90-day assessment window (Tonigan et al., 1997). While quantity and frequency measures are sensitive to the time-of-year peaks and lulls in drinking, such as holidays and exam periods (Greenbaum, Del Boca, Darkes, Wang, & Goldman, 2005), this interview was primarily used to measure a participant's typical drinking pattern. At the conclusion of the interview, participants were asked whether the data represented a typical drinking month. When the month was not reported as a typical, participants were asked as to whether the prior month showed a heavier or lighter drinking pattern. Data collected via TLFB allowed calculating Total number of drinks/month; Number of drinking occasions/month; Average number of drinks/occasion; and Highest number of drinks/occasion, all of which served as predictors.

Family history (FH; Appendix F). To control for possible influences of family history of alcoholism on the P300 amplitude (see Begleiter, Porjesz, Bihari, & Kissin, 1987), the family history information was obtained. The Family History Grid, developed by the Collaborative Study on the Genetics of Alcoholism (COGA), is a semi-structured interview, which assesses the prevalence of alcohol problems (i.e., legal, health, relationship, work or school problems), current or lifetime, among the respondent's first-degree relatives (including, grandparents, parents, aunts and uncles and siblings).

Responses to these items allow for computation of a “density” measure of genetic predisposition to alcoholism. Additionally, participants can be classified into Family History positive (FH+) and Family History negative (FH–) categories (Andreasen, Endicott, Spitzer, & Winokur, 1977).

Procedure

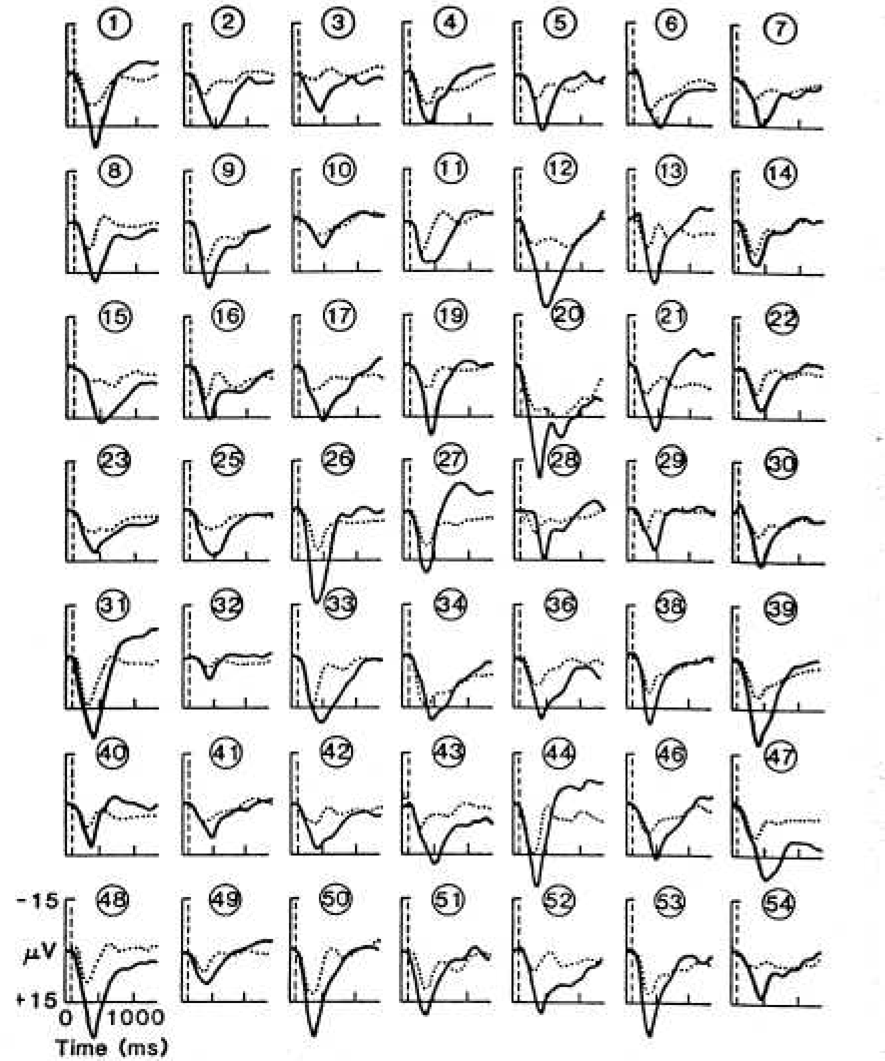
Participants were recruited from the undergraduate research participation pool at the University of South Florida, and via advertisements and fliers around the campus. Advertisements promoted a study in which individuals would be presented with numerous statements regarding various habits, activities, and beliefs while their brainwaves being recorded. All individuals interested in participating were screened over the telephone to determine eligibility status, based on the inclusion criteria detailed above (see *Participants* section). None reported a major medical condition or a history of substance abuse treatment that would preclude them from participating. Eligible participants attended a one-time, hour and a half long, laboratory study.

At the conclusion of the telephone screening interview, eligible participants were asked to adhere to a pre-experimental protocol that included refraining from any alcohol or nonprescription drugs use for 24 hr prior to their appointment, sleeping well on the previous night (for at least six hours), eating a light meal 4-6 hr prior to their appointment, and refraining from strenuous physical exercise within 3 hr of their appointment. Upon arrival at the lab, participants read and signed an approved Informed Consent document. The Informed Consent provided information regarding confidentiality, benefits and risks of participating in research, and storage of data. After signing the consent form, they were asked to fill out the Demographic Information Form, to confirm the screening data pertaining to their health status collected during the telephone interview.

Following application of the sensor net (a more detailed description is provided in the *EEG data acquisition* section), participants were seated in a sound-attenuated room at a distance of 70 cm from a display monitor. First, a standard “oddball” task was administered, when participants were instructed to respond (key press) each time they saw the specified target letter (either an “X” or an “O”, depending on a set, counterbalanced across participants), and to refrain from responding when the non-target stimulus occurred. The non-target, or the standard, stimulus was presented at random with a probability of .80 and the target was presented at a probability of .20. Each stimulus was presented for 600 ms and the intra-stimulus-interval (ISI) was set to 1000 ms. There were a total of 200 trials. This task served as a baseline for the participant’s individual response (amplitude and latency of which can be quite variable[*]) to a standard oddball sequence, as well as a potential index of the general cognitive differences previously observed between at-risk and low-risk drinkers.

[*] There is a normative individual variation in both amplitude and latency of the scalp-recorded P300 due to other than experimentally controlled variables, including such factors as scalp thickness and shape, which influence how the brain activity is distributed on the scalp; arousal-related "biological determinants" (Polich & Kok, 1995), such as body temperature, ultradian and circadian cycles, and even hormonal fluctuations; as well as individual differences in neural circuitry of attention, in cognitive factors such as mental speed of processing, and even in personality, as measured by the big five traits (Stelmack, Houlihan, & McGarry-Roberts, 1993). Figure 1, borrowed from Fabiani, Gratton, Karis, & Donchin (1987), clearly demonstrates these individual variations in P300 across subjects: While the P300 component is readily visible in all waveforms, it is evident that there is substantial variance in amplitude, morphology/shape and latency of the individual waveforms.

Figure 1. Averaged Pz waveforms of 54 individual subjects for rare (20%, solid line) and frequent (80%, dashed line) stimuli in a standard oddball task. Dashed vertical lines mark stimulus onset. Positive voltages are plotted as downward deflections.
The Figure is borrowed from Fabiani, Gratton, Karis, & Donchin (1987).

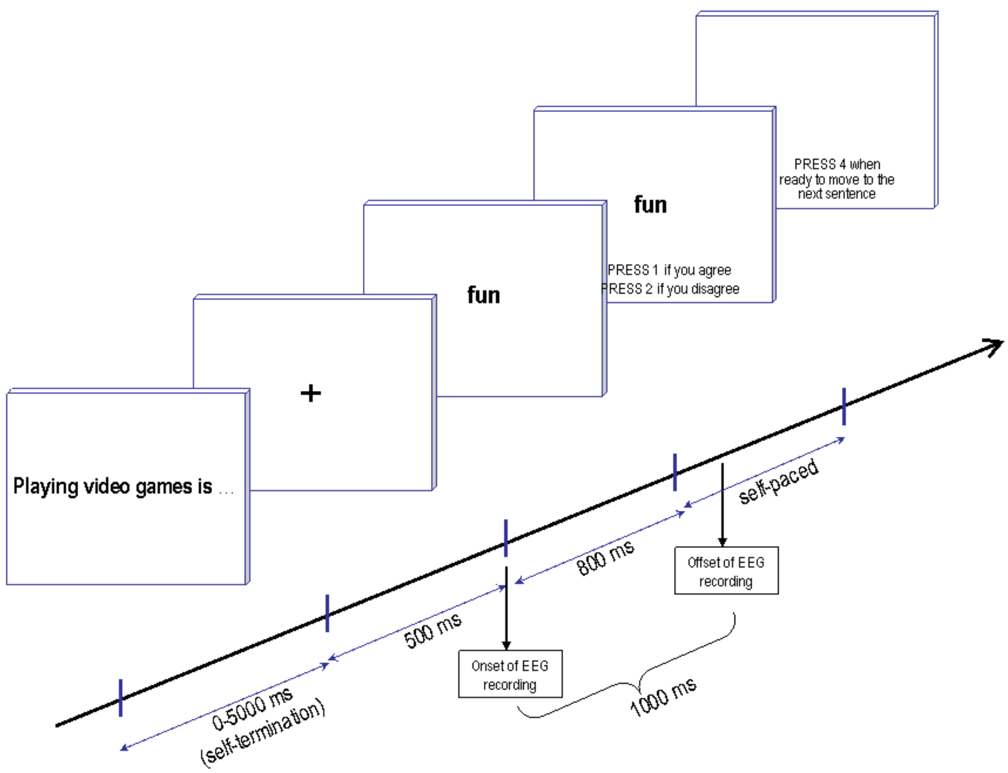


After completion of the standard oddball task, participants were given a 5-minute break during which the electrode impedances were examined again, and adjusted as needed. Subsequently, the alcohol expectancy violation task was administered.

Participants were informed that the task would involve rating some daily activities and habits while their brainwaves are being recorded. The specific aim of measuring the participants' alcohol expectancies was not disclosed until after conclusion of the experiment.

As described in details in the *Materials* section, participants were presented with a series of statements describing various habits or activities consistent with the college students' life-style, including studying for exams, spending time with peers, exercising, partying, drinking, smoking, etc. Each statement was missing the last word, e.g., "On a Friday night, alcohol makes me...." Participants were instructed to press a key on a response box to move to the next screen to see the missing word (e.g., "happy"), preceded by a fixation point. A fixation point ('+' symbol) appeared for 500 ms, followed by the last (missing) word of the sentence presented for 800 ms. Target (last word) onset was synchronized with the onset of ERP recording, with the recoding epoch lasting for 1000 ms. At the offset of the target word (to prevent any motor response during the 800 ms of target presentation) participants were asked to perform a judgment task (Do you agree/disagree with the statement?), using one of the two buttons on a response box to indicate their response. They were instructed to make their response as soon as the target word disappeared from the screen. Reaction times of this response were also measured and recorded by the software alongside the electrophysiological signals. After the participant's response, there was a 2000-ms inter-trial interval, followed by the next statement. Participants could start each trial at their own pace by pressing a button on the response box. To minimize eye and movement artifacts, participants were asked to relax as much as possible, to make no excessive movements and to not blink during the presentation of the target word (i.e., the last word of each sentence). The latter was achieved during the practice block, by practicing withholding the blinks each time a fixation point, which preceded the appearance of the target word, appeared on the screen. Figure 2 shows schematics of the sequence of the experimental paradigm.

Figure 2. Experimental sequence for the Expectancy Violation Task.



The alcohol expectancy violation task began with a practice block, during which no ERPs were recorded. Ten practice sentences were presented to familiarize participants with the task and response options prior to beginning of the ERP recording session. The experimenter guided the participants throughout the practice block. Following practice, experimental stimuli were presented in one block of 70 semi-randomized sentences (no two statements from the same category – alcohol, smoking, etc. – were allowed to appear in a row; and no more than two statements of the same valence – e.g., positive alcohol expectancy – could follow each other, even if separated by filler items). The trial order is presented in Appendix 1. All participants were presented with the same trial list. The stimuli were presented in white letters, in Courier New font, 22 dots-per-inch, on a black background. All letters were lowercase, except for the first letter of each sentence. The ERP portion of the experiment, including net application and the recording session, lasted approximately 30-45 minutes.

Following the ERP task, participants had the recording equipment removed and were led into another room where they were asked to complete several questionnaires and interviews, measuring their alcohol use patterns and expectancy levels. Specifically, AEQ, AEMax, Pattern of Alcohol Use questionnaire, TLFB and Family History Interview were administered, in this order. This portion of the experiment lasted approximately 30 minutes, bringing the total time spent in the lab to 60-75 minutes. Upon completion of questionnaires and interviews, participants were debriefed regarding the purpose of the study and were given the option to ask further questions.

Apparatus

Stimulus presentation. For both oddball and expectancy violation tasks, stimulus delivery and the recording of overt responses (reaction time and accuracy) were controlled by E-prime software provided by Psychology Software Tools (PST; www.pstnet.com), in combination with the PST serial response box.

EEG data acquisition. EEG data were recorded with the 128-channel Geodesic Sensor Net (Tucker, 1993). The Geodesic Sensor Net consists of a geometric tension structure stabilizing a dense array of plastic wires holding sponge Ag/AgCl sensors. The Net allows rapid, comfortable applications (requiring 15-20 minutes, including impedance testing) and provides an improved spatial sampling (in comparison to 32- or 64-channel nets). All electrode impedances were kept at 50 kΩ or below (Ferree, Luu, Russell, & Tucker, 2001). During signal collection, each electrode was referenced to the Cz (vertex) site. Data were sampled at a rate of 250 per second, and filtered with a 0.1-40 Hz bandpass filter and 60 Hz notch filter.

EEG data analyses. EEG data were recorded using NetStation 4.0, an EEG recording system provided by Electrical Geodesics, Inc. (EGI; www.egi.com). All offline processing was performed using the EGI's Analysis Tools included in the NetStation package. PCA on the EEG data was performed using PCA Toolbox, a freely available open source toolbox (http://people.ku.edu/~jdien/downloads.html) running under Matlab (The Mathworks Inc.).

Statistical Analysis Overview

Off-line EEG data preprocessing. To eliminate extraneous noise, several standard offline signal processing operations were performed. EEG data were first digitally filtered with a 40-Hz lowpass filter* and segmented into epochs starting 100 ms prior to stimulus onset to 1000 ms following stimulus onset. These raw EEG epochs were then subjected to automated artifact detection (based on the artifact criterion of amplitudes of more than 70 μV in any one of the channels), corrected for vertical and horizontal eye movements (Gratton, Coles, & Donchin, 1983), and baseline-corrected using the average of the 100-ms pre-stimulus epoch (to correct for differences in starting voltage). The artifact-free trials were then averaged separately for each experimental condition, so that 6 separate average waveforms (i.e., Alcohol-Positive/Arousing, Alcohol-Negative/Sedating, Smoking/Positive, Smoking/Negative, Incongruent, and Other) were obtained for each participant. That is, more precisely, for each participant 6 average ERP waveforms were generated at each of the 128 electrode sites. The oddball task data were subjected to similar sequence of processing steps, ultimately generating two separate average waveforms for rare (target) and frequent (standard) conditions for each participant.

