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Kava drinking in traditional settings: Towards understanding effects on cognitive function

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Abstract

Background: Kava drinking is a tradition among Pacific Island people, although growing in popularity with other ethnicities. However, drinking substantial quantities of kava has raised concerns regarding physical manifestations of slow response and lack of precision in bodily control. These impairments can have significant consequences when after consuming large volumes of kava an individual makes a choice to drive.

Aims: The objective of this study was to measure selected cognitive functions following high traditionally consumed kava volumes (greater than 2,000 mg of kavalactones) aimed at identifying potential risks for kava drink-drivers.

Methods: The reaction and divided attention of 20 control participants was assessed against 20 active kava-drinking participants during and following a 6-hr kava session in a "naturalised" setting. Assessment measures were drawn from Vienna Test System—Traffic's test battery.

Results/Outcomes: Results showed no statistical significant difference between control and active participants at any measurement point over a 6-hr testing period regardless that the movements and speech of the active participants were observed to slow as the test session and kava consumption progressed.

Conclusion: Inconsistencies between test results and observations during testing and by road policing officers demonstrate an urgent need for more research in this field.

KEYWORDS

cognition, divided attention, driving, kava, naturalised test setting, reaction

1 | INTRODUCTION

Kava is a traditional drink made by steeping the ground roots and/or rhizome of the *Piper methysticum* plant in water. Both the plant and drink have great cultural significance to many Pacific people, being consumed at almost every major event from birth to death (Aporosa, 2019b). Kava is found in Eastern Pacific Oceania (Polynesia), where it is mixed to a lesser strength than in Vanuatu and areas of Western Pacific Oceania (Aporosa, 2019b). Frequently, kava is used to facilitate *talanoa*, or culturally influenced spaces of transparent, participatory, and inclusive dialogue (Aporosa, 2014a), where sitting cross-legged on woven mats on the floor, kava is served to drinkers from a centrally located *kumete* (wooden kava bowl; see Figure 1). The average duration for a Fijian or Polynesian kava session is recognised as approximately 6 hr, in which drinkers can consume up to 3.6 L (6.33 pints; Aporosa, 2014b). That consumption volume can equate to more than 8,000 mg of kavalactones (Aporosa & Tomlinson, 2014)—the psychoactive ingredient within kava—well exceeding the pharmacologically recommended daily dose of 250 mg of kavalactones (Braun & Cohen, 2010).

It is conservatively estimated that there are more than 20,000 kava drinkers in New Zealand (NZ) on an average Friday or Saturday night (Aporosa, 2015). Although this figure may appear small in a country of 4.6 million people of which 7% identified as Pacific people (Ministry of Health, 2014), this excludes the increasing number of non-Pacificans, many who have taken up kava as an alternative to

FIGURE 1 Kava being served from a *kumete* (kava bowl) to drinkers sitting cross-legged on woven mats. (Photographer: Todd Henry, 2019)

alcohol (Aporosa, 2015). The increase in kava's popularity is also evident in the United States, with the growth of dedicated kava bars (Showman et al., 2015; Wolinski, 2018). This contradicts a popular belief that kava is a novelty drug used by only small section of the Pacific community.

2 | THE KAVA EFFECT

Users describe the effect of kava drink, as creating a soporific relaxant state of mind, without marked euphoria, impaired decision making, or causing hilarity or disinhibition as often experienced with alcohol use (Aporosa, 2019a; Aporosa & Tomlinson, 2014; Chanwai, 2000). Kava's use extends beyond cultural and social drinking boundaries, as the kavalactones within the plant and drink are responsible for its use in traditional medicine (Lebot & Cabalion, 1988). This includes antistress inhibitors recognised by Western pharmacology. This has led to kava being prescribed (Medical Editor, 2017) as a nonaddictive anxiolytic alternative to benzodiazepine, in the treatment of generalised anxiety disorder (GAD; Sarris, Stough et al., 2013; Lim, 2016). Kava prescribed for GAD is typically administered in tablet (and occasionally syrup extract) form and restricted to no more than 300 mg of kavalactones per day. This complies with pharmacological guidelines (MediHerb, 1994), providing therapeutic value without causing cognitive impairment (Mills & Bone, 2005).

Chua et al. (2016) explain that kava contains a "group of structurally-related, lipophilic compounds known as kavalactones (or kavapyrones) … [which are] responsible for the clinical effects of kava" (p. 2). Those effects are reported to include antistress, anxiolytic, sedative, local anaesthetic, analgesic, anticonvulsant, and neuroprotective properties (Lim, 2016). Each kavalactone has its own unique pharmacological profile, with the six most abundant kavalactones allocated a number to aid chemotype classification (Dragull, Lin, & Tang, 2006; Lebot & Levesque, 1996). The following kavalactones are prefaced with their chemotype number and followed with their abbreviation: 1. *demethoxy-yangonin* (DMY); 2. *dihydro kavain* (DHK); 3. *yangonin* (YAN); 4. *kavain* (KAV); 5. *dihydromethysticin* (DHM); and 6. *methysticin* (METH; see Figure 2).

