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## Assessing the San José State University Simultaneous Polydrug Use Questionnaire – Online (SJSU SPUQ – Online) A Pilot Study

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ASSESSING THE SAN JOSÉ STATE UNIVERSITY  
SIMULTANEOUS POLYDRUG USE  
QUESTIONNAIRE – ONLINE (SJSU SPUQ – ONLINE): A PILOT STUDY

A Thesis

Presented to

The Faculty of the Department of Psychology

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Joseph P. Hennessee

August 2013

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The Designated Thesis Committee Approves the Thesis Titled

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SIMULTANEOUS POLYDRUG USE  
QUESTIONNAIRE – ONLINE (SJSU SPUQ – ONLINE): A PILOT STUDY

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August 2013

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## ABSTRACT

### ASSESSING THE SAN JOSÉ STATE UNIVERSITY SIMULTANEOUS POLYDRUG USE QUESTIONNAIRE – ONLINE (SJSU SPUQ – ONLINE): A PILOT STUDY

by Joseph P. Hennessee

Alcohol use is one of the most prevalent forms of drug use among college students. Because of the near ubiquity of college drinking, additional research is needed to determine whether such alcohol use is related to any cognitive impairment.

Furthermore, many of those who use alcohol consume one or more additional drugs simultaneously, and little research has assessed whether such simultaneous polydrug use (SPU) has a further effect on cognitive functioning. This study was developed to bridge these two gaps in the literature and aid in the development of the SJSU SPUQ – Online.

Through the use of computerized tasks assessing working memory and executive functioning, the cognitive impact of recent alcohol use and frequent SPU were assessed in a sample of college students. Additionally, recent datasets utilizing the original paper version of the SJSU SPUQ and the current SJSU SPUQ – Online were compared. Results indicated that those who used alcohol within the last week spent less time planning the executive functioning task than those who did not. Data from both versions suggest that SPU is very frequent on this college campus and typically involves combinations of the drugs participants use individually. Additionally, the results of this study indicated some ways that the SJSU SPUQ – Online could be further developed and improved, such as expanding the item selection.

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## **Introduction**

Alcohol is one of the most widely used and abused drugs among college students and its abuse can have a variety of negative effects on physical health and cognitive functioning (Levinthal, 2008, pp. 216-231). Although researchers such as O'Malley and Johnston (2002) have found that the majority of college students consume alcohol, the impact of alcohol use on cognitive functioning is not fully understood. Furthermore, few studies have included simultaneous polydrug use (SPU) habits in their analyses of alcohol and cognition. As defined by Earleywine and Newcomb, simultaneous polydrug use involves the "ingestion of multiple drugs in such a way that their intoxication occurs at the same time" (1997, pp. 353-354). For heavy drinkers, SPU is common, and the adverse effects of the drugs in the combination may combine in an additive or synergistic pattern (Fisk, Murphy, Montgomery, & Hadjiefthyvoulou, 2010; Martin, Kaczynski, Maisto, & Tarter, 1996). Therefore, SPU may be a uniquely important confound in studies of alcohol use and cognitive performance.

As there is a paucity of standardized scales usable to measure SPU, the current study was designed to pilot and aid in the development of the San José State University Simultaneous Polydrug Use Questionnaire - Online (SJSU SPUQ Online; Laraway & Snyckerski, 2009). A secondary goal of this study was to assess if there is a relationship between alcohol use and SPU habits in college students with their performance on computerized working memory and executive functioning tasks. These analyses were made as much to assess this relationship as to determine if the SJSU SPUQ – Online can efficiently be used for such a task. The remainder of this introduction outlines research

regarding alcohol use and the neurological effects of alcohol use, SPU, working memory, executive functioning, the relationship between alcohol use and SPU with cognitive functioning, and the measurement of drug use and cognitive variables.

### **Alcohol Use**

Alcohol consumption is extremely popular among adolescents and young adults, despite the fact that many of them are too young to drink legally in the United States. A 2002 study by the World Health Organization found that 65% of those 15 years of age or older drank alcohol in that year, and only 17.7% of surveyed participants reported lifetime abstinence (WHO, 2011). When examining data on college students specifically, O'Malley and Johnston (2002) estimated that the 30-day prevalence rate for alcohol consumption was 69.6%. Therefore, the vast majority of college students consume alcohol, and sampling participants as young as 15 years of age results in prevalence rates only slightly lower than that seen on college campuses. It is apparent that many college-aged drinkers started drinking at a younger age. The most commonly consumed alcoholic beverages in order of consumption were beer, spirits (e.g., vodka and whiskey), and wine.

Furthermore, although many adolescents and young adults are light social drinkers, a considerable proportion of them drink heavily on a regular basis. O'Malley and Johnston (2002) estimated that nearly half (40%) of college students report heavy drinking—defined as having five or more drinks on the same occasion—in any given two-week period, suggesting that an unhealthy level of use is widespread and frequent. This may be partly due to the popularity of drinking games at that age range and the

strong presence of peer pressure. Data from 2004 indicated that approximately 5.5% of males and 1.9% of females ages 15 years or older have a diagnosable alcohol use disorder (WHO, 2011). Clearly, even among adolescents and young adults, alcoholism is a serious concern.

Unfortunately, alcohol use is not without consequence, as chronic and heavy use can have a deleterious impact on health. Adolescent and young adult drinkers may experience negative effects on their liver, bone density, physical growth, and endocrine development due to excessive alcohol consumption (Clark, Lynch, Donovan, & Block, 2001; Dick, Rose, Viken, & Kaprio, 2000; Emanuele, Wezeman, & Emanuele, 2002; Neville et al. 2002). Furthermore, as alcohol use can reduce adolescent sex hormone production, sustained use may have a negative influence on physical development (Emanuele et al., 1998). As adolescence is a critically important time for physical and neurological growth, the health problems linked with early alcohol use are an important concern.

At a neural level, alcohol use has been shown to damage neural structures and functioning while also hindering the creation of new neurons (see Crews, 2008, for a review). In particular, the presence of alcohol has been shown to hinder the creation of neurons in the hippocampus, and alcoholism is linked to a smaller size of frontal cortical regions (Bison & Crews, 2003; Harper & Matsumoto, 2005). Interestingly, for up to three weeks after the cessation of alcohol use, neural regrowth typically occurs at above normal rates (Bison & Crews, 2003). This recovery period partially mitigates the long-term impact of alcohol use on neural structures. Nevertheless, if heavy consumption

patterns are sustained for long enough, lasting impairments are observable both neurologically and in terms of cognitive functioning (Bison & Crews, 2003; Green et al., 2010).

### **Neurological Effects of Alcohol Use**

Through the use of various methodologies, such as neuroendocrine challenge testing and positron emission tomography (PET), it has been shown that chronic and excessive alcohol use impairs neurotransmitter system functioning in a variety of different brain regions (Fahlke et al., 2012; Nishikawa et al., 2009). Serotonin, dopamine, and noradrenaline, in particular, tend to be affected by alcohol use (Balldin et al., 1992; Smith, Co, McIntosh, & Cunningham, 2008). At the same time, neurotransmitter activity is often improved in select brain regions. Therefore, it is important that findings from different methodologies be compared and contrasted.

Serotonin systems have repeatedly been found to be impaired in alcohol-dependent and heavy drinkers (Balldin, Berggren, Engel, & Eriksson, 1994; Fahlke et al., 2012). In a study by Fahlke et al. (2012), neuroendocrine challenge testing was used to determine the impact of alcohol dependency upon serotonin, dopamine, and noradrenaline systems. Participant prolactin response to Citalopram, growth hormone response to Apomorphine, and growth hormone response to Clonidine were examined to assess serotonin, dopamine, and noradrenaline systems, respectively. A 48% blunted response to Citalopram occurred, suggesting that serotonin system functioning was heavily impaired in alcohol-dependent drinkers. Growth hormone responses to Apomorphine and Clonidine were lower at almost all time points for those with an

alcohol dependence, which suggests that statistically significant impairment would have been discovered with a larger sample size. At the same time, it is important to note that the alcoholics used in this study may not fully represent alcoholics in the greater population because almost all participants had a job, a permanent residence, and membership in at least one alcohol-treatment program. Balldin et al. (1994) showed similar serotonergic impairments in those classified as heavy drinkers according to the Diagnostic and Statistical Manual of Mental Disorders 4<sup>th</sup> ed. (DMS-IV, American Psychiatric Association, 2000). Prolactin responses to fenfluramine hydrochloride were severely blunted in those classified as heavy drinkers compared with light social drinkers, suggesting that heavy drinking often leads to an impaired serotonin system. Thus, both alcohol dependency and non-dependent heavy drinking may lead to impaired functioning in serotonin systems.

Although Fahlke et al. (2012) did not show impairments in dopamine or noradrenaline systems for those with alcohol dependency, others have done so (Badanich, Maldonado, & Kirstein, 2007; Balldin et al., 1992). More specifically,  $\alpha$ -2-adrenoceptor sensitivity may be reduced during the first week of withdrawal in alcohol-dependent drinkers (Balldin et al., 1992). This difference was found using neuroendocrine challenge testing utilizing Clonidine. In another study, rats who were trained to drink ethanol for 20 days and then spent 14 days without ethanol exhibited increased extracellular dopamine levels in the anterior shell of the nucleus accumbens (Badanich et al., 2007). Therefore, altered dopamine levels in the nucleus accumbens likely play a role in alcohol addiction. Taken together, these two studies show that neurotransmitter

system functioning during ethanol deprivation may be just as important to understand as functioning during periods of alcohol use and that multiple neurotransmitter systems may be heavily impaired by excessive alcohol use.

Although neuroendocrine studies often show that alcohol-dependent individuals have overall impairments in their serotonin systems, studies utilizing PET with humans or animal research can give a more detailed description of the areas that show impairment (Ballidin, et al., 1994; Fahlke et al., 2012). In an ingenious study by Nishikawa et al. (2009), magnetic resonance imaging (MRI) scans were co-registered onto PET scans, along with a radiotracer, to compare the rates of serotonin synthesis between both alcohol-dependent and non-alcoholic human participants. By administering participants with the radiotracer  $\alpha$ -[ $^{11}\text{C}$ ]-methyl-L-tryptophan, tryptophan conversion into serotonin was determined, thus indirectly assessing how well serotonin was synthesized. No differences in either white or gray matter volume were detected between the two groups. For alcohol-dependent drinkers, serotonin synthesis decreased in the medial portions of the brain, Brodmann Areas (BA) 9, 10, and 32. Brodmann Areas 9 and 10 are part of the prefrontal cortex and are involved in planning, self-control, and moderating social behavior, whereas BA 32 is the anterior cingulate gyrus. However, serotonin synthesis was greater among alcohol-dependent drinkers in the superior temporal gyrus (BA 41) and occipital lobe (BA19). Because visual hallucinations are sometimes experienced during alcohol withdrawal, the authors argued that the increased serotonin in the occipital lobe (BA19) could be partly responsible for these symptoms. By using this unique methodology, it was found that alcohol-dependent drinkers have both regional increases

and decreases in serotonin synthesis. Therefore, results from this methodology give a better description of alcohol's impact on neurotransmitter systems than the overall measure of neurotransmitter synthesis provided by neuroendocrine challenge testing.