Finally, the averaged data were re-referenced to a mean-mastoid reference. This procedure generates a 129th channel of mathematically linked reference recorded

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* Filtering operation is intended to filter out activity in frequencies that are not of interest, including other (than brain's) naturally occurring in the body electrical activity, such as muscle activity, which ranges between 20 Hz and 200 Hz in frequency, or other extraneous activity, such as 60-Hz electric fields associated with power current. Traditional ERP research has focused on brain activity in frequencies below 30 or 40 Hz.

separately from the ear lobes (i.e., mastoids). All analyses reported below used the resulting 129-channel data.

PCA: Extracting the ERP components. As a result of the pre-processing sequence described above, 6 ERP waveforms – one for each condition – were generated for each participant, in each of the 129 electrodes. Before analyzing these waveforms for presence or absence of the hypothesized P300, an important distinction needs to be made between an ERP *component*, on the one hand, and a *peak* or *deflection* in the waveform, on the other hand. In contrast to a peak or deflection, the term component should be reserved to denote a *theoretical construct* rather than an observed waveform. This theoretical entity is believed to represent "some essential physiological, psychological or hypothetical construct whose properties are under study" (Donchin et al., 1977, p. 10). The confusion between the observational and theoretical definitions can be easily illustrated by an instance when the theoretical P300 may observationally appear as "P400" (i.e., with latency of 400 msec) or even "P600", perhaps due to the complexity of the task. Thus, the method of "*peak peaking*" (i.e., measuring the largest peak amplitude in a predefined time window) as a way to measure ERP components is considered faulty, due to at least three factors: first, selecting the time interval at which to *peak the peak* can be misled by intra- and inter-subject individual variations as well as by experimenter's biases; second, selecting a priori one of the 128 electrode sites at which to *peak the peak* can be difficult; third, peak detection is likely to be confounded by the fact that most ERP components overlap in time and space (for instance, N400 and P300 have similar scalp distribution and vary in overlapping time windows, so that it is almost impossible to define where the positivity of the P300 ends and the negativity of the N400 begins).

Moreover, most everyone in the field agrees with the notion most clearly expressed by Donchin, Ritter, and McCallum (1978) that in addition to the component latency and scalp distribution, the theoretical definition of ERP component must also be based on its function – that is, its response to experimental variables. Hence, the components need to be defined not on the basis of peaks or troughs in the waveform but on the basis of experimental variation, or using the motto of Donchin and his colleagues: “All we can study is that which varies” (Donchin et al., 1978, p. 354).

An alternative to measuring pre-defined peaks and troughs in the ERP waveform has been proposed by Donchin and Heffley in 1978. These authors advocated using principal components analysis (PCA) as an aid to infer existence of theoretical components from observed waveforms. PCA is one of the techniques in a class of factor-analytic procedures, which are intended to describe the complex relations between a large number of variables in terms of a smaller number of hypothetical, unobserved, *latent* variables. PCA differs from other factor-analytic techniques in that the factors extracted (termed principal components) are closely related to the original dependent variables, which is not necessarily so in other techniques. In PCA, each principal component is simply a weighted linear combination of all the original dependent variables, and, theoretically, as many principal components may be extracted as there are dependent variables. In ERP data, the variables are the microvolt readings either at each electrode (hence, the *spatial* PCA) or at each consecutive time point (hence, the *temporal* PCA). The major source of the covariance between these variables is assumed to be the ERP components. Furthermore, the principal components are extracted from the data set in a hierarchical fashion: The first component accounts for the largest proportion of the variance in the data, and the successive components must be both orthogonal to the preceding ones and account for the largest portion of the residual variance. For typical ERP data, this percentage drops off rapidly after the first five or six components, which usually account for 90–95% of the variance in the data.

In sum, PCA of ERP data serves simultaneously several functions. First, it is used to reduce the often enormous amount of data collected in typical high-density ERP datasets, prior to the statistical analysis of the data. In other words, by reducing hundreds of variables (e.g., for a 1000 msec of recorded EEG with 4 msec sampling rate, each participant has 250 time points X 129 electrodes X 6 conditions = 192,000 data points) to a handful of latent factors, PCA can assist with extracting the dependent variables (i.e., *true* ERP components), which then can be subjected to statistical analyses to test the experimenter's hypotheses. Clearly, this can greatly simplify analysis and description of the complex data. But more importantly from the theoretical point of view, applying PCA to the observed measurements recorded at the scalp provides insight into the unobserved, theoretical ERP components, which vary as a function of the experimental variables. A nice illustration of this principle was recently given by Spencer, Dien, and Donchin (2001), who made a distinction between the classical ("Suttonian") P300 and the Novelty-P300 based on the differential scalp distribution discerned by spatial PCA, a distinction which was otherwise opaque due to the very similar time course of these two components. Specifically, these authors demonstrated that by decomposing spatial variance in the ERP dataset, a previously overlooked dissociation between the separate components became apparent, as they were differentially affected by different experimental conditions.

Hence, PCA of the current ERP dataset was conducted to determine the componential structure of the observed ERP data and, specifically, to isolate the P300 component. First, to reduce the number of spatial dimensions of the data, a *spatial* PCA was conducted across averaged waveforms at each electrode site for all experimental conditions for each participant, with the electrode sites as variables. Such spatial PCA represents an attempt to identify clusters of electrodes that are so highly correlated that some of the electrodes can be considered redundant (Spencer, Dien, & Donchin, 2001). Accordingly, the PCA replaces the original 129 electrodes by a much smaller number of linear combinations of intercorrelated electrode sites, referred to as "spatial factors." Thus, in a spatial PCA, the variables are the microvolts measured at a given electrode channel, while the time points (across subjects and conditions) serve as observations or cases. Accordingly, for the alcohol expectancy violation task, the data matrix for the spatial PCA consisted of the voltage readings at each of the 129 electrodes (128 plus reference) by 35,100 observations: 225 time points (with 4 msec sampling rate, for the epoch of 0-900 msec post-stimulus) X 6 conditions X 26 participants.

After reducing the spatial dimensionality of the dataset to a set of spatial factors, a *temporal* PCA on the spatial factor scores was applied to reduce the temporal dimensionality. In this step, the spatial factor scores associated with the time points of the original dataset became the variables for the PCA, and the observations were the spatial factors (which replaced the electrodes) across participants and experimental conditions. Thus, the data matrix for the temporal PCA consisted of voltage readings at each of 225 time points by the number of the retained spatial factors X 6 conditions X 26 participants.

The resulting *spatiotemporal* factor scores (i.e., scores for a given spatial factor at a given temporal factor) were then examined across different experimental conditions and essentially served as dependent variables. Specifically, a combination of the spatial factor accounting for the most variance in the centro-parietal channels (corresponding to the well-established scalp distribution of P300) and the temporal factor accounting for the most variance in the window corresponding to the P300 latency (300-600 msec) was estimated to represent the P300 ERP component and was subjected to the following statistical analyses.

Statistical analyses of hypotheses. As stated above, the specific hypotheses of the study were that stimuli describing alcohol effects that are deviant from the participant's subjective set of alcohol expectancies would elicit a large P300. Specifically, it was predicted that, for individuals with high positive/arousing expectancies (i.e., heavier drinkers), statements describing negative/sedating effects of alcohol consumption would appear as unexpected or less congruent with their individual cognitive sets, and would thus elicit a large P300. Similarly, it was predicted that for individuals with high negative/sedating expectancies (i.e., lighter drinkers), positive/arousing expectancies would be less congruent with their individual cognitive schema associated with alcohol, and would thus elicit a large P300. Given the continuous nature of alcohol expectancy construct, the hypotheses were tested by calculating correlation coefficients between the P300 amplitude (i.e., spatiotemporal factor score corresponding to P300) in response to either Alcohol-Positive/Arousing or Alcohol-Negative/Sedating items, on one hand, and participants' scores on the verbally-based measures of alcohol expectancies (i.e., AEQ and AEMax), on the other hand. Additionally, correlations were calculated between the P300 amplitude and drinking variables, including frequency and quantity.

Results

Description of the sample. The sample included 19 males and 11 females.* Mean age of participants was 20.7 years (SD = 2.6) with a range of 18 to 28 years. The sample was primarily Caucasian (83%); 13% (n = 4) self-identified themselves as Hispanic, and 3% (n = 1) as of Mixed ethnicity. Participants ranged from light drinkers (four students, or 13% of the sample, reported consumption of one drink or less per drinking episode) to individuals who drank heavily by any definition (33%, or 10 individuals, reported consuming more than 5 drinks, and 10% consumed more than 8 drinks per drinking episode; 4 individuals reported drinking three times per week or more). Overall, alcohol consumption ranged from 1 to 179 standard drinks during the thirty days prior to each individual's participation in the study. Seven individuals (23% of the sample; all but one are males) reported a history of parental alcohol problems (in either or both biological parents) and 14 participants (47% of the sample; 11/14 are males) reported having at least one first-degree relative (including, but not limited to parents) with history of alcohol problems. Six participants (20% of the sample; 3 males and 3 females) were current smokers, nine (30% of the sample; 6/9 are males) were former smokers and the rest (15 or 50%) reported never having smoked.

* As described in the *Methods* section, there was no targeted recruitment by gender. Given that this was largely an exploratory study, and that there are no known gender effects on P300 amplitude or latency, the sample was not purposely balanced for males and females. However, given the gender differences with regards to alcohol consumption, gender was taken into consideration in most of the analyses and gender differences were tested when possible.

Questionnaire Data. Examination of the distributions of the self-report measures revealed lack of normality for most of the drinking variables, including frequency and quantity calculated from TLFB data. Drinking data distributions are notoriously non-normal by their very nature, and use of transformations has been a common analytical approach in this field. Based on the shape of the distribution (positively skewed, with most values concentrating at the lower end of distribution), natural log transformation was applied to all drinking measures (Tabachnick & Fidell, 2001). Additionally, a constant of 1 was added to avoid taking the log of zero, as the original distributions included some zero values for both monthly frequency and quantity measures. Therefore, the transformation of the data took the form of Ln (X + 1). The changes in the skewness and kurtosis of the drinking variables can be seen in Table 1.

Table 1.

Mean Scores and Normality indicators of Drinking-Related Variables, prior to and following Log transformation

Drinking Variable	*M (SD)*	*Skewness (SE)*	*Kurtosis (SE)*
Total Drinks/month	29.83 (41.89)	2.54 (.40)	6.76 (.78)
Total Drinks/month ^{ln}	2.68 (1.30)	-.09 (.40)	-.55 (.78)
Drinking Occasions/month	5.03 (4.11)	1.41 (.40)	1.43 .78)
Drinking Occasions/month ^{ln}	1.59 (.65)	.01 (.40)	-.03 (.78)
Average Quantity/Occasion	4.37 (2.93)	1.27 (.40)	1.80 .79)
Average Quantity/Occasion ^{ln}	1.55 (.53)	-.03 (.40)	-.48 (.79)
Highest Number of Drinks/Occasion	6.40 (5.87)	1.94 (.40)	3.97 (.78)
Highest Number of Drinks/Occasion ^{ln}	1.74 (.78)	-.11 (.40)	.16 (.78)

Pearson correlations among self-report measures of drinking and expectancies may be found in Table 2. As evident from the table, most of the scores on expectancy measures were strongly correlated with the alcohol consumption variables, consistent with the effects reported in the literature. For instance, Total number of Drinks/month was positively correlated with AEQ Global Positive Changes scale (r [30] = .55, p < .001), AEQ Social and Physical Pleasure Scale (r [30] = .60, p < .001) and AEMax Positive/Arousing factor (r [30] = .40, p < .05). Similar correlations were apparent between these expectancy scales and other drinking measures (see Table 2). Of note, as described in more details in the *Methods* section (under *Materials*), these two AEQ subscales and the AEMax Positive/Arousing factor have been each previously described as the strongest predictors of drinking, in comparison to other AEQ subscales and AEMax factors.

Additionally, as can be seen in Table 2, the Total Alcohol Involvement score, derived from 3 self-report items with 8 response options each (see Appendix E), had high positive correlations with all four drinking measures calculated from the TLFB calendar-based interview. This suggests that participants were consistent when providing estimates of their drinking patterns using these two forms of data collection. Thus, given this considerable overlap between the variables, only the TLFB-derived indices were used in future analyses, as they provide a richer dataset than the Total Alcohol Involvement composite score.

There were no significant differences between males and females on any of the self-report expectancy measures. However, the typically found gender differences on drinking variables were evident in this sample as well: Males reported drinking more drinks on an average occasion, and drinking more often than women (see Table 3).

Table 2.

Zero-Order Correlations between Selected Independent Variables

Measure	1	2	3	4	5	6	7	8
1. AEMaxPosAr								
2. AEMaxSed	.14							
3. AEQGloPos	.50**	.11						
4. AEQSoc	.43**	.18	.68***					
5. TotalDr ^{ln}	.40*	-.03	.55***	.60***				
6. DrinkOcc ^{ln}	.36*	.00	.56***	.58***	.95***			
7. AveQuant ^{ln}	.34	-.07	.43**	.52***	.92***	.75***		
8. HighestDr ^{ln}	.23	-.09	.38*	.52***	.92***	.80***	.96***	
9. TotalAlcInv	.47*	-.07	.51**	.48*	.85***	.74***	.79***	.82***

Note. AEMaxPosAr, AEMaxSed = AEMax: Positive Arousing factor, Sedating factor, respectively; AEQGloPos, AEQSoc = AEQ: Global Positive Changes scale, Social scale, respectively; TotalDr ^{ln} = Total number of standard drinks over the past 30 days, log-transformed; DrinkOcc ^{ln} = Number of drinking occasions over the past 30 days, log-transformed; AveQuant ^{ln} = Average number of standard drinks per drinking occasion, log-transformed; HighestDr ^{ln} = Highest number of standard drinks per drinking occasion, log-transformed; TotalAlcInv = Total Alcohol Involvement composite score.

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 3.

Mean Scores of Expectancy and Drinking-Related Variables by Gender

Variables	Gender	Mean	SD
AEMaxPosAr	Females	32.63	7.64
	Males	33.41	5.61
AEMaxNeg	Females	19.81	5.88
	Males	19.95	4.18
AEMaxSed	Females	30.94	7.76
	Males	28.05	6.10
AEQGloPos	Females	7.53	6.56
	Males	9.43	5.97
AEQSoc	Females	6.94	1.39
	Males	7.64	1.05
TotalDr ^{ln}	Females	2.19*	1.20
	Males	3.00	1.23
DrinkOcc ^{ln}	Females	1.39	.66
	Males	1.67	.64
AveQuant ^{ln}	Females	1.33**	.45
	Males	1.73	.52
HighestDr ^{ln}	Females	1.38**	.64
	Males	2.05	.65

Note. Means shown for drinking measures are of log-transformed variables. AEMaxPosAr, AEMAxNeg, AEMaxSed = AEMax: Positive Arousing factor, Negative factor, Sedating factor, respectively; AEQGloPos, AEQSoc = AEQ: Global Positive Changes scale, Social scale, respectively; TotalDr ^{ln} = Total number of standard drinks over the past 30 days, log-transformed; DrinkOcc ^{ln} = Number of drinking occasions over the past 30 days, log-transformed; AveQuant ^{ln} = Average number of standard drinks per drinking occasion, log-transformed; HighestDr ^{ln} = Highest number of standard drinks per drinking occasion, log-transformed.