Further research using rats has shown where regional differences in neurotransmitters such as serotonin, dopamine, noradrenaline, GABA, glutamate, and aspartate may occur (Smith et al., 2008). In a study by Smith et al. (2008), rats were trained to binge drink ethanol for 50 or more days, with some continuing consumption up until death, whereas others were ethanol deprived prior to death.  $D$ -Glucose,  $L$ -[ $G$ - $^3H$ ] tryptophan, and  $L$ -[2,3,5,6- $^3H$ ] tyrosine were used to determine the turnover rates (TORs) of the before mentioned neurotransmitters. There were three uniquely different rat profiles. As expected, the sucrose and non-drinking rats showed the best neurotransmitter functioning for all neurotransmitters. Rats with a history of ethanol binge drinking, but deprived of EtOH before death, showed the most impairment in neurotransmitter functioning. This group showed 44 region-specific TOR decreases involving serotonin, dopamine, noradrenaline, GABA, and glutamate and seven regional TOR increases for these neurotransmitters. Neurotransmitter impairments were strongest in the nucleus accumbens and amygdala. Serotonin was generally impaired throughout the brain, with 23 brain regions showing reduced serotonergic functioning. Dopamine was decreased in limbic regions and increased in the entorhinal subicular cortex and brain stem. Noradrenaline was also decreased in several regions and increased in the anterior cingulate cortex and amygdala. Interestingly, rats with a binge-drinking history that were not deprived of ethanol prior to death showed considerably less impairment with TORs in

six brain regions, such as the anterior cingulate cortex and hypothalamus, fully returning to levels similar to the healthy control conditions. Overall, a history of binge drinking can lead to altered (typically impaired) serotonin, dopamine, noradrenaline, glutamate, GABA, and aspartate functioning; these differences are intensified during periods of alcohol deprivation. Additionally, their study supports the theory that chronic alcohol use often produces an allostatic state wherein failure to use alcohol regularly leads to negative affect, and in this case, impairments in various neurotransmitter systems (Koob, 2005).

Sun et al. (2012) suggested that alcohol-related neurotransmitter system impairment leads to numerous negative consequences, including how alcoholics respond to drinking cues. In this study, the authors explained that tryptophan (Trp), and tyrosine (Try)/phenylalanine (Phe) are necessary for the biosynthesis of serotonin and dopamine. Without these amino acids, serotonin and dopamine are reduced *in vivo*. The researchers gave a sample of males with alcohol dependence—classified accordingly to the DSM-IV—either a Trp and Try/Phe enriched beverage or a non-enriched beverage. These participants were later asked to fill an empty glass with alcohol and smell the alcohol, or to fill an empty glass with water and smell the water. Both participants' urge to drink and diastolic blood pressure were elevated more in response to exposure to the alcoholic beverage when not given the enriched beverage compared to those who were given the enriched beverage. This suggests that monoamine depletion and attenuated serotonin and dopamine synthesis may lead to alcoholic drinks becoming more salient. In light of these

findings, neurotransmitter system impairment caused by heavy and chronic alcohol use likely leads to an increased urge to drink, thus continuing the cycle of alcohol use.

### **Measuring Alcohol Use**

A variety of measures are available to the researcher interested in assessing patterns of alcohol use. Although most researchers often include a few of their own questionnaire items pertaining to alcohol use in their studies, it is common to use standardized measures of alcohol use. Two highly common measures of alcohol use include the Diagnostic and Statistical Manual of Mental Disorders IV-TR (DSM-IV-TR, American Psychiatric Association, 2000) and the Alcohol Use Disorders Identification Test (AUDIT, Saunders et al., 1993). The DSM-IV-TR is frequently used in alcohol research to group participants with a clinically diagnosable alcohol use disorder versus those with non-clinical levels of alcohol consumption (e.g., Caspers et al., 2010; Fernandez-Serrano, Perez-Garcia, Rio-Valle, & Verdejo-Garcia, 2010). By DSM-IV-TR criteria, a person is diagnosable for alcohol abuse if they are not diagnosable for alcohol dependence and their recurrent use has had at least one of the following effects in the past 12 months: (a) a failure to fulfill major role obligations at work, school, or home, (b) alcohol consumption in physically hazardous situations (e.g., drunk driving), (c) alcohol-related legal problems, or (d) continued alcohol use despite the presence of social or interpersonal problems caused or exacerbated by alcohol use. By DSM-IV-TR criteria, a person is diagnosable for alcohol dependence if he or she has had at least three of the following problems in the past 12 months due to continued alcohol use: (a) an increased level of alcohol tolerance, (b) alcohol-related withdrawal or drinking to avoid such

symptoms, (c) drinking in larger amounts or over longer periods of time than intended, (d) at least one unsuccessful attempt to control drinking habits or a persistent desire, (e) social, occupational, or recreational activities given up or reduced because of drinking, (f) a great deal of time spent in activities related to procuring alcohol, using alcohol, and recovering from said use, or (g) continued drinking despite knowledge that drinking caused or exacerbated a personal physical or psychological problem. Note that the fifth edition of the DSM was recently released and alcohol dependence is now labeled alcohol addiction (American Psychiatric Association, 2013). Although using the DSM to officially diagnose someone with alcohol abuse or dependence requires an experienced and licensed psychological clinician, it still remains a highly popular way to assess participants' alcohol-use patterns for research purposes. The DSM's popularity as a research tool is perhaps not surprising given its long history as a reputable tool for diagnosing psychological problems, such as problematic alcohol use.

The AUDIT is another widely used measure of alcohol use. This measure includes items assessing alcohol consumption, drinking behavior (e.g., dependence), adverse psychological reactions, and alcohol-related problems. Alcohol behavior items ask participants to report how often in the past year they have been unable to stop drinking once they start, failed to do what was normally expected of them (e.g., interpersonal commitments), and needed a drink in the morning to help recover from a heavy drinking session. Items assessing adverse psychological reactions ask participants how often in the past year they had a feeling of guilt or remorse after drinking and how often they were unable to remember the events of the night before due to excessive

drinking. Items assessing alcohol-related problems ask participants whether a relative, friend, doctor, or health worker has been concerned about their drinking or asked them to cut down, and whether alcohol use has led to injuries to one's self or others. Items regarding alcohol consumption ask participants how often they have a drink containing alcohol, how many drinks they consume on a typical drinking day, and how often they have six or more drinks on one occasion. The individual AUDIT items and the overall score have acceptably high to excellent re-test reliability, with most coefficients being above .75, and with several above .90 (Saunders et al., 1993).

Although some of the AUDIT items are clearly similar to criteria from the DSM-IV-TR, AUDIT scores are more quantitative in nature than DSM diagnoses. Each question is scored from 0 to 4, and the test generates a total score between 0 and 40. Additionally, the later items regarding alcohol consumption provide researchers with multiple continuous variables that may more accurately assess the severity of alcohol consumption than simple dichotomous variables (i.e., clinical diagnosis vs. no diagnosis). Previous statistical research by McCallum et al. (2002) has shown that the use of dichotomous variables most often attenuates correlations and effect sizes for the variable in question. They argued that continuous variables, when usable, are often a more accurate and useful way to measure a construct for research purposes. Therefore, although clinical diagnoses have immense real-world importance and utility in clinical settings, researchers will likely benefit from focusing on continuous measures of alcohol use, such as the AUDIT, when possible.

Much of the research on alcohol use patterns and cognitive functioning is based on standardized measures of alcohol use, such as the DSM and the AUDIT; however, most researchers also include small questionnaires with their own alcohol-use items. These items most often assess the recency of alcohol use, frequency of use, quantity typically consumed, and age of onset. Participants' recency of use is often indirectly assessed by wording frequency of use items in terms of use in the last year or in the last six months; however, some researchers prefer to specifically ask participants how long it has been since they last drank alcohol (e.g., Bates & Tracey, 1990; Fitzpatrick & Crowe, 2013). It may be useful to include alcohol use recency items since research suggests that neuroregeneration occurs at above-normal rates during extended periods of abstinence (Bison & Crews, 2003). This suggests that it may be more difficult to find any alcohol-related cognitive impairment after long periods of abstinence and highlights the importance of assessing alcohol use that is relatively recent. Participants' frequency of alcohol consumption is often assessed by asking them how many days in a typical month they consume alcohol (e.g., Caspers et al., 2010). For timeline follow-back methodologies, this can be effectively computed as the percent of days per month (Sobell & Sobell, 1992; Thoma et al., 2011). Quantity of alcohol use is typically determined by asking participants how many drinks they drink on a typical drinking day (e.g., Thoma et al., 2011). Solowij et al. (2011) presents a potentially effective way to measure participants' age of onset by asking them both their age of first use and the age they began regular use. By including questionnaire items pertaining to the recency of alcohol use, frequency of use, quantity typically consumed in a day, and age of onset, researchers

are able to have multiple effective measures of alcohol use that can supplement or be used in place of standardized measures.

### **Simultaneous Polydrug Use**

Although most of the psychological literature on drug usage has focused on single drug use, in reality many people use more than one drug simultaneously, which poses unique methodological concerns (Doumann & Gouzoulis-Mayfrank, 2006; Ives & Ghelani, 2006). As mentioned earlier, simultaneous polydrug use involves the “ingestion of multiple drugs in such a way that their intoxication occurs at the same time” (Earleywine & Newcomb, 1997, pp. 353-354). Although metabolites from each drug may persist for days, phrasing SPU in terms of overlapping intoxication may help participants to recall the event more easily. In 2006, a study on the prevalence of drug use found that 55% of university students smoked tobacco or cannabis last time they drank alcohol, and 16% used an illicit drug simultaneously with alcohol (Barrett, Darredeau, & Pihl, 2006); these results are similar to those found in older studies of SPU prevalence rates (Earleywine & Newcomb, 1997; Martin et al., 1996). Furthermore, Martin et al. (1996) found that up to 72% of those diagnosable for alcohol abuse had an occurrence of SPU in the past four months. Therefore, SPU is remarkably frequent, especially among alcohol users.

### **Measuring Simultaneous Polydrug Use**

It is likely that there are fewer standardized measures of SPU, compared with alcohol use, because much less research has been made on long-term SPU and such research is often quite recent. Researchers interested in SPU often simply create and

administer a few questionnaire items regarding the combinations they are interested in based on the goals and hypotheses of their current study. However, one option for a standard measure of SPU is Barrett and colleagues' (2006) structured interview for polysubstance use. In this interview, the experimenter asks participants to list every substance they have used to get "high, drunk, stoned or buzzed in their lifetime" (p. 256). The experimenter then reads from a standard list of drugs to aid in participant drug recall. Participants are asked about their age of first use and number of uses in the preceding 30 days for the drugs they listed. For each of the drugs on this list, participants are asked if they had ever co-administered other substances during a session in which it had been used, and to list all of the substances ever used in combination with the drug. Participants are also asked to provide specific details about the last time they used each drug, in order to anchor recollections to a specific occasion. Although this interview does not currently include items regarding participants' SPU frequency, this could be asked after the interview. Problems with structured interviews include the possibility of increased reactivity to face-to-face questions regarding socially unacceptable and/or illegal behavior and increased amount of time required to conduct such interviews. Therefore, many researchers have chosen to use anonymous questionnaires.

When not using standardized measures to assess SPU, researchers often create their own questionnaire items to assess the drug combinations in which they are specifically interested. In McCabe, Cranford, Morales, & Young (2006), for example, the researchers asked participants to report the number of days in the past 12 months that they used prescription stimulant medication, not prescribed by a doctor, at the same time

they used alcohol. This item served as their frequency measure for SPU. Other researchers have assessed SPU frequency, but instead asked their frequency question(s) for multiple drug combination categories to broaden their possible number of findings (e.g., Earleywine & Newcomb, 1997; Fisk et al., 2010). On the one hand, for research regarding long-term SPU patterns, it may be prudent to only ask about a few drug combinations of interest, because such data are readily usable for statistical analysis. This reduces the time needed to code specific drug combinations that the researcher may not be interested in. On the other hand, it is beneficial to allow participants to report which combinations they specifically use, such as in an open-ended answering format, because that would likely give a more realistic description of what drugs participants are using in combination.

### **Cognitive Functioning: Working Memory**

Working memory (WM) is a key component in cognitive functioning and has received extensive research. The concept of WM was developed by Baddeley (1986) and is currently considered to be a limited memory storage that serves as the necessary connection between perception, long-term memory, and behavior. Baddeley's model explains WM as being composed of a phonological loop and a visuospatial sketchpad. The phonological loop is comprised of a phonological store, which stores auditory information for a few seconds, and an articulatory rehearsal process similar to subvocal speech. Information retrieval and re-articulation renews memory traces in the phonological store (Baddeley, 2003). The visuospatial sketchpad is a WM component specializing in visual and spatial information and can only store 3 or 4 objects at a time

(Baddeley, 2003). Both the phonological loop and the visuospatial sketchpad are then connected to the final unit, the central executive. This center utilizes information from the other two WM units, and is involved in attentional control.

In examining the brain, WM involves the activation of many different regions. For example, the development of effective WM capacity is linked with activity in the left superior frontal and left intraparietal areas (Klingberg, 2002). These areas exhibited sustained activity during a WM intensive delayed match to sample (DMS) task. Additionally, activity in the middle frontal gyrus, the posterior part of the superior frontal gyrus, and the posterior part of the intraparietal sulcus predicted accurate recall on a spatial WM task with a distractor stimulus (Sakai, 2002). Sakai (2002) suggests that the PFC plays an important role in making WM distractor-resistant.

When defining any complex construct, it is important to determine whether one is looking at a truly domain-general ability or simply a collection of different abilities, one for each type of task. A particularly thorough study by Kane et al. (2004) provided support that working memory can be viewed both as an overall ability, known as working memory capacity, and as two separate abilities (i.e., verbal and visuospatial abilities). To determine the generalizability of working memory capacity, they tested young adults on six basic short-term memory tasks, five working memory tasks, and 13 reasoning tasks. The authors found that 70 – 85% of the performance on the verbal and visuospatial working memory tasks was shared across this selection of tasks. Therefore, performance on one WM task was highly predictive of performance on a different WM task. Short-term memory tasks, in contrast, only shared 40% of their variance with one another.

Confirmatory factor analysis showed that a one factor model fit the WM task data quite well, indicating that WM can be considered a domain-general ability. In line with the theory of WM developed largely by Baddeley (1986), Kane et al. (2004) found that a two factor model fit the WM data slightly better: working memory can best be described as including auditory and visuospatial memory. In summary, research supports that working memory can accurately be described as either a generalized ability (working memory capacity) or as two separate abilities: phonological memory and visuospatial memory.

Although research supports that WM is best separated into two factors (e.g., Kane et al., 2004), the nature of visuospatial WM is more ambiguous. Research by Sala et al. (1999) suggests that this component of working memory may be better separated into spatial WM and visual WM. In order to assess whether visual and spatial working memory are truly unified, they examined the Corsi Block Test, which involves spatial processing, and a Visual Patterns Test (VPT) they developed to more purely assess visual memory without a spatial component. The VPT requires participants to memorize block grids with shaded and non-shaded patterns as small as 2 x 2 (2 shaded blocks) and with some as large as 5 x 6 (15 shaded blocks). Interestingly, the authors found that the correlation between performance on the VPT and the more spatial Corsi Block Test is remarkably small ( $r = .27$  to  $.35$ ). Subsequent experiments by Sala et al. supported this finding. First, they found a double dissociation between VPT and Corsi Block Test skills in that some brain damaged patients performed poorly on one test, yet performed at normal levels on the other test. Other brain damaged patients they assessed performed

well on only the opposite test. Second, they found that selective interference tasks (i.e., visual or spatial) primarily affected only the test specialized for visual or spatial memory, respectively, suggesting that these two tests tap into specific visual and spatial memory abilities. Thus, visuospatial WM is likely composed of separate cognitive processes for memory that are either purely visual or more spatial in nature.

In summary, working memory is an important limited memory storage comprised of an auditory component and a visuospatial component. Furthermore, research by Sala and colleagues (1999) suggests it may be more accurate to keep the visual and spatial components of visuospatial memory distinct. Because of the almost ubiquitous necessity of WM on everyday tasks, in evaluating cognitive functioning it seems prudent to measure WM as it relates to SPU and other types of drug use

### **Cognitive Functioning: Executive Functioning**

Another key element of cognitive functioning is executive functioning. Everyday life is filled with complex problems, and executive functioning can loosely be defined as a set of abilities utilized to solve problems such as these. In solving problems, a goal must be established and understood, plans (or solutions) need to be generated and developed to bring one closer to the goal, these plans need to be evaluated, and then a chosen plan must be carried out.

Although it has been accepted that there is currently no conclusive definition of executive functioning, many aspects of executive functioning have been labeled and investigated (Jurado & Rosselli, 2007; Miyake et al., 2000). Three well-researched and crucial components of executive functioning are (i) updating representations in working

memory, (ii) inhibition of ineffective impulses, and (iii) shifting of the mental set (Miyake et al., 2000). Updating is a necessary component of executive functioning wherein representations of goals, subgoals, solutions, and plans are changed to incorporate new information. By keeping WM representations updated, the problem solver is able to make gradual progress and to properly evaluate this progress. While solving a problem, impulses and incorrect ideas will often arise automatically that need to be inhibited. These impulses and ideas would hinder progress on the problem, thus the selective inhibition of undesirable and ineffective impulses is a necessary component of effective executive functioning. Finally, one will often need to shift between different problems, operations, or mental sets; therefore, shifting is also an important component of executive functioning. Miyake et al. (2000) has alternately described shifting as “task switching” and “attention switching.”

There are, of course, more aspects to executive functioning than updating, inhibition, and shifting. It has also been explained that executive functioning requires effective reasoning, generation of goals and plans, maintaining focus and motivation, and altering goals and plans in response to changing contingencies (Suchy, 2009). Although detailed explanations of reasoning and solution generation are beyond the scope of this paper, it is important to note that these aspects play an important role in executive functioning and general problem solving. Suchy further explained that executive functioning is a more deliberate (and thus explicit) form of problem solving in contrast to more automatic and implicit forms of behavior. Interestingly, as a problem becomes increasingly familiar to the problem solver, the behavior becomes more automatic and

less reliant on executive functioning. This suggests that executive functioning is necessary primarily on problems that are rather complex and novel in nature.

Nevertheless, considering the nearly infinite number of possible problems in everyday life—from the most miniscule to the grandest in complexity—it should be readily apparent that executive functioning is a fundamental part of cognitive functioning.

### **Measures of Cognitive Functioning**

Assuming that working memory and executive functioning are important aspects of cognitive functioning, it is necessary to have effective measures for these two constructs. One effective and popular measure of working memory is the Wechsler Adult Intelligence Scale, which is now in its fourth version (WAIS-IV, Wechsler, 2008). The WAIS-IV includes several subtests for assessing working memory, including the Digit Span Backward, Digit Span Forward, and Digit Span Sequencing. In the Digit Span Forward subtest, the participant is read a sequence of numbers and attempts to recall the numbers in the same order. In the Digit Span Backward subtest, the numbers are to be recalled in the reverse order. For the Digit Span Sequencing subtest, the numbers are to be recalled in ascending order. The overall test has been examined via confirmatory factor analysis, and the overall WAIS-IV battery does appear to be measuring seven distinct factors including: verbal comprehension, perceptual reasoning, processing speed, auditory working memory, visual working memory, auditory memory, and visual memory (Holdnack et al., 2011). Alternatively, Holdnack et al. found that a five-factor model fits the data equally well, wherein auditory and visual working memory are collapsed into the same factor (“Working Memory”), auditory and visual memory are

collapsed into a single factor (“Memory”), and an additional factor describes hierarchical general ability. Thus, the WAIS-IV is one of the effective ways that working memory and additional cognitive variables can be measured.

Executive functioning is another important cognitive variable, and the Wisconsin Card Sorting Task is a popular way to measure it (Kongs et al., 2000). In this task, a participant is presented with an array of cards with colored designs on them, and is told to match the cards, but is not told how the cards could be matched. Therefore, ingenuity is required on the part of the participant for her or him to determine a large number of categories. Psychometric scores include percentages of the categories achieved, trials, errors, and perseverative errors. This test may have strong discriminant validity, as those with mental illness—specifically schizophrenia—have been shown to perform worse than healthy controls (Everett, Lavoie, Gagnon, & Gosselin, 2001).

Although there are a wide variety of other measures of cognitive functioning, it is possible that Ashford, Gere, and Bayley’s Continuous Recognition Test (2011), and the Cambridge Neurological Test Automated Battery (CANTAB, Cambridge Cognition Ltd., Cambridge, UK) are two of the more innovative ways to measure cognitive functioning. These two tests are useful for entirely different reasons. The Continuous Recognition Test’s key advantages are that it is inexpensive to use and exceptionally time-efficient. In this test, participants are typically examined in large groups, and early research has utilized groups as large as 142 participants (Ashford et al., 2011). With the use of basic presentation software, 50 slides with discrete items are presented to the audience. The original study used items from five categories, including: tractors, utensils, hats, barnyard

items, and household decorative items. In this study, 14 of the slides included items previously presented. Participants are given answering sheets at the beginning of the test, and are asked to mark any questions wherein a repeat was shown. This test is a recognition based test of memory, and the authors found that the test effectively predicts age related decreases in recognition-based memory in their sample (Ashford et al., 2011). Although more research is necessary for the further development of effective group-based testing such as the Continuous Recognition Test, it is readily apparent that such a test could effectively reduce the amount of money and time needed to collect data on participants' cognitive functioning.