$^{*}p < .05$; $^{**}p < .01$

ERP data: Descriptive analyses. Descriptive data analysis began with inspecting the waveform plots. To examine the predicted individual difference effect between participants who hold differential alcohol expectancies, ERPs were aggregated and averaged for individuals with high and low alcohol expectancies. Specifically, the sample was split into two (using median split) with regards to the distribution on the AEQ Social and Physical Pleasure Scale, as this measure had the highest correlation with all the drinking indices (see Table 2). Thus, two groups were created – individuals with high and low positive alcohol expectancies (from now on referred to as High and Low groups).[*] As expected, the two groups indeed represented heavier and lighter drinkers, based on the significant differences on all four drinking variables, as summarized in Table 4.

Table 4.

Mean Scores of Drinking-Related Variables for High vs. Low Expectancy groups

		Drinking Variable			
		TotalDr ^{ln}	DrinkOcc ^{ln}	AveQuant ^{ln}	HighestDr ^{ln}
AEQSoc	*n*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
High	14	3.41 (1.07) **	1.94 (.65) **	1.82 (.39) **	2.06 (.53) *
Low	16	1.98 (1.10)	1.24 (.47)	1.29 (.52)	1.45 (.77)

Note. Means shown are of log-transformed variables.
AEQSoc = AEQ: Social scale; TotalDr ^{ln} = Total number of standard drinks over the past 30 days, log-transformed; DrinkOcc ^{ln} = Number of drinking occasions over the past 30 days, log-transformed; AveQuant ^{ln} = Average number of standard drinks per drinking occasion, log-transformed; HighestDr ^{ln} = Highest number of standard drinks per drinking occasion, log-transformed.

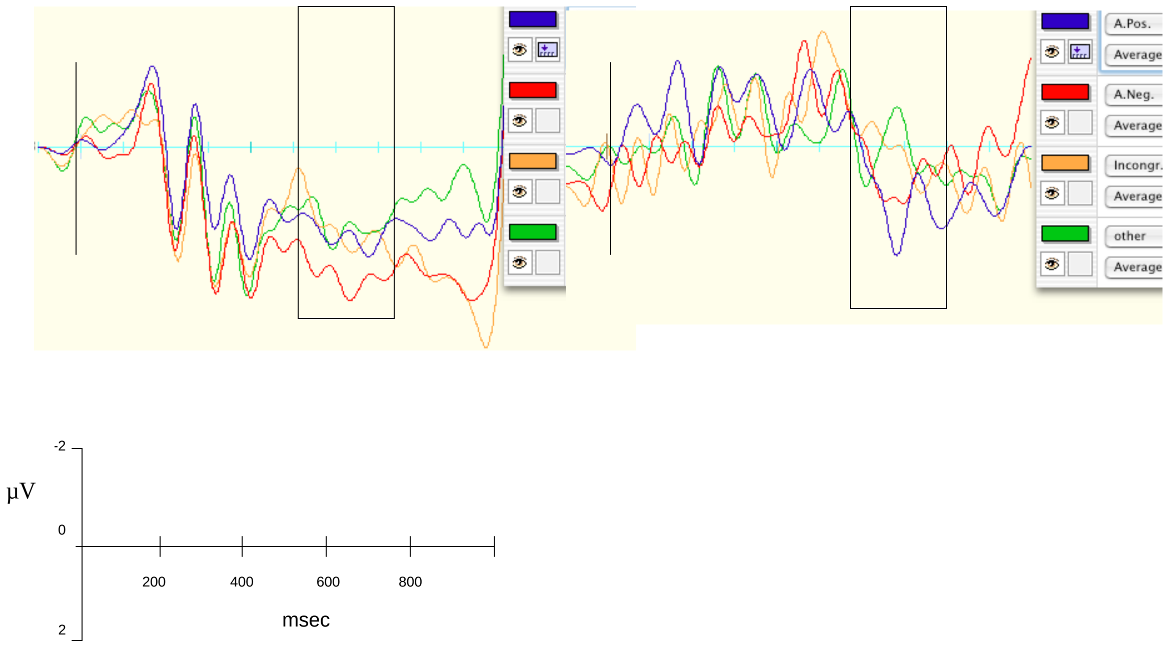
$^{*}p < .01$; $^{**}p < .001$

[*] Examples of items making up the AEQ Social and Physical Pleasure Scale are “Drinking adds a certain warmth to social occasions” and “Drinking makes me feel good”. Individuals in High group were likely to endorse such items, while individuals in Low group were likely to disagree with these statements.

As can be seen from the table, the High group had significantly higher means on Total number of drinks/month, Number of drinking occasions/month, Average number of drinks/typical drinking occasion, and Highest number of drinks/typical drinking occasion (t = -3.95, -3.70, -3.41, -2.75, respectively, all ps < .01), once again confirming the predictive validity of the AEQ Social and Physical Pleasure Scale.

Figure 3 illustrates ERP waveforms at Pz (parietal midline electrode, where the P300 is typically at its maximum) averaged across individuals with High and Low alcohol expectancies. Visual inspection of these waveforms reveals a characteristic large positive deflection with a peak latency of about 550-600 msec after the target word, which seems to vary as a function of different experimental conditions. Specifically, it is clearly noticeable that for the High group the larger positivity was in the Alcohol/Negative condition (i.e., in response to negative/sedating alcohol items), while for the Low group the larger positivity was in the Alcohol/Positive condition (i.e., in response to positive/arousing alcohol items). Thus, it appears that, consistent with the hypothesis, participants with differential alcohol expectancy networks exhibited P300 in response to quite opposing sets of items, each violating their particular set of expectancies.

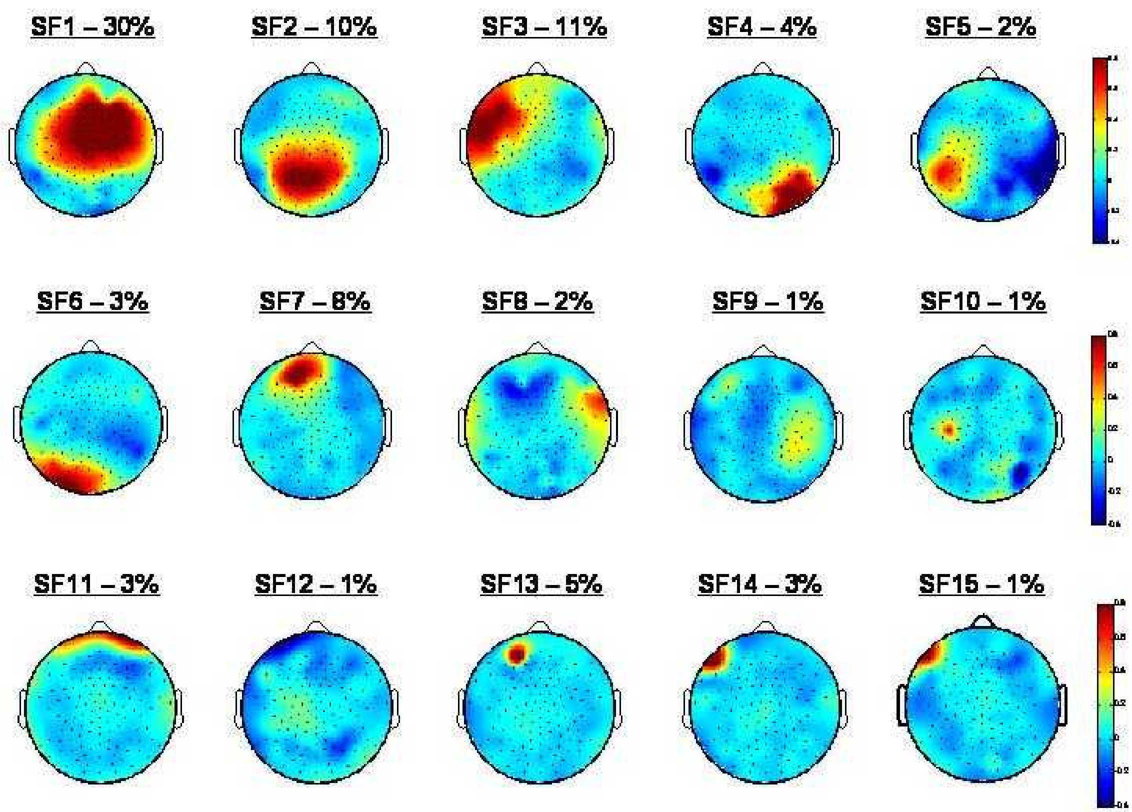
Figure 3. Pz waveforms averaged for individuals with low (right) and high (left) positive/arousing alcohol expectancies. Black vertical lines mark stimulus onset. Positive voltages are plotted as downward deflections.



ERP data: Components extraction. To test this observed difference, a reliable measure of P300 amplitude needed to be extracted. As described in details in the Methods section, the ERP data were therefore entered into PCA to extract the latent components, which could be used as dependent variables in further analyses. Specifically, so called spatial PCA was performed first, with an association matrix of covariance between each pair of the 129 electrodes. The covariances were computed over all participants, all experimental conditions and all time points (129 variables by

[26 x 6 x 225] observations). Using the Scree test (Cattell, 1966), 15 spatial factors,* accounting for 88.7% of the total variance in the data set, were extracted for rotation. Varimax rotation was chosen because it maximizes the amount of variance associated with the smallest number of variables (Donchin & Heffley, 1978). The resulting spatial factors are presented in Figure 4 as topographic maps of the spatial factor loadings (i.e., correlations between the original variables – electrode sites – and the new factors).

Figure 4. Topographic maps of the factor loadings for the spatial factors (virtual electrodes) for Expectancy Violation task. The percentage of variance accounted for by each factor after rotation is indicated.



* While PCA latent variables are normally termed "components", to avoid confusion with ERP components, the term "factors" is used throughout this section when referring to PCA results.

Visual inspection of these topographic maps reveals that the first factor (from now on termed Spatial Factor 1 or SF1) accounts for variance in the central electrodes (covering the top of the scalp), with slight right asymmetry, which is characteristic of N400*. The second factor (SF2) appears to have parietal distribution characteristic of P300. Spatial factor 3 (SF3) may represent motor activity associated with the motor response of key pressing (at least for the right-handers, who represented 74% of the sample) associated with the task. These first three factors accounted for 51% of the spatial variance in the dataset. The remaining factors were of negligible size and/or not readily interpretable. It is safe to assume that they did not carry any variance related to the experimental conditions. Finally, as with any PCA, the contribution of each spatial factor to the dataset was represented by the set of factor scores. Thus, there were now 15 factor scores (one for each spatial factor) associated with each original observation (each time point, at each experimental condition, for each participant). These factor scores indicate the extent to which a factor is present in a given waveform. In other words, if PCA extracts factors that represent ERP components with known or presumed *functional* significance (i.e., P300), then the components' factor scores may be used to make inferences about the extent to which these *functions* vary as a result of experimental condition.

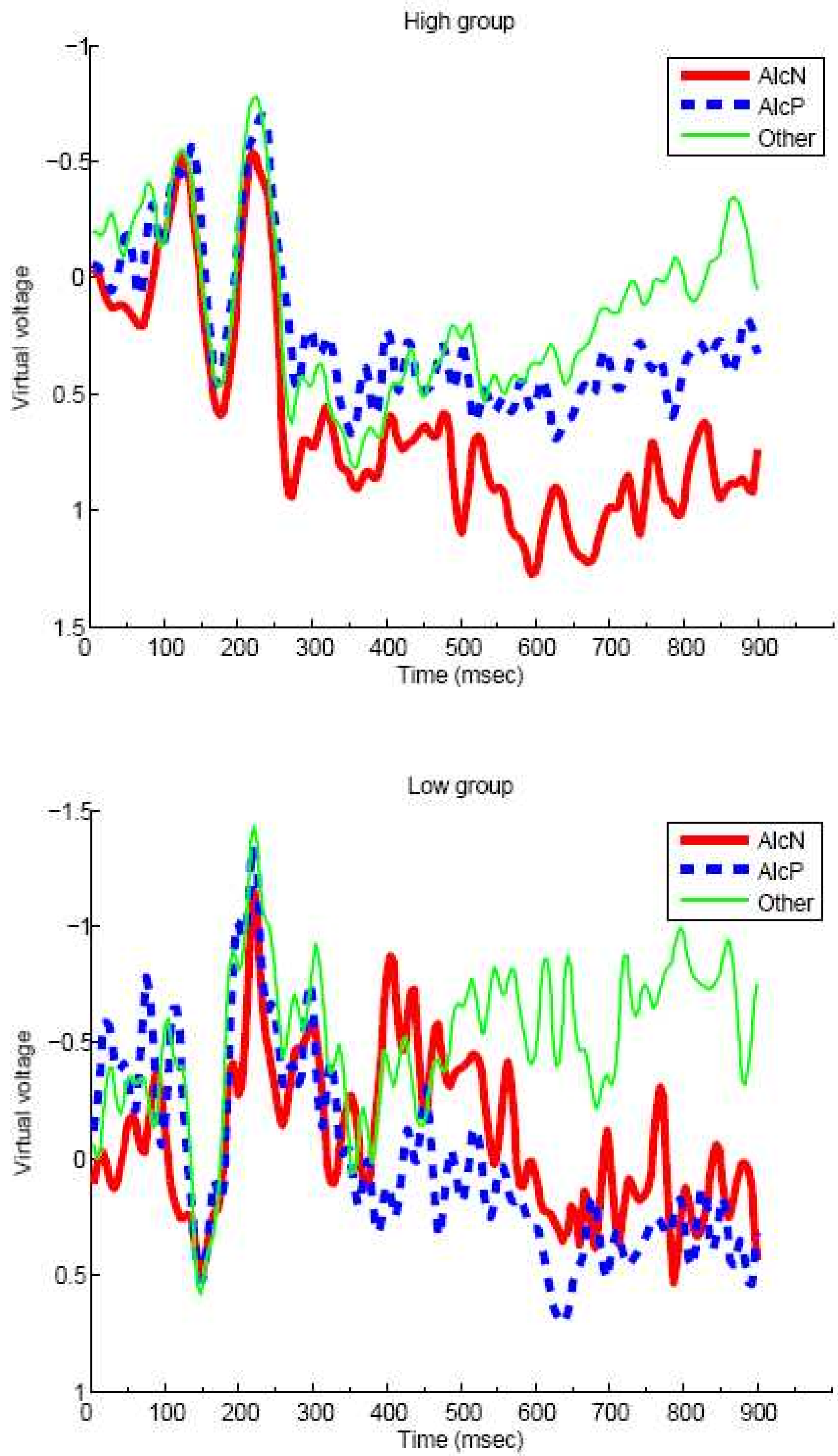
According to the nomenclature introduced by Spencer, Dien and Donchin (2001), the resulting spatial factors, which can be thought of as clusters of scalp distributions, are considered "virtual electrodes" that account for the spatial variance in the dataset and can

* The reader is reminded that among the 70 statements included in the ERP task, there were 10 sentences, which were expected to elicit an N400 component in all participants, as long as they paid attention and were fully engaged in the task. Given that N400 has indeed been reliably elicited in all participants, it is not surprising that a PCA factor associated with this component was the first one to be extracted.

replace the original 129 electrodes. Further, plotting the spatial factor scores at each time point of the original dataset (i.e., at 225 time points for the 0-900 ms of the recording epoch) produces what are considered to be "virtual ERPs" at each of the "virtual electrodes". These virtual ERPs plots allow visualizing the relationships between the activity represented by the spatial factors and the conditions and subject groups.