Although mass-testing has its benefits, one-on-one cognitive testing can incorporate more complex tasks and currently allows for a more thorough understanding of working memory and executive functioning performance. One example of such a complex and thorough test is the CANTAB. Testing participants with CANTAB is flexible because researchers are able to create their own testing batteries made with a selection of the available CANTAB subtests. These tests are administered on computer, and the participants respond via touchscreen or pressure pad. These tests were designed to measure a range of cognitive variables including: visual memory, executive functioning, attention, semantic/verbal memory, decision making, response control, and social cognition. Many of the CANTAB subtests have been shown to have both acceptable reliability and validity (Lowe & Rabbit, 1998; O'Connell et al., 2004). Furthermore, the responses to several of the subtests are not impacted by language or culture due to their non-verbal interactive nature, and thus these tests are ideal for

assessing participants with different background and levels of English fluency (Cambridge Cognition Ltd., 2012, [www.cantabclipse.com](http://www.cantabclipse.com)). Thus, CANTAB is a particularly efficient way to measure cognitive functioning and has strong psychometric properties.

One may wonder: are not measures of scholastic performance a great proxy measurement for cognitive functioning? Research indicates that students' grade point averages (GPAs) and Scholastic Assessment Test (SAT) scores are well correlated with cognitive variables such as working memory, with correlation coefficients approaching .40 (Rohde & Thompson, 2007). This indicates that scholastic performance is likely related with better cognitive functioning task performance. However, correlation coefficients near .40 indicate that individual measures of scholastic performance only account for, at most, 16% of the variation in cognitive task performance. This suggests that there is still a great deal of cognitive task variance not accounted for by scholastic performance. In addition, scholastic performance is influenced by other factors, including motivation, health, employment, family issues, and other life circumstances. Therefore, while there appears to be a relationship between cognitive task performance and scholastic performance, it may not be advisable to use scholastic performance as a proxy measure in lieu of actual cognitive testing. If one is interested in measuring cognitive functioning, it appears more prudent to choose a scale specifically developed for this purpose, such as the CANTAB.

## **Alcohol Use and Cognitive Functioning**

Research on the cognitive effects of alcohol use is still far from complete, and many studies have contradictory findings. The clearest findings have been with middle-aged and older adults who have been heavy drinkers for a long time. Green et al. (2010) examined adults over 50 years of age with a history of heavy alcohol use (i.e., 30 to 80g of ethanol per day). They assessed cognitive variables using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). This battery included subtests for visuospatial skills, wherein participants had to draw geometric figures meticulously and match lines of different orientations with their duplicates. On the memory subtests, participants had to recall and recognize words from word lists and selected stories, and participants had to also recall the figures they drew earlier. Participants with a history of moderate to heavy drinking performed markedly worse on the visuospatial and immediate memory tasks, and on delayed memory tasks their impairments approached significance. The effect sizes for impairments were sizable, ranging from a Cohen's *d* of 1.08 to 1.17. This suggests that a history of heavy drinking is connected with substantial impairments to visuospatial processing and memory, although the correlational design of this study precluded it from establishing a line of direct causation. Fitzpatrick and Crowe's (2013) research on alcohol-dependent adults using RBANS found similar deficits in visuospatial skills and memory, but with additional impairments in reading facial emotions, language skills, and psychomotor speed. Thus, chronic alcoholism is related with numerous substantial cognitive deficits in later adulthood.

For adolescents and young adults, alcohol use has been associated with impaired executive functioning (Fernandez-Serrano et al., 2010; Thoma et al., 2011). Fernandez-Serrano et al. (2010) specifically examined substance-dependent young adults and found that those with alcohol dependency showed significant impairments on many executive functioning domains and may have had mild impairment in working memory. Alcohol-dependent adults were impaired on a variety of executive abilities, including fluency, working memory, reasoning, inhibition, shifting, and decision-making with moderate to large effect sizes for each domain (Cohen's *d* range: 0.6-2.4). Alcohol-dependent adults likewise showed lower scores on both of their WM measures than very light drinking controls; however, only scores on one of the tests approached significance. Interestingly, including the duration of cannabis or cocaine use into the analysis allowed for greater prediction of executive functioning and working memory impairments. Thoma et al. (2011) likewise found strong executive functioning and attention impairments in adolescent alcohol-dependent drinkers, with the number of drinks per drinking day negatively correlated with executive functioning performance.

The relationship between frequent and heavy alcohol consumption and working memory performance is less clear for adolescents and young adults, although some research suggests that alcohol does affect their working memory. For example, acute administration of alcohol can have a significant and dose-dependent deleterious effect on young adults' working memory (Gevins et al., 2012). It would be surprising if heavy and long-term alcohol use did not make some of these working memory impairments more long-lasting. Research by Squeglia, Schweinsburg, Pulido, and Tapert (2011) may have

shed some light on why adolescent heavy and dependent drinkers do not often exhibit clear working memory deficits. Female binge-drinkers in their study exhibited lower brain activation in eight regions of interest during a spatial working memory task, whereas males had greater overall activation during this task. Furthermore, female drinkers' lower activation in frontal regions was linked with worse processing speeds and attention. Male binge-drinkers with greater frontal activation, in contrast, showed significantly improved performance on two working memory tasks. These findings suggest that young men may be more resilient to the effects of drinking with additional cortical systems used in a compensatory manner. Young males' compensatory use of other brain regions may partly explain why alcohol dependency is less clearly linked with working memory deficits in adolescents and young adults than with middle-aged and older adults.

Note that several studies using college students as participants have failed to find significant associations between alcohol use and cognitive performance or have found associations in non-intuitive directions (e.g., female drinkers performing better than abstainers; Bates & Tracey, 1990; Caspers et al., 2010; Piechatzel et al., 2009). There are numerous factors that affect the results of research on alcohol use and may partly explain these contradictory findings. Of the studies previously mentioned, significant cognitive impairments tended to be linked with recent alcohol use instead of merely lifetime alcohol abuse. As mentioned before, neural regeneration typically occurs for weeks after cessation of alcohol use (Bison & Crews, 2003). Therefore, participants who have not consumed alcohol for weeks or even months may not exhibit impairments that recent

drinkers may have. Some of the researchers who did not look specifically at current alcoholism may have failed to discover impairments for this reason alone. Additionally, none of these studies surveyed whether participants were using other drugs simultaneously with alcohol. It is quite possible that SPU altered or obscured some of the effects of alcohol use. In order to get a more comprehensive and realistic understanding of the effects of alcohol use on the cognitive functioning of college-aged students, both the recency of alcohol use and amount of SPU should to be taken into consideration.

### **Simultaneous Polydrug Use and Cognitive Functioning**

Research on the relationship between SPU patterns and cognitive functioning is much less developed than research concerning individual drug use, but is growing annually. For example, the simultaneous usage of ecstasy with alcohol has recently been linked with more adverse ecstasy-related side effects, such as paranoia, mood instability, poor health, and irritability (Fisk et al., 2010). In another study, participants were given alcohol, cigarettes, or both, and their event related potentials were measured using EEG (Michel & Battig, 1989). Alcohol use caused a decrease in stimulus-processing rates and increased reaction times on a memory task involving visual stimuli. Participants who smoked a cigarette after drinking displayed normal stimulus-processing rates, although their reaction times were still impaired. This suggests that stimulants may counteract some of the acute effects of alcohol use, but they by no means eliminate all effects. Further research is necessary to determine the extent of the relationship between SPU involving alcohol and MDMA or tobacco with cognitive functioning.

When combined with alcohol, other drugs such as marijuana and prescription drugs may also have unique effects on cognitive performance, but, again, more research is needed. Prescription drug use is a notable concern, as university students have been found to have more alcohol and other drug-related problems when using alcohol and prescription drugs in combination (McCabe et al., 2006). Notable problems exacerbated by alcohol and prescription drug SPU included substantially increased prevalence of vomiting and experiencing blackouts. Also, concurrent use of marijuana with alcohol has been found to have a strong negative relationship with memory test performance (Solowij et al., 2011; Thoma et al., 2011). This is not surprising given that long-term heavy cannabis use (5+ joints per week) has been associated with lower measured IQ (approximately 5 pts. less), slower visual processing speed, and impaired immediate and delayed memory (Fried, Watkinson, & Gray, 2005).

Additional research supports the notion that combination drug use can affect WM-task performance. In McQuail and Burk (2006), rats administered both scopolamine and mecamylamine in combination had greater impairments in working memory task performance than rats administered only one of these drugs. The authors suggested that administration of both drugs in combination had relatively large effects on working memory performance because this may have affected more receptors than individual drug use. Additionally, research by Albertazzi and colleagues (2000) suggests that combined use of oestradiol and norethisterone acetate (Kliogest®) may be more effective than tibolone (Livial®) at improving recognition memory in postmenopausal

women. Thus, there is support that cognitive variables such as WM may be uniquely impacted by SPU, as opposed to the use of drugs individually.

Even a drug as seemingly benign as caffeine may affect the results of research on alcohol use and cognitive performance. A recent study by Alford, Hamilton-Morris, and Verster (2012) examined this exact topic by giving participants alcohol with an energy drink, alcohol, or a placebo drink. The energy drink contained 80 mg of caffeine, and participants given the energy drink were given the same amount of alcohol as those in the alcohol-only condition. The researchers found that choice reaction times were impaired by alcohol use, but were decreased when participants also consumed the energy drink. In contrast, performance on a word recall task was impaired by alcohol consumption, but was not improved with the energy drink. This research indicates that caffeine consumption may mitigate the negative impact of alcohol consumption on reaction times, but that it does not improve memory performance. These findings seem predictable considering that caffeine is a CNS stimulant, and both acute and habitual consumption of caffeine has been linked with lower reaction times on psychological tests (Hameleers, 2000; Nehlig, 2010). Taken together, this research suggests that even caffeine use affects the reaction times of young alcohol drinkers.

Based on this research regarding SPU, it is apparent that when multiple drugs are used in combination, side effects can combine in an additive or synergistic fashion. Working memory task performance, in particular, may be uniquely affected by SPU. At the same time, not all effects of SPU are simple; some types of stimulants may reduce some, but not all, of the negative effects associated with alcohol use. Because many

heavy drinkers use multiple drugs in combination, assessing how alcohol and SPU interact to effect cognitive functioning would likely give a more realistic understanding of how drugs impact cognition.

### **The Present Study**

Despite the presence of several studies that have examined alcohol use and performance on tasks measuring cognitive functioning, almost none have properly addressed that participants' simultaneous usage of multiple drugs may be a serious confound in their results. As explained above, combined use of alcohol with other drugs is highly common and produces unique effects upon both cognition and health. Although a substantial portion of college students use drugs in combination, these types of participants are most often excluded or the effects of SPU are ignored entirely. More research is necessary to understand the impact of different drug combinations on cognitive functioning, and to determine whether alcohol used alone, or with other drugs, can have long-term effects on cognitive functioning. Furthermore, the development of improved measures of SPU would greatly aid in this endeavor.

In order to address this gap in the literature, the current study was devised. This study's main goal was to pilot and aid in the further development of the SJSU SPUQ – Online. Comparisons of data collected using an older paper version of the SJSU SPUQ and the SJSU SPUQ – Online were made to determine if the current selection of items was adequate to properly survey peoples' drug use histories. It was hypothesized that an online version of the questionnaire might reduce participants' reactivity to a questionnaire asking them about socially unacceptable and possibly illegal behavior.

Additionally, over the past year, college students were administered both the current version of the SJSU SPUQ – Online and select cognitive tasks from the Cambridge Neuropsychological Test Automated Battery (CANTAB, Cambridge Cognition Limited, Cambridge, UK) software package. This research was conducted to determine if the SJSU SPUQ – Online can adequately be used to assess the relationship between alcohol and combination drug use with cognitive functioning.

A few predictions were made regarding whether participants' alcohol use and SPU will be related with cognitive task performance. First, it was expected that those with the most recent consumption of alcohol would not perform as well on a test of executive functioning as those who have not drank alcohol recently. As mentioned before, previous research suggests that executive functioning is often impaired in adolescent and young adult drinkers (Fernandez-Serrano et al., 2010; Thoma et al., 2011). Additionally, it was predicted that those with the most recent consumption of alcohol would not perform as well on a test of working memory as those who have not drank recently. Finally, it was predicted that participants' SPU frequency would be related with performance on the working memory and executive functioning task. Previous research suggests that acute drug effects combine in an additive or synergistic way; therefore, I would expect that SPU has long-term consequences as well (Fisk et al., 2010; McCabe et al., 2006). It should be noted that although the chief purpose of this study was not to measure the relationship between alcohol use and SPU with cognitive functioning, these analyses could help determine if the SJSU SPUQ –Online is currently suitable for such an endeavor.

## Method

### Participants

One hundred and eleven college students were recruited from the San José State Psychology Research Pool. These participants were generally from Psychology 1 courses, wherein their receiving of course credit was contingent upon their participation in psychological research. All participants in this study consented orally to a standard informed consent form, as oral consent helps to improve anonymity in participation. Treatment of subjects was in accordance with the ethical standards of the APA and San José State University's Institutional Review Board.

In order to minimize the effects of extreme outliers on the cognitive performance variables, the 1.5 interquartile range (IQR) method for determining outliers was used. The IQR is the distance between quartiles 1 and 3 (Q1 & Q3) in a distribution. As developed by Tukey (1977), the 1.5 IQR method stipulates that any data points more than  $Q1 - 1.5 \times (IQR)$ , or above  $Q3 + 1.5 \times (IQR)$  should be classified as outliers. In this sample, 12 participants had scores above or below the cutoff values for extreme outliers, and were eliminated. The final sample for analysis included 99 participants with a mean age of 19.57 years ( $SD = 1.88$ ).

Additionally, prior responses to the original paper version of the SJSU SPUQ and the SJSU SPUQ – Online were analyzed. These participants were also recruited from San José State University. For the paper version of the SJSU SPUQ, responses from 235 participants were collected from 2009 - 2010. For the SJSU SPUQ – Online, responses from 299 participants were collected from 2010 - 2011. In order to compare the two

versions of the SJSU SPUQ, responses from these 299 participants were merged with responses from the current study for a total of 410 SJSU SPUQ – Online participants.

### **Apparatus and Materials**

All 111 participants in the current study completed three test batteries using CANTAB and the SJSU SPUQ – Online. For the CANTAB portion of the study, a 2007 Dell desktop computer was used with a Dell monitor set to a 1024 x 768 resolution. A MagicTouch™ touchscreen was attached to this monitor, resting approximately six inches from the edge of the desk, and was the sole way of participant response. No mouse, keyboard, or pressure pad was used during this experiment. In administering the SJSU SPUQ – Online, a second Dell desktop computer was used in a separate room with the program Survey Monkey™. Participants responded to this survey primarily with a mouse.

CANTAB was specifically chosen because it has been shown to provide valid and reliable measurement of neurocognitive functioning (Lowe & Rabbit, 1998; O’Connell et al., 2004). The CANTAB portion of this study included three subtests: the Motor Screening Test, Delayed Matching to Sample, and the Stockings of Cambridge.

**Motor Screening Test (MOT).** The first CANTAB test participants completed, the MOT, gave participants an opportunity to familiarize themselves with the computer and touch screen (Cambridge Cognition Limited, 2011). Use of a touch screen is novel for many people, so beginning with this practice session is standard practice in administering CANTAB test batteries (refer to CANTABeclipse: Test Administration Guide, 2006, p. 33). Furthermore, this test helps the researcher identify verbal, motor, or

comprehension problems. In the MOT, purple crosses are presented on a black screen, and participants are asked to use their forefinger to touch each cross as it appears. A tone sounds when the cross has been successfully touched. This test lasts approximately three minutes. This test, and all following tests, were set to “clinical” (one-completion) mode.

**Delayed Matching to Sample (DMS).** In the second CANTAB test, the DMS, a visually complex pattern is shown, hidden, and then a set of four patterns is presented (Cambridge Cognition Limited, 2011). The visually complex pattern is a square composed of four quadrants with a unique pattern and color in each quadrant. The participants’ task is to pick which pattern from the new set was originally presented. Both the patterns and colors in the new pattern must match the original pattern. Twenty-three counter-balanced trials of this task are used, with stimuli presentation delays of 0, 4, and 12 seconds. This task takes approximately 10 minutes to complete. The computer records response times and correct/incorrect responses. This test assesses participants’ working memory.

**Stocking of Cambridge (SOC).** In the third and final CANTAB test, SOC, two sets of colored balls are presented in three columns, and participants must arrange the balls on the bottom portion of the screen to match those presented on the top of the screen (Cambridge Cognition Limited, 2011). Balls may only be moved if they are on top of the stack, thus, like the Tower of Hanoi puzzle, participants must move balls in a strategic fashion in order to solve the puzzle. Furthermore, they must do so with the fewest number of moves and in the quickest time. There are a total of 20 problems, each requiring at minimum of 1-5 moves to complete. This task takes approximately 15

minutes to complete. The computer records response times and correct/incorrect responses. This test assesses participants' executive functioning.

**San Jose Staté University Simultaneous Polydrug Use Questionnaire.** The SJSU SPUQ was constructed by Laraway and Snycerski (2009). As mentioned before, the SJSU SPUQ was adapted to Survey Monkey<sup>TM</sup> for ease of administration and named the SJSU SPUQ – Online. This questionnaire measures: (a) the recency of single-drug use and SPU, (b) the specific drugs used in combination and their frequency of use in the last month, (c) motives for using these drugs, (d) subjective effects of drug combinations using the Drug Effects Questionnaire (Rush et al., 2003), and (e) demographic information (e.g., race/ethnicity and gender). Participants also completed the Duke Religion Index (DRI; Koenig, Parkerson, & Meador, 1997) and the Rosenberg Self-Esteem Scale (Robins, Hendin, & Trzesniewski, 2001; Rosenberg, 1965). The DRI is a survey that assesses participants' frequency of religious activity and the self-reported importance religiosity has in their lives. Although these measures of self-esteem and religiosity are included in the experiment, they were not a part of the current study, so they will not be discussed further.

For the purposes of the current study, responses regarding the recency of alcohol use and frequency of SPU were analyzed. In this portion of the SJSU SPUQ, 22 drug categories/types are listed, and participants are asked to circle how recent they used each of these drugs individually with the following response options: “never,” “in my lifetime,” “in the last year,” “in the last month,” “in the last week.” A later section of the survey assessed SPU frequency by having participants type-in which drugs they used in a

combination and how many days they used this specific combination in the last month. Space for three different drug combinations was provided. Although this is the first study the SJSU SPUQ – Online has been utilized in, self-reports of alcohol- and drug-use are generally accepted as reliable and valid measures of alcohol- and drug-use behaviors (Williams, Aitken, & Malin, 1985). Thus, the SJSU SPUQ - Online should effectively measure the key constructs we intended to use in our analysis.

### **Procedure**

Participants in this study were assessed one at a time, in two neighboring labs at San José State University. Upon reaching the research site, participants were seated at a computer and given a consent form by the current experimenter. Those who gave oral consent were then walked through the CANTAB in accordance with the CANTABeclipse Test Administration Guide (2006). All experimenters were thoroughly trained before allowed to administer the CANTAB to participants. The CANTAB testing took approximately 30-40 minutes per participants, and then they were led to the neighboring lab to complete the SJSU SPUQ – Online.

During the SJSU SPUQ – Online, participants were alone in the room due to the sensitive nature of the SJSU SPUQ – Online questions; however, a separate research assistant was on site should the participant need any assistance. The SJSU SPUQ – Online takes approximately 10-15 minutes to complete. After completion of the SJSU SPUQ – Online, participants were given a debriefing sheet that outlined the full purpose of the study, and provided details regarding health and counseling services on campus should the participant feel that his or her drug use was a problem.

## **Design and Variable Definitions**

This study was a survey-based pilot study wherein we sought to compare reported drug use patterns on the paper-based SJSU SPUQ and the newer version of this measure, the SJSU SPUQ – Online. This study included the analysis of data collected previously by Laraway and Snycerski (2009), in addition to data collected using the SJSU SPUQ – Online this past year. Through the use of a correlational design, we also sought to assess the relationship between participants' answers on the survey portion (i.e., alcohol-use recency and SPU frequency) and their performance on the computerized tasks assessing executive functioning and working memory.

To assess the relationship between alcohol use recency and cognitive performance, two drug-use groups were formed based on participants' self-reported recency of alcohol use in the SJSU SPUQ – Online. The criteria for these two alcohol-use groups and descriptions of the four dependent variables are listed below:

**Recent alcohol-use group:** Group consisted of participants who reported alcohol use in the past week.

**Non-drinking comparison group:** Group consisted of participants who reported not having drunk alcohol in at least the past week. This group included all those who reported having never drunken alcohol and those who have drunk in their lifetime, in the past year, or in the past month.

**DMS percent correct:** This measure reports the percent of the delayed DMS trials a participant answered correctly on his or her first attempt. Lower scores on

this variable indicate that the participant got more problems incorrect and suggest that he or she likely had impaired working memory.

**DMS mean correct latency:** This measure reports how quickly it took participants to answer a delayed DMS trial. Participants' mean latency across the delayed trials was recorded in milliseconds, with timing starting once each target pattern was displayed. Longer latencies indicate that the participant took longer to solve the working memory problems and suggest impairments in working memory and/or simple reaction time.