Figure 5 presents "virtual ERPs" for SF2, plotted separately for High and Low groups. It is evident that (a) these plots resemble the original averaged ERP waveforms at Pz (midline parietal electrode) for these groups (see Figure 3 for comparison), confirming that the chosen SF2 indeed represents segment of the variance, which overlaps with that observed at Pz, where P300 component is typically at its maximum; (b) moreover, assuming that SF2 represents P300 component, virtual ERPs plotted separately for High and Low groups appear to vary as a function of experimental conditions in a manner similar to P300: Namely, it is apparent that the two groups differ on condition that elicits the largest positive peak in the 600-700 msec latency range, such that the High group has the largest positive scores in the Alcohol/Negative condition while the Low group has the largest positive scores in the Alcohol/Positive condition (in accordance with the expectancy violation principle). Thus, examination of the virtual ERPs indicates that the SF2 segment of variance is associated with different patterns of temporal activity, which varies as a function of experimental condition and individual differences (i.e., level of expectancy endorsed by self-report, which is closely associated with actual drinking patterns).

Figure 5. "Virtual ERPs" at "virtual electrode" SF2, for High and Low Expectancy groups.



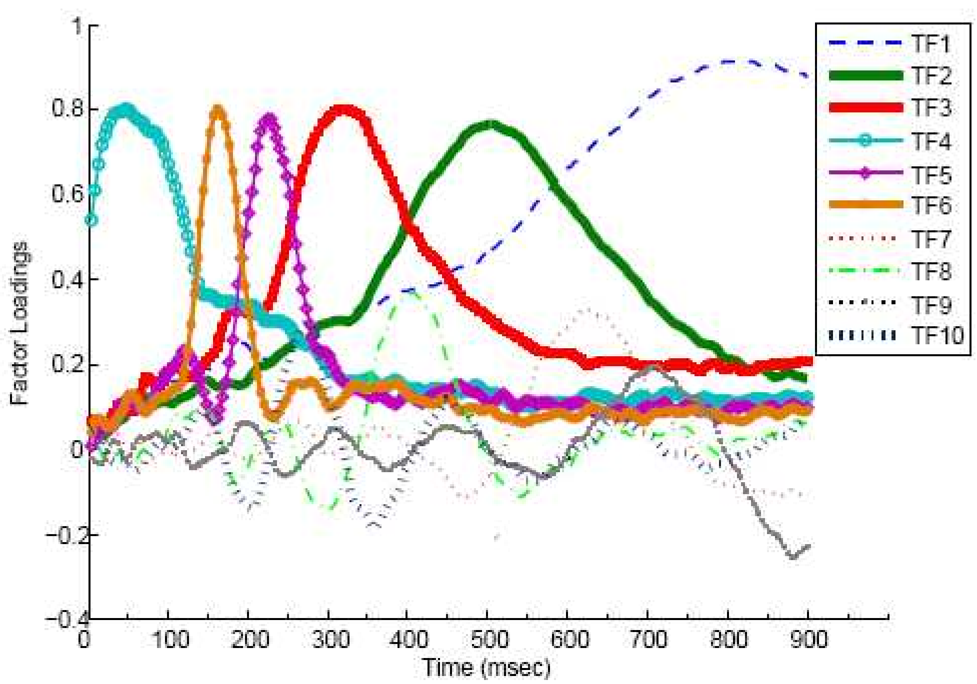
Once the spatial dimensionality of the dataset has been reduced from 129 electrodes to 15 spatial factors, a temporal PCA on the spatially reduced dataset was performed, to achieve the analogous reduction in dimensionality in the temporal domain. That is, PCA was carried out on a matrix consisting of virtual ERPs (i.e., spatial factor scores associated with the time points) as variables, and participants and experimental conditions at each of the 15 virtual electrodes as observations or cases (see *Methods* section for more details). The Scree test suggested retention of 10 factors accounting for 94% of the variance, which were then rotated to simple structure using Varimax. Thus, the temporal PCA reduced the dimensionality of the dataset from 225 time points to 10 temporal factors, or "virtual epochs", using the terminology of Spencer and colleagues (2001).

Figure 6 represents factor loadings for each of the virtual epoch. Since the factor loadings signify the extent to which that factor has an influence on each time point, higher loadings indicate time points when the factor is strongly active, whereas smaller loadings indicate time points when the factor is relatively inactive. The first temporal factor (TF1), which accounted for 44% of the variance, appears to reflect the classical Slow Wave, which typically emerges among the first factors in temporal PCAs (Spencer et al., 2001).[*] The second factor, TF2, loads highly in the 450-600 ms range – the time window in which the differences between the High and Low groups emerged in the raw

[*] Wastell (1981) noted that PCA tends to extract components in the order of their frequency content – that is, first the components that vary slowly over time, followed by the faster components (slowly varying components usually operate over a longer epoch and hence explain more variability). This implies that one should be careful in attaching significance to the amount of explained variance of a component, which decreases with each component that is extracted. In other words, while the fourth or fifth components may not explain as much variance as does the first, this does not imply that they are less meaningful. The variance in the component scores is more important, because it is related to the experimental manipulations.

averaged data (see Figure 3). Thus, TF2 likely represents the temporal activity associated with the P300. The third factor, TF3, which loads highly in the 300-400 ms range of the epoch, is probably associated with N400 elicited by classic incongruent sentences used as one of the control conditions in this task. TF2 and TF3 accounted for 18% and 12% of the variance, respectively. Other temporal factors were either outside of the range of interest (too early to represent P300) or negligible in size.

Figure 6. Factor loadings for the temporal factors (virtual epochs).



Ultimately, the two PCA steps resulted in a finite set of factor scores, which could now serve as dependent variables and be subjected to statistical analyses. Specifically, based on the scalp distribution and the temporal variance accounted for, the primary candidate for further analyses were the scores for TF2 (at the P300 latency range) associated with SF2 (posterior virtual electrode, at which P300 amplitude is typically at its maximum). This TF2/SF2 score was considered to represent the P300 ERP component, and therefore was used in further analyses.

ERP data: Inferential analyses. Next, TF2/SF2 scores for the Alcohol-Positive/Arousing and Alcohol-Negative/Sedating conditions were saved for each participant. To assess the extent to which this component varied as a function of individual's expectancies and experimental conditions, Pearson correlations between the self-report measures and the TF2/SF2 scores were calculated. As is evident from Table 5, TF2/SF2 score for Alcohol-Negative/Sedating items was positively correlated with the participants' levels of expectancies, as measured by AEQ Social and Physical Pleasure and AEMax Positive Arousing scores (r [26] = .52, $p < .01$, and r [26] = .42, $p < .05$, respectively). In other words, the higher were the individual's expectations of positive effects of alcohol, the larger were his or her P300 amplitude in response to items contradicting these beliefs. Examination of the scatterplots revealed that these correlation coefficients were not influenced by outliers, but rather reflected a real pattern in the data (see Figure 7).

Table 5.

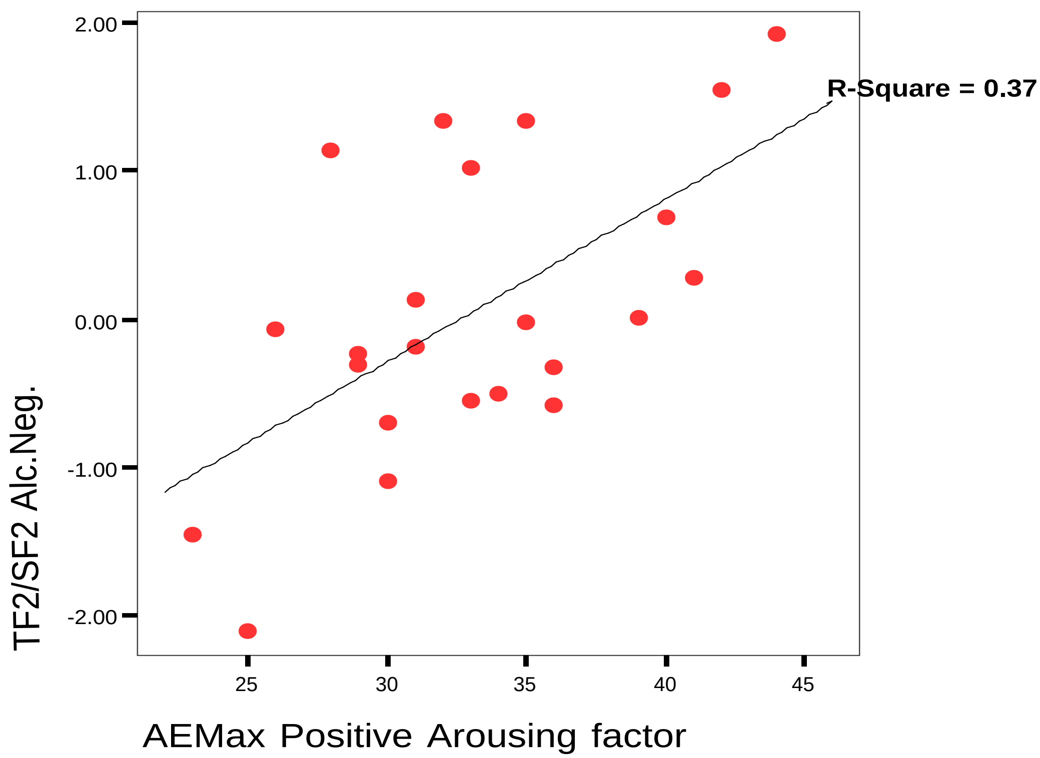
Zero-Order Correlations between Selected Independent Variables and TF2/SF2 (P300) scores

	Measure	1	2	3	4	5	6	7	8	9
1.	TF2/SF2Neg									
2.	TF2/SF2Pos	.42*								
3.	AEMaxPosAr	.42*	.08							
4.	AEMaxSed	.07	-.08	.14						
5.	AEQGloPos	.29	.13	. 50**	.11					
6.	AEQSoc	.52**	-.23	.43**	.18	.68***				
7.	TotalDr ^{ln}	.16	.30	.40*	-.03	.55***	.60***			
8.	DrinkOcc ^{ln}	.02	.30	.36*	.00	.56***	.58***	.95***		
9.	AveQuant ^{ln}	.30	.32	.34	-.07	.43**	.52***	.92***	.75***	
10.	HighestDr ^{ln}	.27	.35	.23	-.09	.38*	.52***	.92***	.80***	.96***

Note. TF2/SF2Neg, TF2/SF2Pos = TF2/SF2 factor scores in response to Alcohol/Negative-Sedating and Alcohol/Positive-Arousing conditions, respectively; AEMaxPosAr, AEMaxSed = AEMax: Positive Arousing factor, Sedating factor, respectively; AEQGloPos, AEQSoc = AEQ: Global Positive Changes scale, Social scale, respectively; TotalDr ^{ln} = Total number of standard drinks over the past 30 days, log-transformed; DrinkOcc ^{ln} = Number of drinking occasions over the past 30 days, log-transformed; AveQuant ^{ln} = Average number of standard drinks per drinking occasion, log-transformed; HighestDr ^{ln} = Highest number of standard drinks per drinking occasion, log-transformed.

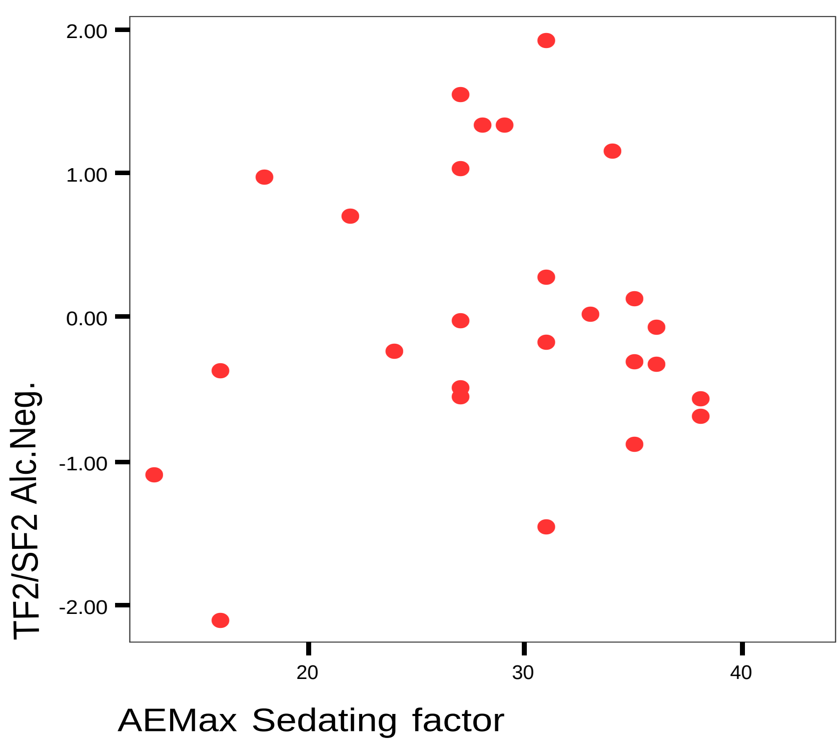
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Figure 7. Scatterplot of relationship between TF2/SF2 amplitude in response to Alcohol/Negative-Sedating items and scores on the AEMax Positive Arousing factor.



Careful inspection of other correlation coefficients allows ruling out an alternative explanation that individuals with higher positive expectancies also happen to have a larger P300 in general, not specifically in response to negative alcohol items. In particular, the (predicted) low correlation between TF2/SF2 in response to negative alcohol stimuli and the level of endorsement of negative/sedating expectancies as measured by AEMax Sedating factor (*r* [26] = .07, *ns*) supports the hypothesis that it is the violation of one's expectancies, be it in alcohol or any other domain, that results in a large, measurable P300 component. To further strengthen this position, examination of the scatterplot of the relationship between TF2/SF2 in response to negative alcohol stimuli and AEMax Sedating factor (see Figure 8) reveals that, in fact, there might be a negative relationship obscured by a few cases at the lower end of the distribution. In particular, were it not for the 3 individuals with lower scores on both TF2/SF2 and AEMax Sedating factor, this scatterplot would reveal a negative correlation, such that the higher the sedating expectancies reported by an individual (characteristic of lighter drinkers), the smaller is her or his P300 in response to negative and sedating alcohol items (which describe outcomes *expected* by lighter drinkers, and thus do not elicit a P300).

Figure 8. Scatterplot of relationship between TF2/SF2 amplitude in response to Alcohol/Negative-Sedating items and scores on the AEMax Sedating factor.



Interestingly, no significant correlations emerged between the expectancy measures and TF2/SF2 amplitude in response to Alcohol-Positive/Arousing items; that is even participants with "low" positive expectancies did not find these items deviant or incongruent. Further, as can be seen in Table 5, no significant correlations emerged between TF2/SF2 amplitude in either condition and drinking variables. These findings will be discussed in detail in the *Discussion* section.

An additional post-hoc analysis was performed in a subsample of the current sample, including only those participants who can be considered heavier drinkers. When only drinkers drinking at least three standard drinks per average occasion (n = 17) were included the analyses, all the correlations between drinking variables and P300 amplitude in both Alcohol-Positive/Arousing and Alcohol-Negative/Sedating conditions were enhanced: Seven out of eight correlation coefficients were now ranging from .32 to .56, reaching .05 significance level in four out of eight comparisons (see Table 6).

Table 6.