**SOC mean initial thinking time:** Participants are encouraged to plan their solution before attempting the SOC puzzles. This measure reports the mean length of time (in milliseconds) between when a problem is presented and a participant begins solving it. This can be considered a measurement of how long a participant spends planning their solution (CANTABeclipse: Test Administration Guide, 2006, pp. 245-246). Longer mean initial thinking times may indicate that planning a solution was difficult for the participant and could be a manifestation of executive functioning impairment.

**SOC problems solved in minimum moves:** This measure reports how many problems each participant solved using the minimum number of moves necessary to solve the problem. This is a succinct measurement of overall planning accuracy on the SOC (CANTABeclipse: Test Administration Guide, 2006, p. 245). Lower scores indicate an impaired ability to solve the puzzles that most likely stems from executive functioning impairment.

## **Statistical Analysis**

All statistical analyses were calculated using the Statistical Package for Social Science version 20.0 (SPSS Inc., 2012). Simple descriptive statistics, including demographic statistics, and individual and combination drug use frequencies, were computed for both the paper version of the SJSU SPUQ and the SJSU SPUQ – Online. These descriptive statistics allowed for comparisons to be made between both formats of the SJSU SPUQ. Group means and standard deviations on the CANTAB cognitive performance indices were calculated for the two alcohol-use groups. Independent samples *t*-tests were used to determine if the recent alcohol-use group and non-drinking comparison groups differed on the CANTAB cognitive performance indices. Effect sizes for group differences were calculated using Cohen's *d*. Finally, Pearson's correlations were used to determine whether SPU was related with the four cognitive test dependent variables. For all inferential statistics, alpha was set to .05.

## Results

### Descriptive Statistics

Prior to analyzing whether a relationship existed between drug use and cognitive task performance, descriptive statistics were calculated to better understand the representativeness of the samples and drug use patterns for both the paper-based SJSU SPUQ and the SJSU SPUQ – Online. Demographic data for the SJSU SPUQ are depicted in Table 1, whereas the data for the SJSU SPUQ – Online are depicted in Table 2. Despite the relatively wide range of ages, the majority of participants in both samples were in their late teens or young adulthood. In both samples, females were much better represented than males, with the ratio of females to males being 2.51:1 for the SJSU SPUQ sample and 1.51:1 for the SJSU SPUQ – Online sample. As expected, “freshman” was the modal grade level for participants in the SJSU SPUQ sample ( $n = 112$ , 47.7%) and the SJSU SPUQ – Online sample ( $n = 162$ , 39.5%), as Psychology 1 is one of the most popular psychology courses that require research participation. Lastly, this sample was very ethnically diverse, with the majority of participants classifying themselves as Asian-American, Caucasian, Hispanic, Latino, or Spanish. Together, these statistics indicate that the samples were young—mostly in their teens or early 20s—and they each had considerably ethnic diversity.

Table 1

*Descriptive Statistics for SJSU SPUQ*

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	%	Minimum	Maximum
Age	20.10	3.66	-	-	18.00	47.00
Grade Level	2.02	1.22	-	-	1.00	6.00
Ethnicity						
Asian-American	-	-	80	34.0%	-	-
Caucasian	-	-	78	33.2%	-	-
Hispanic, Latino, or Spanish	-	-	35	14.9%	-	-
African-American	-	-	20	8.5%	-	-
Other	-	-	21	9.0%	-	-
Gender						
Males	-	-	67	28.5%	-	-
Females	-	-	168	71.5%	-	-

*Note.* *N* = 235. Gender was coded 1 = "male", 2 = "female". Grade level was coded 1 = "freshmen," 2 = "sophomore," 3 = "junior", and 4 = "senior".

Table 2

*Descriptive Statistics for SJSU SPUQ - Online*

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	%	Minimum	Maximum
Age	20.27	3.44	-	-	18.00	51.00
Grade Level	2.18	1.17	-	-	1.00	4.00
Ethnicity						
Asian-American	-	-	136	33.2%	-	-
Caucasian	-	-	114	27.8%	-	-
Hispanic, Latino, or Spanish	-	-	108	26.3%	-	-
Other	-	-	28	6.9%	-	-
African-American	-	-	24	5.9%	-	-
Gender						
Males	-	-	163	39.8%	-	-
Females	-	-	246	60.0%	-	-

*Note.* *N* = 410. Gender was coded 1 = "male", 2 = "female". Grade level was coded 1 = "freshmen," 2 = "sophomore," 3 = "junior", and 4 = "senior".

## Individual Drug Use

Next, individual drug use patterns were assessed. Data for individual drug use recency for the SJSU SPUQ are displayed in Table 3, whereas data for the SJSU SPUQ – Online are presented in Table 4. For both of these samples, caffeine, alcohol, cannabis, tobacco, and cough syrup were the most commonly used drugs for recreational purposes.

Caffeine use was by far the most prevalently used drug in both samples, with 70.6% and 86.8% of participants reporting monthly or more recent use in the SJSU SPUQ and SJSU SPUQ – Online, respectively. Alcohol was the second most prevalently used drug, with 59.6% and 71.0% reporting monthly or more recent use in the SJSU SPUQ and SJSU SPUQ – Online, respectively. Cannabis was the third most widely used drug, with 20.9% and 38.3% reporting monthly or more recent use in the SJSU SPUQ and SJSU SPUQ – Online, respectively.

Perhaps the most interesting finding regarding individual drug use patterns is that a much smaller proportion of participants reported illicit drug use in the paper SJSU SPUQ versus the SJSU SPUQ – Online for all of the five most widely used illicit drug categories. Participants using the online version were more likely to report monthly use of drugs such as alcohol (19.1% more likely), cannabis (83.3% more likely), cocaine (92.3% more likely), amphetamines (over 9 times more likely), and MDMA (over 9 times more likely). Those using the online version were also more likely to report monthly use of certain legal drugs, such as caffeine use (23.0% more likely) and tobacco use (40.3% more likely). Those using the paper version of the SJSU SPUQ were slightly more likely to report monthly use of cough syrup (32.5% more likely), pain medications (53.3% more likely), and anxiety medications (40.0% more likely) than those using the online version. In summary, these results indicate that those filling out the paper copy of the SJSU SPUQ were much less likely to report illicit drug use compared to those filling out the online version.

Table 3

*Individual Drug Use Based on SJSU SPUQ Data*

Drug	Use Frequency				
	Never	In lifetime	Last Year	Last Month	Last Week
Caffeine	27 (11.5%)	14 (6.0%)	22 (9.4%)	45 (19.1%)	121 (51.5%)
Alcohol	30 (12.8%)	24 (10.2%)	36 (15.3%)	65 (27.7%)	75 (31.9%)
Cannabis	129 (54.9%)	26 (11.1%)	28 (11.9%)	22 (9.4%)	27 (11.5%)
Cough Syrup	94 (40.0%)	37 (15.7%)	55 (23.4%)	39 (16.6%)	9 (3.8%)
Tobacco	126 (53.6%)	38 (16.2%)	24 (10.2%)	22 (9.4%)	24 (10.2%)
Pain Medications	134 (57.0%)	47 (20.0%)	25 (10.6%)	20 (8.5%)	7 (3.0%)
Anxiety Medications	208 (88.5%)	15 (6.4%)	4 (1.7%)	2 (0.9%)	6 (2.6%)
Cocaine	207 (88.1%)	16 (6.8%)	4 (1.7%)	2 (0.9%)	1 (0.4%)
Amphetamines	220 (93.6%)	10 (4.3%)	2 (0.9%)	1 (0.4%)	1 (0.4%)
MDMA	203 (86.4%)	17 (7.2%)	14 (6.0%)	1 (0.4%)	-

*Note.*  $N = 235$ . Drugs are listed in order of monthly (last week and last month) use. Only the 10 most prevalent forms of drug use were reported. Sample percentages are in parentheses.

Table 4

*Individual Drug Use Based on SJSU SPUQ - Online Data*

Drug	Use Frequency				
	Never	In lifetime	Last Year	Last Month	Last Week
Caffeine	10 (2.4%)	14 (3.4%)	27 (6.6%)	76 (18.5%)	280 (68.3%)
Alcohol	49 (12.0%)	17 (4.1%)	53 (12.9%)	82 (20.0%)	209 (51.0%)
Cannabis	146 (35.6%)	47 (11.5%)	60 (14.6%)	55 (13.4%)	102 (24.9%)
Tobacco	153 (37.3%)	66 (16.1%)	75 (18.3%)	42 (10.2%)	71 (17.3%)
Cough Syrup	183 (44.6%)	62 (15.1%)	94 (22.9%)	39 (9.5%)	24 (5.9%)
Pain Medications	279 (68.0%)	56 (13.7%)	42 (10.2%)	20 (4.9%)	9 (2.2%)
Amphetamines	344 (83.9%)	14 (3.4%)	19 (4.6%)	16 (3.9%)	14 (3.4%)
MDMA	314 (76.6%)	40 (9.8%)	36 (8.8%)	13 (3.2%)	3 (0.7%)
Cocaine	357 (87.1%)	17 (4.1%)	19 (4.6%)	6 (1.5%)	4 (1.0%)
Anxiety Medications	368 (89.8%)	18 (4.4%)	11 (2.7%)	4 (1.0%)	6 (1.5%)

*Note.*  $N = 410$ . Drugs are listed in order of monthly (last week and last month) use. Only the 10 most prevalent forms of drug use were reported. Sample percentages are in parentheses.

## **Patterns of Simultaneous Polydrug Use**

Before examining specific drug combinations, simple descriptive statistics regarding SPU were assessed. For those completing the paper version of the SJSU SPUQ, a substantial portion of the sample indicated that they have had at least one occurrence of SPU in the past ( $n = 71, 30.6\%$ ), although the majority of students reported having never had such an occurrence of SPU ( $n = 161, 69.4\%$ ). This sample reported between 0 and 34 total occurrences of SPU in the previous month ( $M = 4.83, SD = 7.29$ ). Note that only 3 participants who reported SPU did not complete items regarding SPU frequency. This specific version of the SJSU SPUQ did not include an item regarding SPU in the previous year. Compared with the previous sample, a considerably larger proportion of those who completed the SJSU SPUQ – Online reported having used drugs in combination at some time in the past ( $n = 186, 45.5\%$ ), versus those who reported never having an occurrence of SPU ( $n = 233, 54.5\%$ ). Interestingly, a substantially greater number of participants reported having had at least one occurrence of SPU in the previous year ( $n = 167, 89.3\%$ ), compared to those who reported not having had such an occurrence ( $n = 20, 4.9\%$ ). This item was only completed by 187 out of 410 SJSU SPUQ – Online participants, and responses suggest that the majority of those who reported having never used SPU skipped this item. A smaller proportion of the SJSU SPUQ – Online participants ( $n = 63$ ) reported their frequency of SPU in the previous month. Those who did report their SPU frequency reported between 1 to 41 occurrences in the previous month, and had somewhat more occurrences per month than those who complete the paper version ( $M = 7.35, SD = 8.83$ ).

Next, the popularities of different combinations of SPU were assessed via a simple frequency count. These data are presented in Table 5 and Table 6. One key pattern observable from these tables is that in both samples, the four to seven most prevalently used drug combinations are simply permutations of the most popular drugs used individually: caffeine, alcohol, tobacco, and cannabis. Additionally, the prevalence of using each of the drug combinations is noticeably lower for those who completed the paper version of the SJSU SPUQ compared with those who filled out the SJSU SPUQ – Online. This pattern is perhaps more easily observable when one examines the prevalence of each of the 11 ranked-ordered categories regardless of what drugs are in each category. With this method of analysis, all ranked category slots (1 through 11) are reported to be more prevalent in the SJSU SPUQ – Online compared with the paper version of the SJSU SPUQ. This indicates that those completing the SJSU SPUQ – Online were more likely to write out which drugs they have used in combination compared with those who completed the paper SJSU SPUQ. Lastly, it is worth noting that those completing the SJSU SPUQ – Online reported more SPU combinations involving MDMA, and a greater prevalence for such combinations compared with those completing the paper SJSU SPUQ.

Table 5

*Drug Combination Use In Last Month Based on SISU SPUQ Data*

Combination	Use Frequency
Alcohol, Cannabis	38 (16.2%)
Alcohol, Tobacco	19 (8.1%)
Alcohol, Cannabis, Tobacco	11 (4.7%)
Alcohol, Caffeine	9 (3.8%)
Alcohol, Caffeine, Cannabis, Tobacco	5 (2.1%)
Caffeine, Tobacco	5 (2.1%)
Alcohol, Caffeine, Tobacco	3 (1.3%)
Alcohol, Cannabis, Cocaine, Tobacco	3 (1.3%)
Alcohol, Cannabis, MDMA, Tobacco	3 (1.3%)
Alcohol, Cocaine	3 (1.3%)
Cannabis, Tobacco	3 (1.3%)

*Note.*  $N = 235$ . Only the 11 most prevalent drug use combinations were reported. Sample percentages are in parentheses.

Table 6

*Drug Combination Use In Last Month Based on SISU SPUQ - Online Data*

Combination	Use Frequency
Alcohol, Cannabis	86 (21.0%)
Alcohol, Cannabis, Tobacco	44 (10.7%)
Alcohol, Tobacco	40 (9.8%)
Alcohol, Caffeine	29 (7.1%)
Alcohol, MDMA	13 (3.2%)
Alcohol, Caffeine, Cannabis	12 (2.9%)
Cannabis, Tobacco	12 (2.9%)
Alcohol, Caffeine, Tobacco	11 (2.7%)
Alcohol, Cannabis, MDMA	11 (2.7%)
Caffeine, Cannabis	10 (2.4%)
Cannabis, MDMA	9 (2.2%)

*Note.*  $N = 410$ . Only the 11 most prevalent drug use combinations were reported. Sample percentages are in parentheses.

### **Alcohol Use and Cognitive Performance**

In order to determine whether the recent alcohol-use and non-drinking comparison groups differed on the four measures of cognitive performance, independent

samples *t*-tests were calculated. It was predicted that those in the recent alcohol-use group would perform worse than the non-drinking comparison group on the executive functioning and working memory tasks. Group mean scores and the results of the four *t*-tests are presented in Table 7.

Table 7

*CANTAB Performance by Alcohol-Use Group*

CANTAB subscore	Alcohol-Use Group				<i>t</i>	<i>p</i>	<i>d</i>
	Non-Recent		Recent				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
DMS percent correct	90.57	7.09	91.44	5.1	-0.72	0.485	0.14
DMS mean correct latency	3.23	0.86	3.07	0.82	1.01	0.317	-0.19
SOC problems solved in minimum moves	9.87	1.53	9.74	1.42	0.43	0.667	-0.09
SOC mean initial thinking time	15.17	9.15	11.67	5.79	2.24	0.028*	-0.46

*Note.* *N* = 99. Values for DMS mean correct latency and SOC mean initial thinking time are presented in seconds. Independent samples *t*-test data and Cohen's *d* are presented to show on which variables the two use-groups significantly differ, and to what extent. \* *p* < .05

Group means on the SOC were examined to determine whether the recency of alcohol use was related with executive functioning. The two alcohol-use groups were not found to significantly differ on the number of SOC problems they solved in the optimum number of moves. However, the mean time participants spent thinking before solving the problem did differ between the two alcohol-use groups. Interestingly, the recent alcohol-use group spent approximately 3.5 seconds less time thinking ( $SE_{\text{difference}} = 1.57\text{seconds}$ ) before attempting the puzzles than did the non-drinking comparison group.

Group mean differences on the DMS were then examined to determine if alcohol-use recency was related with working memory. The percentage of trials answered correctly and the mean correct latency were not found to differ significantly between the

recent alcohol-use group and the non-drinking comparison group. The results of these two tests indicate that the recency of alcohol-use was not significantly related with our included measurements of working memory performance.

### **Simultaneous Polydrug Use and Cognitive Performance**

Originally, in order to determine the relationship between SPU and cognitive functioning, participants' reported SPU frequency in the previous month would have been utilized. However, only 17 participants out of 99 answered the relevant items. Lack of response to these items precluded analysis, as the statistical power of any analyses would be unsatisfactory. The next-best alternative in the SJSU SPUQ – Online would be to examine whether participants reported having at least one occurrence of SPU in the previous year. This item was answered by a greater number of participants ( $n = 45$ ), however, this item was almost exclusively answered only by those who had at least one occurrence of SPU in the previous year ( $n = 42$ ). This imbalance in responses precluded further statistical analysis. Thus, the only viable measure of SPU frequency was the questionnaire item asking participants if they have ever had at least one occurrence of SPU in their life time. All participants in the current study answered this item ( $n = 99$ ), and although there was a large proportion of those who reported having used SPU ( $n = 45$ ), slightly more indicated that they have never used drugs in combination ( $n = 54$ ). Interestingly, participants reported age, gender, and GPA were not found to be significantly related with whether they have ever had an occurrence of SPU ( $r \leq .10, p \geq .32$ ).

In order to determine the relationship between SPU and cognitive task performance, Pearson correlations were computed. First the correlations regarding working memory test performance and SPU were considered. Participants response to the SPU item were not found to be significantly related with the percent of delayed trials participants answered correctly ( $r = .10, p = .34$ ) or their mean correct latency ( $r = -.03, p = .81$ ). This indicates that reports of ever having used drugs in combination were not found to be significantly related with working memory task performance. Next, performance on the executive functioning task as assessed. Participants responses to the SPU item were also not found to be significantly related with the number of problems participants answered in the optimum number of moves ( $r = -.12, p = .26$ ) or the amount of time they spent planning before attempting the puzzles ( $r = -.14, p = .16$ ). Overall, the findings of these analyses indicate that reporting having used SPU was not found to be significantly related with performance on the working memory and executive functioning CANTAB tasks.

### **Post-hoc Analyses**

Because not enough data were available to assess the relationship between specific SPU combinations with cognitive performance, relationships between cognitive task performance and caffeine-, cannabis-, and tobacco-use recency were then examined. For each of these three drugs, drug-use recency groups were constructed as was done for alcohol-use recency. Independent samples *t*-tests were then calculated to see if the drug-use recency groups differed on the four measures of cognitive functioning. In order to keep the family-wise error rate of these 12 tests within acceptable levels, the Benjamini-

Hochberg method (1995) was utilized. None of the 12 tests were considered significant with the adjusted alpha-levels. The lowest observed  $p$ -value was found relating caffeine-use recency group with SOC mean initial thinking times, and were these planned comparisons, the relationship would have approached significance;  $t(97) = -1.86$ ,  $p = .066$ , Cohen's  $d = 0.40$ . This difference was such that those who recently consumed caffeine had an approximately 3.05 s ( $SE_{\text{difference}} = 1.65$  seconds) longer mean initial thinking times than those who had not consumed caffeine recently. However, this finding surpassed the adjusted  $\alpha$ -level ( $\alpha_{\text{adjusted}} = .004$ ), and thus cannot be considered robust to the family-wise error rate. Overall, these post-hoc comparisons did not show any significant relationships between the recency of caffeine, cannabis, or tobacco use with the two working memory and two executive functioning measurements.

## **Discussion**

The primary goals of this study were to pilot the SJSU SPUQ – Online, thus aiding in its development, and to determine if alcohol and SPU are related with cognitive task performance. In line with previous research, we predicted that SPU would affect performance on both the working memory and executive functioning task (Fisk et al., 2010; Martin et al., 1996). The secondary goal of this study was to determine if recent alcohol use was related with differences in working memory and executive functioning task performance, and if such differences would be observable using CANTAB testing software and the SJSU SPUQ – Online. We expected that alcohol use would lead to impaired performance on both of these types of tasks based on previous research (Fernandez-Serrano et al., 2010; Thoma et al., 2011).

### **Comparison of SJSU SPUQ Formats: Online Vs. Paper**

Before testing whether there was a relationship between drug use and cognitive task performance, drug use patterns were assessed; in this assessment, results from the paper version of the SJSU SPUQ and the SJSU SPUQ – Online were compared. The most prevalently used drugs in this sample were, in order of frequency, caffeine, alcohol, cannabis, tobacco, and to a lesser extent, cough syrup. Considering that the majority of students were below drinking age, it is somewhat disturbing that approximately three out of four students using the SJSU SPUQ – Online reported alcohol-use in the previous month. Note that the prevalence of alcohol-use reported in that sample was very similar to the population prevalence estimate calculated by O'Malley and Johnston (2002).

In comparing responses to the paper version of the SJSU SPUQ versus the SJSU SPUQ – Online, the most noteworthy trend is that those using the paper version much less frequently reported illegal drug use. When looking at the ten most frequently used drugs, those using the paper version of the SJSU SPUQ were substantially less likely to report having used alcohol, cannabis, cocaine, amphetamines, and MDMA compared with those who completed the SJSU SPUQ – Online. Additionally, they were less likely to report having used tobacco and caffeine in the last month. In contrast, those completing the paper version of the SJSU SPUQ were somewhat more likely to report having used cough syrup, pain medications, and anxiety medications for recreational purposes in the previous month. The prevalence of alcohol-use reported with the paper version of the SJSU SPUQ was much smaller than the population prevalence estimate calculated by O’Malley and Johnston (2002). Although it is possible that this sample had unique drug use habits, it appears more likely that underreporting was considerable in this sample. This sample was surveyed only a year before SJSU SPUQ – Online participants were surveyed and at the same university. Thus, it is unlikely that the SJSU SPUQ sample’s drug use patterns would be so substantially different. It is quite plausible that many participants were uncomfortable reporting their illegal drug use on a physical document (SJSU SPUQ), whereas fewer were uncomfortable responding to the online version of the survey. In all administrations of the SJSU SPUQ and SJSU SPUQ – Online, participants were assured of the absolute anonymity of their responses. However, it still may have been somewhat intimidating to report illegal activity on a physically tangible document.