Zero-Order Correlations between Selected Independent Variables and TF2/SF2 (P300) scores, in Heavier drinkers (participants drinking at least 3 drinks per average occasion, n = 17)

Measure		1	2	3	4	5	6	7	8	9
1.	TF2/SF2Neg									
2.	TF2/SF2Pos	.46*								
3.	AEMaxPosAr	.41*	-.08							
4.	AEMaxSed	-.05	.30	-.14						
5.	AEQGloPos	.26	.13	. 52*	.06					
6.	AEQSoc	.50*	.21	.43*	.13	.65*				
7.	TotalDr ^{ln}	.32	.49*	.40*	.04	.49*	.46*			
8.	DrinkOcc ^{ln}	.17	.32	.36*	.08	.66*	.53*	.92*		
9.	AveQuant ^{ln}	.42*	.56*	.34	-.12	.17	.49*	.88*	.60*	
10.	HighestDr ^{ln}	.32	.49*	.23	-.10	.38*	.50*	.78*	.54*	.89*

Note. TF2/SF2Neg, TF2/SF2Pos = TF2/SF2 factor scores in response to Alcohol/Negative-Sedating and Alcohol/Positive-Arousing conditions, respectively; AEMaxPosAr, AEMaxSed = AEMax: Positive Arousing factor, Sedating factor, respectively; AEQGloPos, AEQSoc = AEQ: Global Positive Changes scale, Social scale, respectively; TotalDr ^{ln} = Total number of standard drinks over the past 30 days, log-transformed; DrinkOcc ^{ln} = Number of drinking occasions over the past 30 days, log-transformed; AveQuant ^{ln} = Average number of standard drinks per drinking occasion, log-transformed; HighestDr ^{ln} = Highest number of standard drinks per drinking occasion, log-transformed.

$^{*}p < .05$

ERP data: Standard oddball P300. As described in *Methods*, a standard oddball task was administered prior to the Expectancy Violation Task, in order to measure individual idiosyncratic responses to a standard oddball sequence. Thus, recording each individual's "typical" P300 elicited in a neutral, non-alcohol-laden, context allowed ruling out some alternative explanations for current findings. For instance, based on the widely replicated finding, individuals at risk for developing alcoholism (*CoAs*, or children of alcoholics) manifest significantly lower P300 voltages compared with matched low-risk individuals coming from control families without first- or second-degree alcoholic relatives (see *Introduction* for more details). Given this phenomenon, it is conceivable that lack of the association found in the present sample between drinking variables and P300 amplitude elicited by items describing negative effects of alcohol could be explained by low variability within the heavier drinkers due to potentially diminished generic P300 amplitudes among these individuals. To rule out this alternative explanation, P300 amplitude elicited in response to rare, relevant stimuli presented in the standard oddball task was recorded for each individual and compared between heavier and lighter drinkers.

First, the ERP data collected in the standard oddball task were subjected to PCA, to extract reliable measures of ERP components. Briefly, as a result of spatial PCA, 12 spatial factors, accounting for 90% of the total variance, were extracted. As evident from Figure 9, which depicts the topographic maps of the spatial loadings for each spatial factor, SF2 appears to have centro-parietal scalp distribution characteristic of P300. To demonstrate that SF2 indeed represented the segment of variance associated with P300

ERP component, so called virtual ERPs at the "virtual electrode" SF2 were plotted, as shown in Figure 10.

Figure 9. Topographic maps of the factor loadings for the spatial factors (virtual electrodes) for standard oddball task. The percentage of variance accounted for by each factor after rotation is indicated.

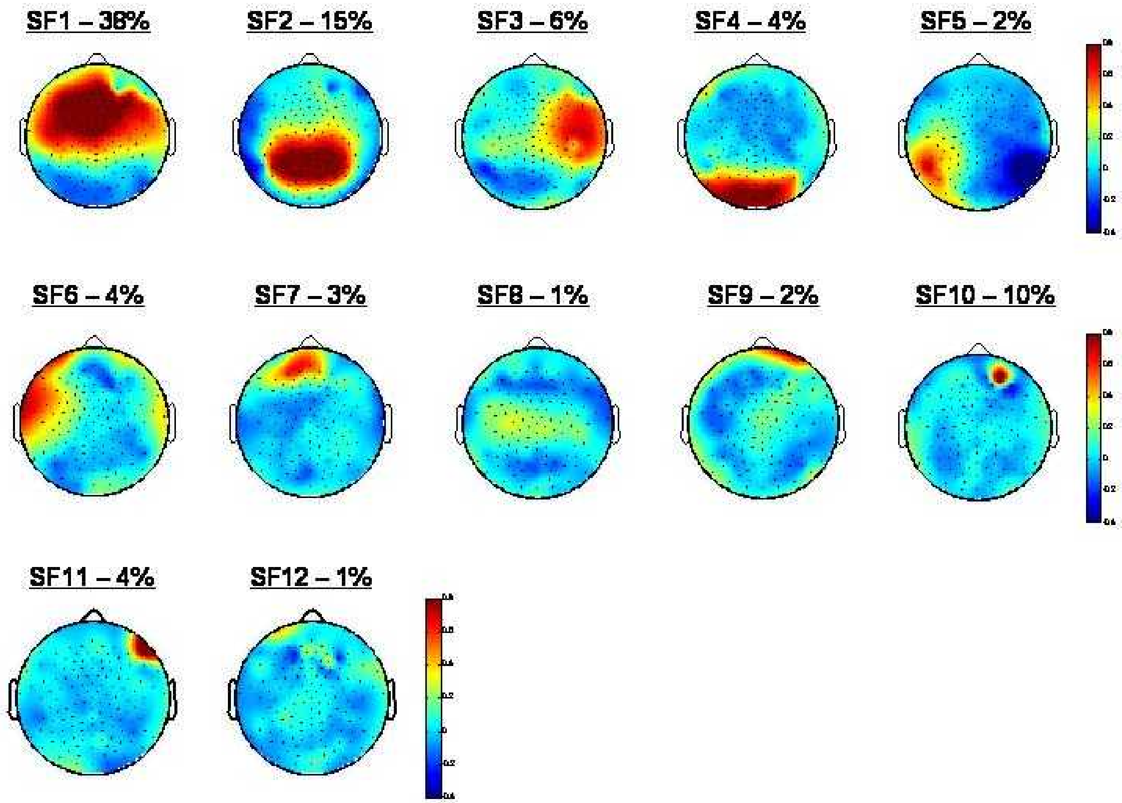
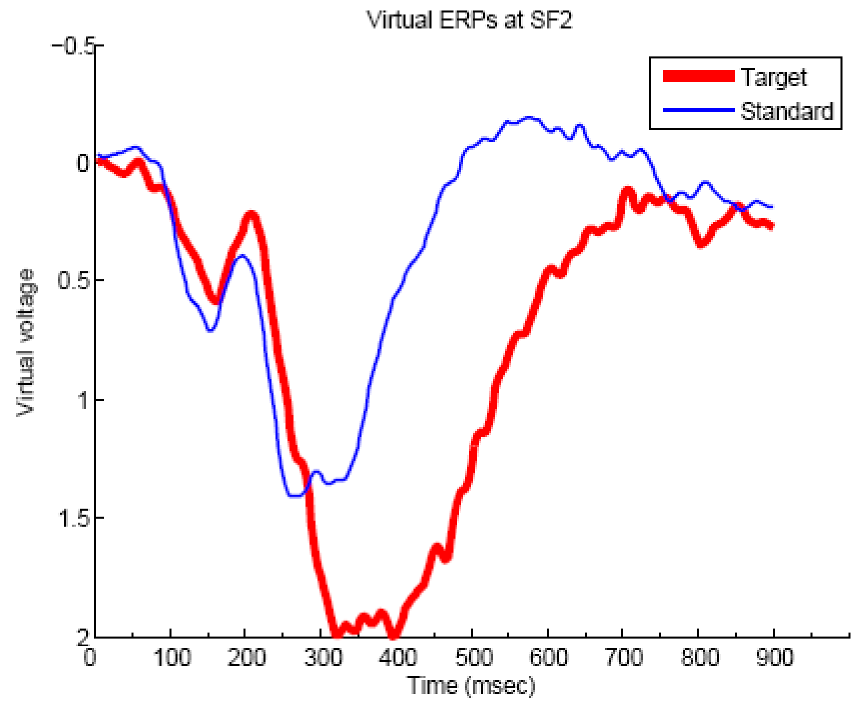
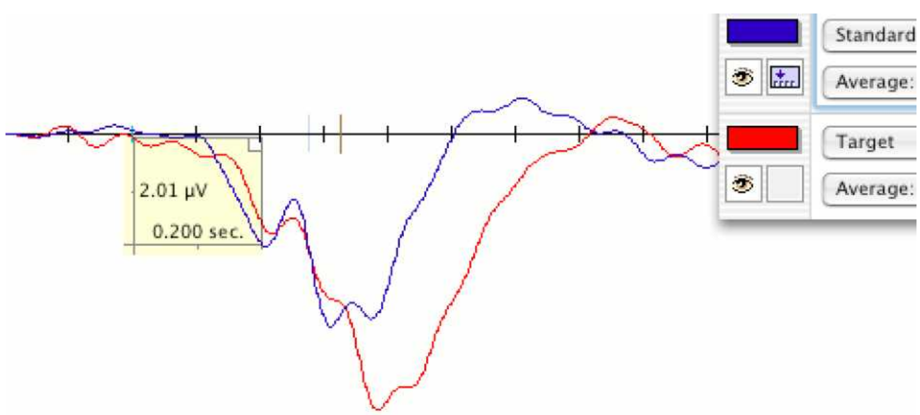


Figure 10. "Virtual ERPs" at "virtual electrode" SF2, in standard oddball task, averaged across all participants. Raw ERP average waveform at Pz electrode is depicted below for comparison.

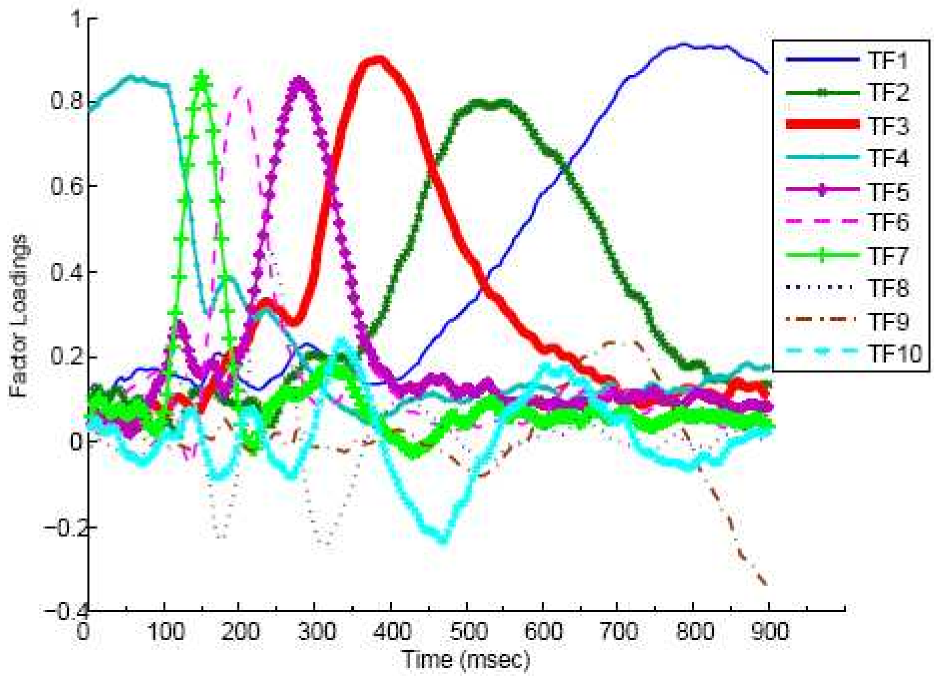




It is apparent that the SF2 spatial scores did vary as a function of experimental conditions, in a predictable manner: Namely, there was a distinctively large positivity in response to rare/target items. This suggests that SF2, indeed, represents a segment of variance that functions (i.e., responds to the same eliciting conditions) like P300 ERP component. Next, as a result of temporal PCA applied to the spatial factor scores, 10 temporal factors, or "virtual epochs", which accounted for 95% of the variance, were extracted and rotated to a simple structure. As evident from Figure 12, which depicts factor loadings for each virtual epoch, several temporal factors – namely, TF2, TF3 and TF5 – fell in the P300-latency range. However, based on both the raw averaged waveforms and virtual ERPs at SF2, it is apparent that, in this sample, standard oddball P300 peaked between 300 and 400 msec. Therefore, given that TF3 loadings were the highest in the 370-400 msec range of the epoch (see Figure 11), it was likely that TF3 represented temporal activity associated with P300. Thus, based on the scalp distribution and the temporal variance accounted for, TF3/SF2 scores were considered to represent the participants' P300 in response to target/rare stimuli (from now on referred to as the standard oddball P300). Thus, TF3/SF2 scores were saved for each participant as standard oddball P300 and subjected to further analyses, as follows.

Pearson correlations calculated between the standard oddball P300 and the TF2/SF2 factor scores for both Alcohol/Negative-Sedating and Alcohol/Positive-Arousing conditions revealed no significant associations (*r*s = .10 and .11, respectively). Further, partial correlation analysis was used to explore the relationship between TF2/SF2 and participants' expectancy levels, while controlling for the standard oddball P300 amplitude. The magnitude of the partial correlations between expectancy levels and TF2/SF2 remained very similar to zero-order correlations (e.g., compare *r* [26] = .51, *p* < .01 – a partial correlation between TF2/SF2 and AEQ Social and Physical Pleasure scores – to their zero-order correlation: *r* [26] = .52, *p* < .01), suggesting that controlling for the standard oddball P300 magnitude had little effect on the strength of the relationship between TF2/SF2 and expectancy levels measured by self-report (AEMax and AEQ).

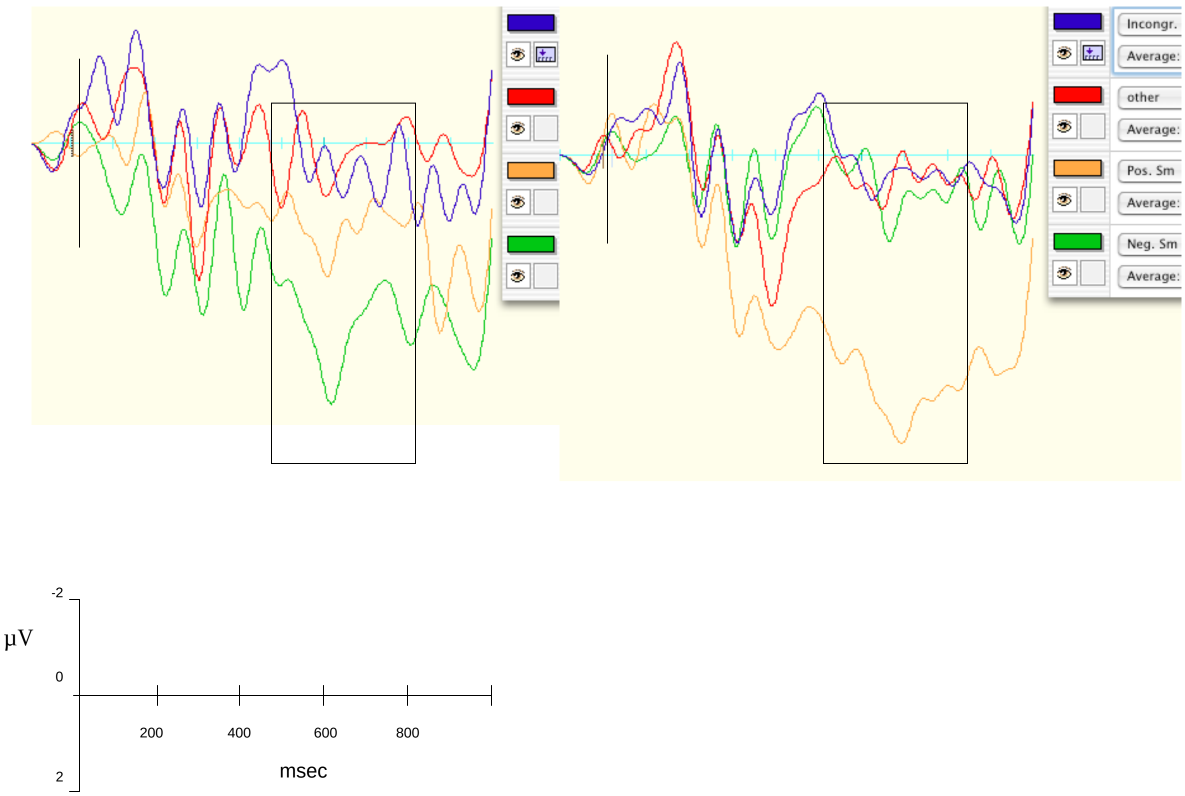
Figure 11. Factor loadings for the temporal factors (virtual epochs), for standard oddball task data.



As for the reported in the literature diminished P300 amplitude effect among at risk individuals, this effect did not reach significance in the present sample. Specifically, participants with and without history of alcohol problems in at least one of the parents (obtained from the Family History Grid data) were compared with regards to the magnitude of their standard oddball P300. Individuals with family history of alcoholism (FM+) did have smaller P300 amplitudes (M = 1.21, SD = 1.40) than individuals with negative family history of alcoholism (FM–; M = 2.10, SD = .99), but not significantly so (t = 1.72, p > .05). The lack of significant difference can be most likely attributed to this sample's makeup, namely to the fact that the present sample consisted of college students. Although alarmingly heavy levels of alcohol consumption are well documented in this population (for review see O'Malley & Johnston, 2002), college students by and large do not represent the population of those "at risk individuals" who are reported to have diminished P300. Specifically, although the present sample included 14 FM+ individuals (i.e., with history of alcohol problems in at least one of the parents), it is likely that these participants were not representative of the population of children of alcoholics (*CoA*s – children with at least one alcoholic parent), who are typically considered "at risk for developing alcoholism." In other words, a family history classification used in the current study clearly applied a less stringent criterion than is typically used when defining individuals at risk (i.e., history of alcoholism vs. history of alcohol-related problems; see Porjesz & Begleiter, 1998 for review).

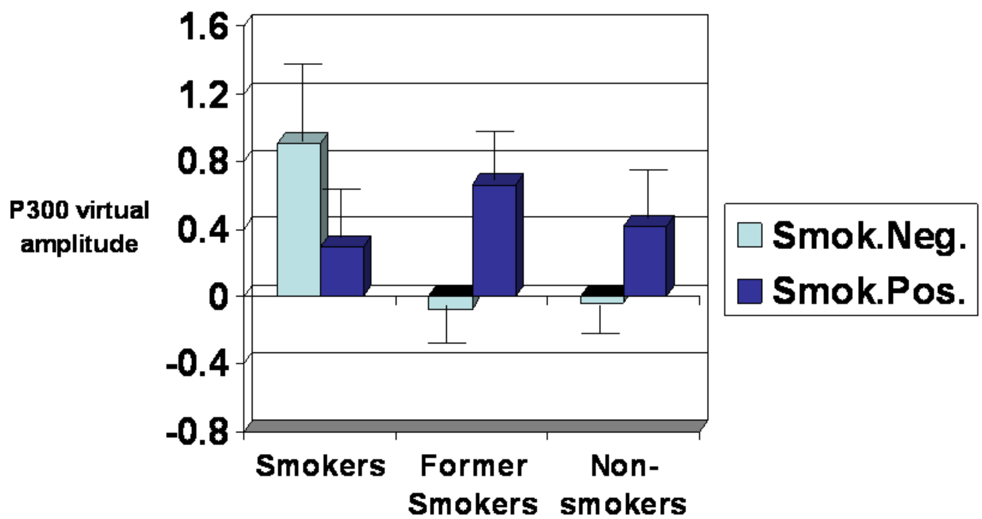
ERP data: Smoking. Although the main purpose of the present study was testing the hypothesis that P300 amplitude elicited by stimuli describing various effects of alcohol would vary as a function of individual's subjective alcohol expectancies, as measured by self-report, some sentences included in the Expectancy Violation task pertained to smoking rather than alcohol (as described in more details in *Methods*). Although the smoking sentences were initially included as filler items, given that there were smokers, former smokers and non-smokers among the participants, it was reasonable to expect that P300 elicited by items describing smoking as either negative or positive (e.g., "Cigarettes taste… bad"; see Appendix B for more examples of smoking items) would vary as a function of one's smoking history. To test this hypothesis, ERPs elicited in response to Smoking/Negative and Smoking/Positive trials were averaged separately for smokers, former smokers and non-smokers (these groups were devised based on the information reported on the Demographic Information Form; Appendix A). The resultant ERP waveforms at the Pz electrode (parietal midline electrode, where the P300 is typically at its maximum) are presented in Figure 12. Visual inspection of these waveforms reveals a characteristic large positive deflection with a peak latency of about 600 msec after the target word, which seems to vary as a function of different experimental conditions and individual's smoking history. Specifically, it is clearly noticeable that for current smokers Smoking/Negative condition elicits the largest positivity, while for former smokers it is the Smoking/Positive condition that elicits the largest positivity. No clear pattern emerged among the non-smokers. In other words, it appears that current smokers exhibit P300 in response to stimuli describing negative aspects of smoking, while individuals who had smoked but quit exhibit P300 in response to stimuli describing positive aspects of smoking (presumably due to a change in their smoking-associated cognitive schema, which they underwent wither prior to or since smoking cessation).

Figure 12. Pz waveforms averaged for current (left) and former (right) smokers. Black vertical lines mark stimulus onset. Positive voltages are plotted as downward deflections.



As the number of individuals for each cell (smokers, former smokers and non-smokers) was relatively small, no formal significance testing could be performed to further test this observable difference. However, this difference might be better appreciated by presenting the means of the TF2/SF2 scores for Smoking/Positive and Smoking/Negative conditions across the three groups. Figure 13 displays virtual P300 amplitude as a function of these two experimental conditions (i.e., stimuli category) and smoking group. It is evident the Smokers have a large virtual P300 in response to negative smoking stimuli (*M* = .90, *SD* = .86) while the other two groups do not; on the other hand, Former smokers appear to have the largest virtual P300 in response to positive smoking stimuli (*M* = .66, *SD* = .76), in comparison with the current smokers and non-smokers.

Figure 13. P300 effects as a function of experimental condition (i.e., stimuli category) and smoking group.



Discussion

Main finding and its implications: P300's sensitivity to alcohol expectancies

While examining group effects is a typical analytical approach adopted in the ERP field, the present investigation was chiefly driven by the possibility of applying ERP methodology to exploring *individual differences* in alcohol associated cognitions, which by taking advantage of broad variations among individuals provide a much richer picture of the phenomenon than median- or otherwise-split groups. More specifically, it was predicted that P300 amplitude elicited by stimuli describing various effects of alcohol would be inversely correlated with the degree to which individual's subjective expectancies of alcohol effects matched those expressed by the ERP eliciting stimuli. Indeed, a significant positive correlation was found between the amplitude of P300 elicited by Alcohol-Negative/Sedating items and the participants' levels of positive expectancies measured by self-report questionnaires, such that the higher the individual's expectations of positive effects of alcohol (measured with either AEQ or AEMax), the larger the P300 amplitude in response to items violating his/her subjective expectations (i.e., negative effects of alcohol). This finding underscores the sensitivity of the P300 amplitude to individual variations along a well-studied psychological domain of interest, namely – alcohol expectancies. Most past ERP studies either focused on group differences only or failed to link the processes indexed by known ERP components to psychological constructs varied on a continuum rather than categorically. In contrast, the present finding of correlation between the information-processing reflected by the P300

ERP component and the self-reported differences pertaining to one's cognitive schema of alcohol can be viewed as evidence that the ERPs can provide valuable information at the level of individual differences, which is the primary level of inquiry in clinical psychology.

The P300 is a well-studied ERP component whose amplitude is correlated with the subjective probability assigned to the ERP eliciting event: as subjective probability decreases, P300 amplitude increases, and vice versa. Further, the elicitation of a P300 component does not require an explicit categorization process, as P300 may be elicited even when participants are unwilling to explicitly report information (Farwell & Donchin, 1991).[*] Thus, while traditional questionnaires that access alcohol outcome expectancies provide measures of explicit cognition, which is subject to demand characteristics (e.g., social desirability) and measurement reactivity, the operation of the subjective probability assignment indexed by the P300 component of the ERPs is independent of introspection and deliberation. As a result, the P300 index of alcohol expectancy reported here provides a glimpse into information-processing mechanisms otherwise opaque to traditional explicit assessment tools. Specifically, these findings suggest that when participants are presented with alcohol primes (in the form of sentences describing effects of alcohol) their semantic networks associated with alcohol are activated very early in the information processing stream. But more importantly, this

[*] While some objective categorization task must be present for P300 to be elicited in an oddball paradigm, P300 amplitude is especially sensitive to "subjective" categorization, which might be different from the categorization required by the task instructions. For instance, Farwell and Donchin (1991) demonstrated that P300 can be reliably elicited by autobiographically-relevant items recognized by participants due to their individual prior experiences, while participants were in fact performing an unrelated classification task. Thus, the large P300 amplitude indicated "detection" of the stimuli that were "recognized" by the participants, even if they were unwilling to explicitly report their recognition.

processing is closely related to the individual's intrinsic variables. The experimental variable (positive vs. negative alcohol condition) by itself did not show an isolated effect on the ERP data, except when it *interacted* with the participant's variables, namely the individual's subjective ratings of anticipated effects of alcohol.

Moreover, despite using such a different assessment strategy of the alcohol expectancy operation, the resultant effect is convergent with previous findings reported with explicit, self-report measures of expectancies, using vastly different research paradigms and probing very different levels of processing. The convergence of findings using such different measurement methods provides strong evidence for alcohol expectancy theory. But, further, this suggests that application of the information-processing perspective to the substance use domain is a viable way to view and study mechanisms giving rise to or associated with substance use behavioral outcomes. Within the current study, further support for this approach is provided by apparent generalization of the effect to tobacco smoking domain. Specifically, similarly to the effect in alcohol domain, differential P300 amplitude variation was found with stimuli pertaining to various effects of smoking. Although lacking sufficient power to detect significant effects, observed ERP waveforms – as well as mere amplitude means comparison – suggest that the P300-expectancy index varied as a function of the stimuli category (positive vs. negative smoking trials) *and* smoking history (current vs. former smokers), replicating the effect found in alcohol domain.

Unsupported hypothesis: Positive alcohol items did not elicit P300 in individuals with "low" positive expectancies

Besides the primary finding of larger P300 amplitude in response to expectancy violating stimuli asserting negative effects of alcohol, other results and patterns in the present data deserve further discussion. Namely, as reported above, no significant correlations emerged between the expectancy measures and the P300 amplitude in response to Alcohol-Positive/Arousing items; that is even participants with "low" positive expectancies did not find these items deviant or incongruent. A parsimonious interpretation of this finding lies in the makeup of the present sample, as follows. Past research has shown that drinkers of all levels associate some positive effects with alcohol consumption; but where the difference lies is in the relative strength of the association in light versus heavy drinkers. Namely, while light drinkers might agree with the statements describing positive effects of alcohol, they "weigh" the sedating effects more heavily, reporting more frequent expectations of sedating outcomes. Heavy drinkers, on the other hand, expect positive and arousing effects more frequently than the aversive and sedating effects (Rather, Goldman, Roehrich, & Brannick, 1992). Thus, it appears that the majority of individuals have somewhat overlapping expectancy networks but with different "critical mass centers" – while heavier drinkers' network is hypothesized to be centered around the social/arousing/positive dimension, the expectancy networks for the lighter drinkers center around aversive/sedating effects, with both groups endorsing the positive effects but to a different degree.

In light of these previously reported findings, it may be the case that because the majority of drinkers do hold some positive expectancies of alcohol effects in their semantic networks, only individuals with very low positive expectancies would perceive the Alcohol-Positive/Arousing stimuli as deviant or violating their expectancies. Therefore, it is arguable that the current study failed to detect the P300 effect (i.e., significant correlation between the expectancy measures and the P300 amplitude in response to Alcohol-Positive/Arousing items) because the sample did not include enough such individuals. This interpretation is, in fact, supported by a more careful examination of the patterns of correlations in Table 5. Specifically, it is evident that P300 amplitude in response to Alcohol-Positive/Arousing items did appear to be negatively associated (although not significantly so) with scores on the AEQ Social scale, which according to both previous research and the present findings is the most robust correlate of drinking in college population (see pattern of correlations in Table 2). In other words, given that AEQ Social scale is the most valid measure of the expectancy construct (in that it robustly predicts drinking in many samples across different studies), then it is reasonable to focus on its correlations with P300 amplitude. The magnitude and the sign of the correlation ($r = -.23$) do suggest that there is a moderate negative association between the P300 elicited by Alcohol-Positive/Arousing items and the individual's self-reported positive/arousing expectancies, such that the lower the positive expectancies the greater the P300 amplitude in response to items contradicting their expectations (and, indeed, this association disappears in a subsample of heavier drinkers or individuals with higher positive expectancies, as seen in Table 6). Of course, given that an argument built on the non-significant result cannot be completely compelling, this effect needs to be replicated in a larger sample with a broader variation on the expectancies continuum.

What about drinking itself?

Another aspect of the pattern of the correlations in Table 5 deserves special consideration. Specifically, as described in the *Results* section, no significant correlations emerged among the P300 amplitude and drinking variables. Although the experimental conditions (categories of alcohol positive vs. negative stimuli) were designed as a direct test of alcohol expectancies rather than drinking (since it is the *expectancy* violation or confirmation that these stimuli asserted), the lack of significant correlations between drinking and P300 is still somewhat puzzling, given the robust relationship between drinking and expectancies (see Table 2). However, a careful examination of the correlations presented in Table 5 suggested an interesting possibility: it is evident that almost all drinking variables do appear to be positively (albeit not-significantly) associated with P300, with correlation coefficients ranging between .27 to .35 in six out of eight comparisons. Moreover, this relationship seems to be indiscriminant of the experimental category, such that the greater the individual's level of drinking the larger his or her responses to *any* stimuli mentioning alcohol. This in itself suggests an intriguing interpretation, which is, in fact, consistent with the literature indicating that P300 amplitude is associated with processing of emotionally important or individually salient stimuli. For instance, increased P300 amplitudes to personally meaningful (or disorder-specific) stimuli have been found in veterans with posttraumatic stress disorder (Attias, Bleich, & Gilat, 1996; Blomhoff, Reinvang, & Malt, 1998) and in patients with posttraumatic symptoms following a motor-vehicle accident (Granovsky, Sprecher, Hemli, & Yarnitsky, 1998), as well as in patients with anxiety disorders (Pauli et al., 1997). Herrmann and colleagues (2000) have demonstrated a similar effect in the alcohol domain: they found what looks like a cue-reactivity effect in alcohol-dependent patients who exhibited greater positivity in the P300 latency elicited by alcohol-related words (e.g., *booze*, *bottle*, *beer*) compared with unrelated – and equally probable – words (e.g., *milk*, *apple*). No such effect was found in the control group.