When looking at SPU, it is quite likely that those completing the paper version of the SJSU SPUQ underreported their use as well. Only 30.6% of those completing the SJSU SPUQ reported having ever used drugs in combination, whereas 45.4% of those completing the SJSU SPUQ – Online reported having had at least one occurrence of SPU in the past. Again, note that both samples were procured at the same university and with only one year between sampling. Previous research suggests that SPU should be more prevalent in college students than was reported on the paper version of the SJSU SPUQ (Barrett et al., 2006). Although it is possible that the sample for this study was unique, it is more probable that underreporting occurred. If SJSU SPUQ participants were uncomfortable reporting their use of illegal drugs individually, it is almost certain that they would be uncomfortable reporting combination drug use involving illegal drugs. Because responses to the SJSU SPUQ – Online have shown individual and combination drug use prevalence rates that are much closer to the population prevalence rates than the original SJSU SPUQ, the SJSU SPUQ – Online is likely a more accurate measure of drug use.

Simultaneous polydrug use for both participants using the paper version of the SJSU SPUQ and the SJSU SPUQ – Online, the most frequently used forms of SPU included different combinations of alcohol with cannabis, tobacco, and/or caffeine. Thus, it is quite likely that choices regarding which drugs a person uses in combination are partly determined by which drugs people like to use most often individually. Note that a substantial number of participants reporting with the SJSU SPUQ – Online endorsed using drug combinations involving MDMA.

In comparing the paper version of the SJSU SPUQ to the SJSU SPUQ – Online, it is also important to examine the selection of items. Although both versions are nearly identical in terms of items and wording, there were a few exceptions. First, the SJSU SPUQ – Online included a new item asking participants whether they had at least one occurrence of SPU in the previous year. This item should have some utility in determining whether participants' SPU is a recent phenomenon and not simply a previous experiment with drugs or a long-ago discontinued pattern of drug use. However, only 187 out of 410 participants answered this item. This is in steep contrast to the item asking about lifetime SPU, as that item was answered by all but one participant. It may be that participants did not want to admit SPU occurrences in the past year because such use may incriminate them; however, given the considerable number of participants who reported illegal drug use on the SJSU SPUQ – Online, this item-skipping may be due to other reasons. It may be useful to look at other factors such as item placement or even to survey participants to determine if it is more intimidating to report recent SPU compared with individual drug use.

The second noticeable difference in item inclusion between the two versions of the SJSU SPUQ is that the original SJSU SPUQ included items asking about individual drug use frequency in the previous month, whereas the SJSU SPUQ – Online did not. This is quite possibly a simple over-sight as the survey was formatted onto Survey Monkey<sup>TM</sup>. Although the primary purpose of the SJSU SPUQ – Online is to assess SPU, the original inclusion of these items did not add greatly to survey length and allowed for a

stronger assessment of the severity of drug use. Thus, it would be useful to bring these items back in the next iteration of the SJSU SPUQ – Online.

### **Simultaneous Polydrug Use and Cognitive Task Performance**

In order to assess the relationship between SPU and cognitive task performance, the current study surveyed a sample of 99 participants. Originally, SPU frequency would have been calculated by summing the total number of occurrences of SPU each participant reported for the previous month. Unfortunately, only 17 out of the 45 respondents who reported ever having an occurrence of SPU answered the relevant items. As the statistical power of analyses with only 17 participants would be exceptionally low, an alternate measure of SPU frequency or recency had to be used. The next-best alternative was an item asking participants if they had used any drugs in combination in the previous year. This item was also unsuitable for analysis because it was almost solely completed by those who have used SPU in the previous year, while those who reported having never used SPU almost universally skipped it. The last viable measure of overall SPU was an item asking participants if they had ever used drugs in combination before. This is, perhaps, one of the least informative measures of overall SPU in the SJSU SPUQ – Online, so it was a last-choice item to use for statistical analysis. Not surprisingly, after computing a series of Pearson correlations, no significant relationships were found between this item and cognitive task performance. Because the best measures of SPU frequency were not available for analysis, these results should be seen as an indication that the SJSU SPUQ – Online has room for improvement, and not that SPU is not related with cognitive functioning. These results should be considered preliminary at best.

## **Alcohol Use and Cognitive Task Performance**

The relationship between alcohol-use recency and cognitive task performance was also analyzed. Results from these four *t*-tests indicated that those who drank alcohol within the last week spent less time planning on the SOC problems. This may correspond with other research suggesting that those who are alcohol-dependent have trouble inhibiting their actions (Fernandez-Serrano et al., 2010). Failure to inhibit action may have made it more difficult for recent drinkers to allocate a large amount of time planning before starting the problem. However, because those who recently consumed alcohol did not have a different number of problems solved in the optimum number of moves than those who had not recently consumed alcohol, it is uncertain why their planning time was so much shorter. For example, although it is possible that recent drinkers' reduced time spent planning was due to an impaired ability to plan—potentially originating from an impaired ability to inhibit immediate action—it is equally plausible that they were more efficient planners. Additional research with different measures of executive functioning and improved measures of alcohol use are needed to determine how specific aspects of executive functioning may be affected by alcohol use. Overall, the current study did not find that those who recently drank alcohol had significantly impaired performance on the executive functioning task.

The relationship between recent alcohol use and working memory was also assessed. Both *t*-tests for this relationship were not found to be significant, indicating that those who recently drank alcohol did not differ in the percent of problems they got correct, or how long their reaction time was compared with those who had not recently

drank alcohol. Thus, alcohol-use recency group was not related with working memory task performance.

Finally, post-hoc analyses were conducted to determine whether the recency of using cannabis, tobacco, or caffeine was related with performance on the cognitive tasks. None of the 12 analyses achieved significance, indicating that drug use recency may not be the best measure to use when assessing the cognitive impact of drug use in young adults. This hypothesis may have merit, because several other researchers have found considerable relationships between the impact of these drugs and cognitive task performance when looking at other measures of drug use (Alford et al., 2012; Fernandez-Serrano et al., 2010; Fisk et al., 2010; Solowij et al., 2011; Thoma et al., 2011).

Overall, the results of the current study did not find that alcohol-use recency was related with impaired working memory or executive functioning task performance; however, they were in line with other research showing that college students who are light social drinkers and subclinical adult drinkers do not readily show substantial cognitive impairments (Bates & Tracey, 1990; Caspers et al., 2010; Piechatzel et al., 2009). Perhaps most importantly, Piechatzel et al. (2009) also did not find significant relationships between both the alcohol use patterns of young adults with tests of working memory, and also between alcohol use and scores on the CANTAB SOC subtest. Together with results from the current study, this may indicate that the average young adult drinker may not exhibit extensive executive functioning impairment, at least as measured by the CANTAB SOC subtest. However, not enough research has been done on this topic to warrant a definitive conclusion.

## **Limitations and Future Directions**

Perhaps the main limitation of this study is that findings regarding drug use and cognitive functioning were based upon relatively weak measures of drug use. Because of the relatively small sample size, the results of this study regarding the relationship between substance use and cognitive performance should be considered mainly preliminary. In particular, items regarding the frequency of SPU were only answered by 17 out of the 45 participants who reported SPU, and thus less informative measures of SPU had to be utilized. The SPU frequency items on the SJSU SPUQ – Online specifically asked how many times “in the last month” that a person used each drug in combination. This may have resulted in many participants not responding because they took the study early in the month, or because they have not used that combination in at least one month. Thus, in future research this item should be reworded to specifically ask what SPU occurred in the “last 30 days,” to avoid missed or distorted data due to calendar date. Additionally, a second item could be included asking: “if you have not specifically used this drug combination in the past 30 days, approximately how many days in a 30-day period do you tend to use this combination?” Such a follow-up item would help ensure that at least some data regarding SPU frequency is collected from each participant. A longer-running study including more efficiently worded SPU frequency items would give enough data for the more effective measures of SPU to be utilized.

A second considerable limitation of this study is that few items were included in the SJSU SPUQ – Online assessing alcohol use. Although the SJSU SPUQ – Online is uniquely focused on characteristics of SPU, there is a paucity of items assessing

individual drug use. In order to better assess whether alcohol use is related with cognitive performance, future research should include items covering the recency, frequency, and quantity (e.g., drinks per drinking day) of college students' alcohol use. Although the current study examined alcohol-use recency, the frequency and quantity of alcohol use were not assessed. At least one study has shown that the number of drinks per drinking day young adults consume is related with impairments to executive functioning (Green et al., 2010); therefore, this measure of alcohol use should be included in further iterations of the SJSU SPUQ – Online. In summary, future research on SPU and alcohol use, and future iterations of the SJSU SPUQ – Online should include items pertaining to the recency, frequency, and quantity of alcohol consumption.

A third limitation of this study, and all research involving college students, is that the majority of college students are not old enough to have a very extensive heavy-alcohol use history. It is possible that cognitive impairments related with chronic alcohol use accumulate with time, and thus those with shorter alcohol use histories do not exhibit as much impairment. For example, when assessing participants with an average history of heavy drinking of 27 years, Fitzpatrick (2013) found substantial impairments in alcoholics' visuospatial skills, language skills, psychomotor speed, executive functioning, learning, and memory. Thus, it is possible that no significant relationships between alcohol use and SPU with cognitive functioning were found in the current study because drug-related cognitive impairments had not had sufficient time to develop. Additionally, surveying older participants from outside of college campuses may result in a broader spectrum of SPU combinations and individual drug use.

## **Conclusions**

This study had several findings regarding the development of the SJSU SPUQ – Online. The results indicated that the SJSU SPUQ – Online was quite likely a more accurate assessment of drug use than the original paper version of the SJSU SPUQ. As explained, respondents using the SJSU SPUQ – Online displayed individual and combination drug use prevalence rates similar to those in other studies (Barrett et al., 2006; O’Malley & Johnston, 2002). Items regarding SPU frequency in the last month may need to be re-worded and supplemented by additional items. They were most often left blank. Although the SJSU SPUQ – Online is in need of some improvement, through the use of this measure, this study showed that almost half of college students may at some time have at least one occurrence of simultaneous polydrug use and that the drugs students use most frequently in combination are typically the drugs they most frequently report using individually.

This study also had some notable findings regarding drug use and cognitive task performance. First of all, college students who drank alcohol within a week of the study did not spend as long planning executive functioning tasks as those who did not. At the same time, alcohol-use recency may not be an exceptionally strong measure of the severity of alcohol use. For this reason, the SJSU SPUQ – Online should include additional items regarding drug use frequency, quantity consumed, and age of regular use onset to improve the utility of the questionnaire in assessing individual drug use patterns. Alternatively, the SJSU SPUQ – Online could be used together with another strong measure of alcohol use such as the AUDIT. In summary, this study shows many ways in

which the SJSU SPUQ – Online can be further developed and improved, while it also confirms that the measure still has considerable utility in measuring simultaneous polydrug use.

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