In light of these data reported by others, the positive (albeit non-significant) correlations between P300 elicited by any alcohol-related stimuli and drinking measures might be interpreted as indicating that the more experience an individual has with consuming alcohol, the more meaningful or salient the stimuli associated with alcohol appear to him/her.[*] This interpretation is based on the contribution of the "Guilty Knowledge" to the P300 variance. The Guilty Knowledge concept (first proposed by Lykken, 1959, as cited in Farwell & Donchin, 1991), is based on the premise that individually meaningful or salient stimuli elicit distinct response when compared to stimuli carrying no personal information, be it a reaction time on a Stroop test or a cardiovascular or galvanic response typically measured by polygraphs. Farwell and Donchin (1991) applied this principle to the ERP domain and demonstrated that P300 is sensitive to critical items indicating "guilt" or "crime" such that stimuli with personal meaning, related to past individual experiences, were implicitly categorized by individuals as a deviant category (regardless of the explicit task instructions) and thus elicited larger P300 amplitude than non-critical items. Taken outside of the realm of "crime", this finding is consistent with the disorder-specific enhanced P300 amplitude described above: In other words, the P300 appears to be sensitive to the distinctiveness

[*] The reader is reminded that alcohol-related sentences constituted about half of all stimuli used in the task (32/70), and hence the higher amplitudes elicited by alcohol items cannot simply be attributed to a classical "oddball" effect in response to rare stimuli.

or individual relevance of the stimuli that is determined by individual's intrinsic variables and/or idiosyncratic experience. Thus, the moderately high, albeit non-significant, correlations found between drinking variables and P300 amplitude in response to *either* negative or positive alcohol stimuli in the present sample are in line with this view.

To further test this possible explanation of the results, this effect was examined in heavy drinkers only, given that they represent the part of the sample that is indeed "guilty" of extensive relationship with alcohol. In a sense, heavier drinkers can be thought of as "experts" in drinking, which makes them especially attuned to information pertaining to alcohol. Indeed, when only drinkers drinking at least 3 standard drinks on an average occasion were included in the analyses (n = 17), all the correlations between drinking variables and P300 amplitude in both conditions were enhanced: Seven out of eight correlation coefficients were now ranging from .32 to .56, reaching .05 significance level in four out of eight comparisons. Of course, although these findings contribute to the validity of the argument presented above, this post-hoc data analysis and its interpretation should be viewed with caution as this effect was not predicted and thus was not set up to be experimentally tested. However, given that this interpretation is consistent with previous reports on the sensitivity of P300 to salience or distinctiveness of stimuli, it deserves consideration and future investigation with a larger sample.

Alternatively, one cannot rule out the possibility that the non-significant correlations between the P300 index and drinking variables were due to measurement error in the latter. The period of data collection was not restricted to a discreet time period, but, rather, took place over two semesters. This may have very well introduced the time-of-the-year effect on drinking described by Greenbaum, Del Boca, Darkers, Wang and Goldman (2005). These authors demonstrated that, besides individual differences, drinking patterns in college students are affected by secular events, including major national and local holidays, as well as by academic calendar, including breaks and exam periods. Thus, the TLFB data reflecting drinking over previous month (i.e., over 30 days preceding the assessment day) may have been confounded by the time factor, given that different participants reported their drinking over non-overlapping periods of time (during two academic semesters), some of which might have included days at which drinking was sure to peak (e.g., New Year's Eve) or to drop (e.g., final exam week) in most college students, regardless of their individual typical drinking patterns. This may have affected the reliability of the drinking data but not that of the expectancy variables, as the latter have been shown to be more stable over the course of the year (Greenbaum et al., 2005). The lower reliability, in turn, may have influenced correlations between P300 and drinking variables. Future studies will need to exercise more care with regards to time periods over which the data are collected.

Present findings vs. diminished P300 effect in at risk individuals

The present findings of the variations in the P300 amplitude as a function of individual's expectancies *and* stimuli category (i.e., positive/arousing vs. negative/sedating effects of alcohol) should be considered separately from the findings in alcohol dependence literature of generally reduced P300 in a classical oddball paradigm (Begleiter, Porjesz, Bihari & Kissin, 1987), which has also been found in those at high risk of alcoholism before it has developed (e.g., Begleiter, Porjesz, Bihari, & Kissin, 1984). It has been proposed that this reduced P300 amplitude is a genetic marker for alcoholism and is the consequence of disturbed frontal networks (Hill et al., 1998; Carlson, Iacono, & McGue, 2002). The psychological correlate of this phenomenon is a reduced ability to direct attention to certain stimuli, which is reflected in the diminished P300 amplitude. In contrast, participants in the present study did not receive instructions to focus their attention on one category of stimuli. Rather, given that all participants were presented with statements which (presumably) either violated or confirmed the participants' individual sets of subjective expectancies associated with alcohol, each participant served as his/her own control in that the P300 amplitude was diminished *only* in the condition composed of stimuli that did not violate their expectancies (a relationship fully predicted by context update model of P300). Thus, the data presented here imply that, independently of their general ability to focus attention on certain stimuli, individuals with higher positive expectancies (i.e., heavier drinkers) engage in revising their mental schema associated with alcohol when encountering stimuli imputing negative and sedating effects of alcohol, but not when faced with stimuli asserting positive or arousing effects of alcohol. In other words, the effects found in the present study are unconstrained by the reduced P300 amplitude effect (elicited with a classical oddball paradigm, which is, unlike the Alcohol Expectancy Violation task, is free of hot-cognition constructs) commonly cited in the alcohol literature.

Theoretical perspective

It is worth noting that there is large body of evidence indicating that final words in sentences containing a semantic anomaly elicit a negative, rather than positive, ERP component. In a seminal study, Kutas and Hillyard (1980) described a negative component (the N400) that appeared to be uniquely associated with language processing. They found that when their participants read sentences in which the last word was semantically unexpected (e.g., “He likes cream and sugar in his *socks*”), the last word elicited a negative component with a peak latency of approximately 400 ms and a maximum amplitude at centroparietal electrodes. While the present study used a similar paradigm, its results (as well as predictions) were quite distinct from the N400 effect elicited by semantic violations. Thus, it appears that the present findings established a fine but powerful distinction between registration of a semantic or linguistic anomaly vs. processing of a larger expectancy-based context above and beyond the linguistic domain. Specifically, despite the fact that the experimental stimuli used in this study were presented in a classic N400-like paradigm, all sentence endings were in fact semantically compatible with the sentence-level context. Consider, for instance, a sentence “Most alcohol tastes terrible.” Clearly, it does not violate any semantic rules, so that the word “terrible” is fairly easily integrated into the sentential context. However, it appears that the context or the framework established by a given sentence – presented externally to the participant – interacts with or activates the internalized expectancies or preexisting cognitive schema (intrinsic to each individual) associated with the concept brought up by the sentence. In other words, a less-than-one-second-long exposure to the stem “Most alcohol tastes…” invokes expectancy networks related to alcohol, which vary from one individual to another, and it is against these internal expectancy networks – not the externally presented context defined by the sentence – that the final word completing the sentence is now being evaluated or contrasted.

Imagine a person who likes to drink (as indicated by their responses to self-report alcohol expectancy questionnaires) taking part in a psychology experiment. Among fairly boring, uniform sentences describing routine life activities such as grocery shopping or studying for exams, he or she encounters a sentence about alcohol. Without perceptible effort, the alcohol concept becomes activated and spreads along the network of links associated – either explicitly or implicitly – with this concept, thereby "priming" strong associations and beliefs related to alcohol, which in an individual with high positive expectancies are likely to include *partying*, *happiness*, *good time*, *sexual arousal*, etc. For a few hundred milliseconds these associated concepts remain in a heightened, activated state, in a sense "framing" the processing of subsequently received information, be it perception, recognition or interpretation. Thus, by the time the final word of the experimental sentence appears on the screen, the participant with high positive alcohol expectancies is "ready" for a word matching these activated associations. Enter the context-update account, a major theoretical interpretation of the P300 component (Donchin, 1981; Donchin & Coles, 1988): According to this model, when the final word contradicts the activated "schema" – as was the case when individuals with high positive expectancies were presented with items describing negative effects of alcohol – the mental schema is in need of a revision or an update, a process thought to be reflected by the P300 component.

However, the application of the context-update model as an explanatory backdrop for ERP findings is not new. What is new, however, is that the current data suggest that alcohol expectancies so often indexed by verbal lexical entries (e.g., *happy*, *outgoing*, *social*) represent more than just linguistic or semantic entities (because if they are just semantic entries in the lexicon – they would elicit an N400, not a P300 component in the present experimental setup). Instead, by demonstrating the P300 effect in response to violation of alcohol expectancies, the current data suggest that expectancies represent some conceptual knowledge almost independent of the words that can describe it. Clearly, language is but one of several means that are available for conveying a concept; in other words, context is not limited to semantics. Consider, for instance, the evidence that P300 is sensitive to musical context, as demonstrated by Besson and Faita (1995) as well as Granot and Donchin (2002). These groups of authors have shown that P300 can be elicited by violation of musical expectancies (i.e., by an incongruous note in a musical phrase), especially in musicians. The results were interpreted as suggesting that formal knowledge of musical rules aided "detection" of incongruity, which resulted in larger P300-like positivity in musicians than in non-musicians.

Another interesting finding bearing upon this distinction between semantic/linguistic and conceptual/general context comes from a study by Coulson and Kutas (2001). These authors set to explore the temporal sequence of joke comprehension ability. They presented the participants with one-line jokes while recording the ERPs elicited by the last word of the joke (the "punch" word) and also tested their ability to get the joke by true/false questions testing the joke comprehension. "I asked the bartender for something cold and full of rum, and he recommended his wife" and "I let my accountant do my taxes because it saves time: last spring it saved me 10 years" are examples of the stimuli used by these authors. They found that while all participants showed greater N400-like negativity for joke than non-joke endings, only good joke comprehenders (i.e., participants able to get the jokes, based on the high rate of correct answers to the comprehension true-false questions following the joke) showed P300-like posterior positivity in response to joke endings, which the authors interpreted as reflecting registration of the surprise inherited in the joke. It is telling that the P300-like positivity was elicited only in those individuals who "got" the joke, while all participants showed N400-like negativity to joke endings. This suggested that all participants perceived the semantic anomaly of the final joke word, but those who missed the joke presumably did not have a "ready" mental representation of the joke context, at least not by the time they were presented with the joke ending. This lack of contextual preparedness or expectancy was reflected in diminished P300 among poor comprehenders, since no violation of expectancy could have taken place in this case.

The current data suggest that, similarly to good joke comprehenders or expert musicians, individuals with well-developed (or well-rehearsed) expectancy networks (as is the case in individuals with high positive alcohol expectancies, by self-report, who "profess" in drinking) exhibited evidence of the surprise element embodied by P300 when facing events disconfirming or violating their internal model of the environment. So, the observable P300 effect in response to negative alcohol items was "due" to the proficiency or expertise of these individuals in activating alcohol expectancy networks whenever faced with an alcohol cue. Once again, the P300 could not have been observed in those individuals with low expectations of effects of alcohol who "didn't get the joke."

Footnote on interpreting ERP data

Finally, it is worth mentioning that ERP data recorded from the scalp do not allow direct inferences about either the identity or the spatial location within the brain of the neural activity that gives rise to it. In other words, there is not a transparent relationship between an electrical field observed on the scalp and the brain regions giving rise to that field. Clearly, it would be of considerable value to be able to discern the intracranial sources of ERP data. Such knowledge would enhance the functional and neural interpretations of the data, and greatly facilitate its integration with findings from studies using other neuroimaging methods. However, for the purposes of the present discussion, it is important to emphasize that the findings reported by this study can only be interpreted within the information-processing and not neuroanatomical context (especially since the intracranial sources of P300 component are still largely unknown), capitalizing on the excellent temporal resolution of ERPs.

Conclusions and Future Directions

In summary, in a sample of college students, individuals with higher scores on self-reported positive alcohol expectancy displayed large P300 amplitudes in response to stimuli describing negative and sedating effects of alcohol consumption, in accordance with both Alcohol Expectancy model of drinking and P300 context update model. This was interpreted as an additional validation of the existence of differential networks of associations to alcohol among individuals with diverging drinking patterns. Future studies should aim to replicate this effect, given the relatively small sample size and the exploratory nature of the experimental proceedings in the present study, which should be taken into consideration in interpreting these results.

After careful replication of this effect, future studies might also focus on examining its temporal boundaries; namely, in both alcohol and smoking domains, a question arises as to when on the developmental continuum does the P300-analog of the substance expectancies develop? Does the P300 expectancy index develop in children prior to their first experience with alcohol beverage, preceding the stage when they can or are willing to explicitly report positive alcohol expectancies on self-report inventories? If it does, can it be used to early identify those children who are at risk for developing high positive/arousing expectancies, which are greatly correlated with heavy levels of drinking later on? On the other end of the continuum, can the P300 expectancy index help identifying those individuals who, despite undergoing substance abuse treatment and endorsing negative alcohol expectancies on explicit self-report measures in order to meet a mandatory standard for treatment termination, in fact still hold high positive and arousing expectancies and thus are in greater risk for future relapse? Furthermore, in the domain of smoking, when in the process of smoking cessation does the P300-analog of smoking expectancies change from being elicited by negative versus positive smoking items? Does it follow or precede the actual cessation and how long does it take for the information processing mechanisms to adapt a new mental schema, which underlies the difference in category eliciting P300 in current versus former smokers? Future research with the current paradigm might address these and other issues having important societal implications.

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Appendices

Appendix A: Demographic Information

- Your age:________________
- Gender (*please circle*): Male Female
- Race/Ethnicity:_____________________
- What year are you in college?_____________________________________
- What is your major?_____________________________________
- Is English your first language? (*please circle*) Yes No
  - If *No* – what is your 1st language?_____________________
- Are you right- or left-handed? (*please circle*) Right Left Ambidextrous
- Have you ever had a head injury? Yes No
  - If *Yes* – please explain:____
- Have you ever had an accident where you lost consciousness? Yes No
  - If *Yes* – about how long were you unconscious:____________________________________
- Do you have a learning disability? Yes No
  - If *Yes* – please explain:____
- Do you have any uncorrected visual impairments? Yes No
- Have you ever been diagnosed with a neurological disorder (e.g., MS, epilepsy, etc.) Yes No
  - If *Yes* – please explain (*THIS INFORMATION WILL REMAIN CONFIDENTIAL)*:_________

    ____
- Are you on any kind of medication? Yes No
  - If *Yes* – please explain (*THIS INFORMATION WILL REMAIN CONFIDENTIAL)*:_________

    ____
- Have you had any alcohol during the last 24 hours? Yes No
  - If *Yes* – when and how much:____
- Do you smoke? Yes No
  - If *Yes* – how much:____
  - If *No* – did you use to smoke? Yes (How much?______________) No

Appendix B: ERP Stimuli

1. Playing video games is a lot of...fun	4 - Other/Pleasant
2. Alcohol makes me feel ...down	2- Alc. Negative
3. Smoking makes one look...cool	4- Other/Sm. Positive
4. A couple of drinks make me more...outgoing	1- Alc. Positive
5. Eating fruits and vegetables is...unhealthy	3- *Incongruent*
6. I like going out and…dancing	4 - Other/Pleasant
7. Alcohol drinks taste...good	1 - Alc. Positive
8. When I am upset, smoking makes me feel...better	4- Other/Sm. Positive
9. A couple of drinks make me...miserable	2- Alc. Negative
10. Smoking a cigarette makes me...sick	4- Other/Sm.N egative
11. Drinking alcohol makes me...horny	1 - Alc. Positive
12. Exercising makes me feel...alert	4 - Other/Arousing
13. Clubbing on weekends is...boring	3 - *Incongruent*
14. When I'm drinking beer, I feel...depressed	2 - Alc. Negative
15. Drinking coffee makes me...awoken	4 - Other/Arousing
16. Jogging makes me feel...exhausted	4 - Other/Sedating
17. Alcohol makes me feel...happy	1 - Alc. Positive
18. If I'm feeling irritable, a smoke will help me...relax	4 - Other/Sm. Positive
19. After a few drinks, I feel...sad	2 - Alc. Negative
20. Studying for school makes me...sleepy	4 - Other/Sedating
21. During Spring break, I like to…blink	3 - *Incongruent*
22. Drinking alcohol makes me feel...powerful	1 - Alc. Positive
23. Cigarettes taste...good	4 - Other/Sm. Positive
24. When I eat junkfood, I feel...unhealthy	4 - Other/Unpleasant
25. If I have more than 2 drinks, I feel...sick	2 - Alc. Negative
26. After a workout at the gym, I always feel...tired	4 - Other/Sedating
27. Alcohol makes me feel more...assertive	1 - Alc. Positive
28. Smoking makes one seem less...attractive	4 - Other/Sm. Negative
29. When I drink alcohol, I expect to have…hangover	2 - Alc. Negative
30. Action movies are... slow	3 - *Incongruent*
31. After a few drinks of alcohol, I feel…sexier	1 - Alc. Positive
32. Smoking makes people…awake	4 - Other/Sm. Positive
33. Drinking alcohol makes me feel...depressed	2 - Alc. Negative

34. Eating chocolate makes me feel...happy	4 - Other/Pleasant
35. Alcohol makes me more...outgoing	1 - Alc. Positive
36. When I smoke a cigarette, its taste is...unpleasant	4 - Other/Sm. Negative
37. I like to cook and prepare nice…pencils	3 - *Incongruent*
38. Drinking beer makes me feel...cheerful	1 - Alc. Positive
39. When I am at school, I feel… bored	4 - Other/Sedating
40. Alcohol makes me...nauseous	2 - Alc. Negative
41. If I'm tense, a cigarette helps me to...relax	4 - Other/Sm. Positive
42. A couple of drinks make me more...aroused	1 - Alc. Positive
43. Playing video games is...boring	3 - *Incongruent*
44. Drinking alcohol makes me feel...lonely	2 - Alc. Negative
45. When I'm angry, smoking makes me feel...at ease	4 - Other/Sm. Positive
46. A drink or two can make me feel...energetic	1 - Alc. Positive
47. Eating fruits and vegetables is...healthy	4 - Other/Neutral
48. Drinking makes me feel...unhappy	2 - Alc. Negative
49. Smoking a cigarette makes me...cough	4 - Other/Sm. Negative
50. After a long day, drinking alcohol is really...refreshing	1 - Alc. Positive
51. Drinking coffee makes me...sleepy	3 - *Incongruent*
52. Alcohol drinks taste...bad	2 - Alc. Negative
53. When I am upset, smoking makes me feel…worse	4 - Other/Sm. Negative
54. Drinking alcohol makes me...sad	2 - Alc. Negative
55. When I smoke a cigarette, its taste is...pleasant	4 - Other/Sm. Positive
56. Alcohol makes me feel more...sociable	1 - Alc. Positive
57. Action movies are... fun	4 - Other/Pleasant
58. When I'm drinking beer, I feel...high	1 - Alc. Positive
59. I like my coffee with sugar and…sand	3 - *Incongruent*
60. Jogging makes me feel...energetic	4 - Other/Arousing
61. Alcohol makes me feel...nauseous	2 - Alc. Negative
62. Clubbing on weekends is...fun	4 - Other/Pleasant
63. After a few drinks, I feel more...social	1 - Alc. Positive
64. Cigarettes taste...bad	4 - Other/Sm. Negative
65. After a workout at the gym, I always feel...energized	4 - Other/Arousing
66. When I drink alcohol, I expect to have…fun	1 - Alc. Positive
67. The night before an important exam I feel...calm	3 - *Incongruent*
68. Drinking alcohol makes me feel...energized	1 - Alc. Positive

69. Smoking makes people…stink	4 - Other/Sm. Negative
70. Most alcohol tastes…terrible	2 - Alc. Negative

Appendix C: Alcohol Expectancy Questionnaire (AEQ)

Alcohol Expectancy Questionnaire

This is a questionnaire about the effects of alcohol. Read each statement carefully and respond according to your own personal feelings, thoughts, and beliefs about alcohol **now**. We are interested in what **you** think about alcohol, regardless of what other people might think.

If you think that the statement is true, or mostly true, or true some of the time, then circle the number 1, for "AGREE." If you think the statement is false, or mostly false, then circle the number 0, for "DISAGREE." When the statements refer to drinking alcohol, you may think in terms of drinking any alcoholic beverage, such as beer, wine, whiskey, liquor, rum, scotch, vodka, gin, or various alcoholic mixed drinks. Whether or not you have had actual drinking experiences yourself, **you are to answer in terms of your beliefs about alcohol**. It is important that you respond to **every question**.

PLEASE BE HONEST. REMEMBER, YOUR ANSWERS ARE CONFIDENTIAL.

RESPOND TO THESE ITEMS ACCORDING TO WHAT YOU PERSONALLY BELIEVE TO BE TRUE ABOUT ALCOHOL

0=DISAGREE1=AGREE

0	**1**	1. Some alcohol has a pleasant, cleansing, tingly taste.
0	**1**	2. Drinking adds a certain warmth to social occasions.
0	**1**	3. When I'm drinking, it is easier to open up and express my feelings.
0	**1**	4. Time passes quickly when I'm drinking.
0	**1**	5. Drinking makes me feel flushed.
0	**1**	6. I feel powerful when I drink, as if I can really influence others to do what I want.
0	**1**	7. Drinking gives me more confidence in myself.
0	**1**	8. Drinking makes me feel good.
0	**1**	9. I feel more creative after I've been drinking.
0	**1**	10. Having a few drinks is a nice way to celebrate special occasions.
0	**1**	11. When I'm drinking I feel freer to be myself and do whatever I want.
0	**1**	12. Drinking makes it easier to concentrate on the good feelings I have at the time.

RESPOND TO THESE ITEMS ACCORDING TO WHAT YOU PERSONALLY BELIEVE TO BE TRUE ABOUT ALCOHOL

0=DISAGREE 1=AGREE

0	**1**	13. Alcohol allows me to be more assertive.
0	**1**	14. When I feel "high" from drinking, everything seems to feel better.
0	**1**	15. I find that conversing with members of the opposite sex is easier for me after I've had a few drinks.
0	**1**	16. Drinking is pleasurable because it's enjoyable to join in with people who are enjoying themselves.
0	**1**	17. I like the taste of some alcoholic beverages.
0	**1**	18. If I'm feeling restricted in any way, a few drinks make me feel better.
0	**1**	19. Men are friendlier when they drink.
0	**1**	20. After a few drinks, it is easier to pick a fight.
0	**1**	21. If I have a couple of drinks, it is easier to express my feelings.
0	**1**	22. Alcohol makes me need less attention from others than I usually do.
0	**1**	23. After a few drinks, I feel more self-reliant than usual.
0	**1**	24. After a few drinks, I don't worry as much about what other people think of me.
0	**1**	25. When drinking, I do not consider myself totally accountable or responsible for my behavior.
0	**1**	26. Alcohol enables me to have a better time at parties.
0	**1**	27. Drinking makes the future seem brighter.
0	**1**	28. I often feel sexier after I've had a couple of drinks.
0	**1**	29. I drink when I'm feeling mad.
0	**1**	30. Drinking alone or with one other person makes me feel calm and serene.
0	**1**	31. After a few drinks, I feel brave and more capable of fighting.
0	**1**	32. Drinking can make me more satisfied with myself.

RESPOND TO THESE ITEMS ACCORDING TO WHAT YOU PERSONALLY BELIEVE TO BE TRUE ABOUT ALCOHOL

0=DISAGREE 1=AGREE

0	**1**	33. My feelings of isolation and alienation decrease when I drink.
0	**1**	34. Alcohol helps me sleep better.
0	**1**	35. I'm a better lover after a few drinks.
0	**1**	36. Alcohol decreases muscular tension.
0	**1**	37. Alcohol makes me worry less.
0	**1**	38. A few drinks makes it easier to talk to people.
0	**1**	39. After a few drinks I am usually in a better mood.
0	**1**	40. Alcohol seems like magic.
0	**1**	41. Women can have orgasms more easily if they've been drinking.
0	**1**	42. Drinking helps get me out of a depressed mood.
0	**1**	43. After I've had a couple of drinks, I feel I'm more of a caring, sharing person.
0	**1**	44. Alcohol decreases my feelings of guilt about not working.
0	**1**	45. I feel more coordinated after I drink.
0	**1**	46. Alcohol makes me more interesting.
0	**1**	47. A few drinks makes me feel less shy.
0	**1**	48. Alcohol enables me to fall asleep more easily.
0	**1**	49. If I'm feeling afraid, alcohol decreases my fears.
0	**1**	50. Alcohol can act as an anesthetic, that is, it can deaden pain.
0	**1**	51. I enjoy having sex more if I've had some alcohol.
0	**1**	52. I am more romantic when I drink.
0	**1**	53. I feel more masculine/feminine after a few drinks.
0	**1**	54. Alcohol makes me feel better physically.
0	**1**	55. Sometimes when I drink alone or with one other person it is easy to feel cozy and romantic.

RESPOND TO THESE ITEMS ACCORDING TO WHAT YOU PERSONALLY BELIEVE TO BE TRUE ABOUT ALCOHOL

0=DISAGREE 1=AGREE

0	**1**	56. I feel like more of a happy-go-lucky person when I drink.
0	**1**	57. Drinking makes get-togethers more fun.
0	**1**	58. Alcohol makes it easier to forget bad feelings.
0	**1**	59. After a few drinks, I am more sexually responsive.
0	**1**	60. If I'm cold, having a few drinks will give me a sense of warmth.
0	**1**	61. It is easier to act on my feelings after I've had a few drinks.
0	**1**	62. I can discuss or argue a point more forcefully after I've had a drink or two.
0	**1**	63. A drink or two makes the humorous side of me come out.
0	**1**	64. Alcohol makes me more outspoken or opinionated.
0	**1**	65. Drinking increases female aggressiveness.
0	**1**	66. A couple of drinks makes me more aroused or physiologically excited.
0	**1**	67. At times, drinking is like permission to forget problems.
0	**1**	68. If I am tense or anxious, having a few drinks makes me feel better.

Appendix D: Alcohol Expectancy Multi-Axial Assessment (AEMax)

This page contains words describing possible effects of alcohol. For each word, imagine it completing the sentence: "**DRINKING ALCOHOL MAKES ONE ________**." Then, for each word **mark the number that indicates how often you think that this effect happens or would happen after drinking several drinks of alcohol**. "Drinking alcohol" refers to drinking any alcoholic beverage such as beer, wine, wine coolers, whiskey, scotch, vodka, gin, or mixed drinks.

There are no right or wrong answers. Answer each item quickly according to your first impression and according to your own personal beliefs about the effects of alcohol.

The available responses/numbers and their meaning are indicated below:

0	1	2	3	4	5	6
Never	**Very Rarely**	**Rarely**	**Occasionally**	**Frequently**	**Very Frequently**	**Always**

"DRINKING ALCOHOL MAKES ONE ________."

1. Appealing	________	13. Horny	________
2. Arrogant	________	14. Ill	________
3. Attractive	________	15. Light-headed	________
4. Beautiful	________	16. Lustful	________
5. Cocky	________	17. Nauseous	________
6. Dangerous	________	18. Outgoing	________
7. Deadly	________	19. Sick	________
8. Dizzy	________	20. Sleepy	________
9. Drowsy	________	21. Sociable	________
10. Egotistical	________	22. Social	________
11. Erotic	________	23. Tired	________
12. Hazardous	________	24. Woozy	________

Appendix E: Pattern of Alcohol Use

1. During the past year, about how frequently did you drink alcohol? Please indicate the response below, which comes closest to describing your drinking pattern.

   (0) Never; I don't use alcohol
   (1) Once or twice during the year
   (2) 3 to 6 times per year
   (3) 7 to 10 times per year
   (4) About once a month
   (5) 2 or 3 times a month
   (6) Once or twice a week
   (7) 3 or 4 times a week
   (8) 5 or more times a week

2. On occasions when you drink, about how many drinks do you typically consume? Please estimate the actual number of drinks, where:

   1 drink = approximately 1 can or bottle of beer, or
   = 1 glass or wine or wine cooler, or
   = 1 shot of liquor or a mixed drink. (Circle only one number)

   (0) None; I don't use alcohol
   (1) One drink
   (2) 2 drinks
   (3) 3 drinks
   (4) 4 drinks
   (5) 5 drinks
   (6) 6-8 drinks
   (7) 9-12 drinks
   (8) 13 or more drinks

3. During the past year, how frequently did you drink enough alcohol to get drunk or "high"? Please indicate the response below which comes closest to describing your drinking pattern.

   (0) Never
   (1) Once or twice during the year
   (2) 3 to 6 times per year
   (3) 7 to 10 times per year
   (4) About once a month
   (5) 2 or 3 times a month
   (6) Once or twice a week
   (7) 3 or 4 times a week
   (8) 5 or more times per week

Appendix F: Family History Grid

Family Grid

This instrument is to be administered as a personal interview

This questionnaire concerns your family and experiences that family members have had with alcohol. Please begin by describing your family by indicating in ***Column A*** the total number of biological (i.e., related by blood) relatives (both living and dead) that you have in each category on each side of your family. For example, although you have only one biological grandmother on your mother's side (as shown in Column A), you may have several aunts (your mother's biological sisters) or none at all. If you have no relatives in a particular category, put the letter "N" (for "None") in Column A in the space next to the category. If you don't know how many relatives you have in a category, put "DK" (for "Don't Know") in the space.

Next, please indicate in ***Column B*** the number of biological relatives (both living and dead) in each category that had in the past, or currently have, what you would call a significant drinking problem, one that did, or should have, led to treatment. Some signs that drinking may be a problem include legal problems (e.g., drunk driving violations), health problems (e.g., cirrhosis of the liver, alcohol withdrawal symptoms), relationship problems (e.g., arguments about alcohol with family members), or work/school problems (e.g., poor performance, absenteeism resulting from alcohol use), or actual treatment (e.g., detox or rehab, AA meeting attendance). If you have no relatives with alcohol problems in a particular category, put the letter "N" (for "None") in Column A in the space next to the category. If you don't know how many relatives you have in a category, put "DK" (for "Don't Know") in the space.

Biological Relative	**A**	**B**
Mother' Side	**Number of biological relatives**	**Number of relatives with alcohol problems**
Grandmother	1	
Grandfather	1	
Mother	1	
Aunt(s)		
Uncle(s)		
Father's Side		
Grandmother	1	
Grandfather	1	
Father	1	
Aunt(s)		
Uncle(s)		
Siblings		
Brother(s)		
Sister(s)		

About the Author

Inna Fishman received a Bachelor's Degree, with a major in Psychology and a minor in Philosophy, from Bar-Ilan University in Israel in 1997. She received a Master's Degree in Psychology from State University of New York at Buffalo in 2002, when she entered the Ph.D. program in Clinical Psychology at the University of South Florida in Tampa, Florida.

While in the Ph.D. program at the University of South Florida, Ms. Fishman was very active in two research laboratories, one led by Dr. Mark Goldman, whose expertise is in the field of alcohol expectancies, and the other led by Dr. Emanuel Donchin, an expert in the field of human electrophysiology and cognitive neuroscience.