Pharmacologists explain that as a result of kava blocking the calcium ion channels, this leads to a reduction of neurotransmitter release excitation and the potentiation of $GABA_A$ through enhanced ligand binding to the GABA (gamma-aminobutyric acid) receptors. This creates a reduction in the neuronal reuptake of noradrenaline responders and possibly dopamine, leading to a reversal of monoamine oxidase B inhibition (Ligresti, Villano, Allarà, Ujváry, & Di Marzo, 2012; Lim, 2016). Although such descriptions imply a high level of kava psychopharmacological understanding, Bwarenaba and colleagues (2017) warn that kavalactone "modes of action are not fully understood" (p. 1), with even less understood about "the neurophysiological mechanisms associated with kavalactone metabolism" (p. 5).

Further complicating kava use understandings are extremes between pharmacologically manufactured dose measured tablets prescribed for GAD and used in psychopharmacological studies (typically limited to 250 mg/day) and that purchased in powder form for traditionally influenced consumption accompanying *talanoa*. Commercially available kava powder used for traditionally influenced consumption varies in quality and strength (Singh, 2004a). Total kavalactone content of the dried root powder can vary from 3% to 20%, with samples purchased in NZ showing similar variation. Additionally, kava powder can be mixed with adulterants such as soil, copra meal, or the stems and leaves of the kava plant—which contain toxic alkaloids (Brunton, 2015). Aporosa (2014b) reports that kavalactone levels ingested during typical 6-hr kava sessions in Fiji, using fresh strong local produce, can equate to more than 9,000 mg or 30 times greater than the pharmacological recommendation.

3 | KAVA AND COGNITION FUNCTION

The first systematic review to assess the effects of kava on cognition was undertaken by LaPorte, Sarris, Stough, and Scholey (2011). They reported that due to a lack of consistency in "study designs and use of

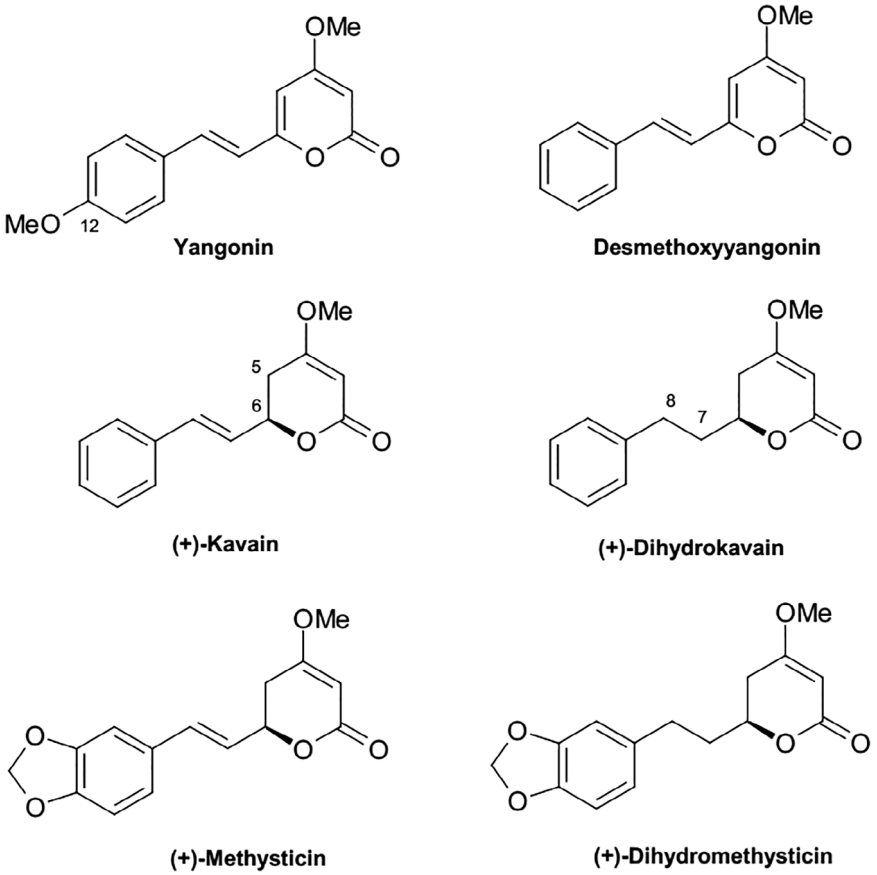

FIGURE 2 Chemical structure of the six major kavalactones present in kava beverage made from the roots and basal stump. Me = methyl group. (Dragull, Lin & Tang, 2006, p. 21)

control" (p. 108), it was found difficult to establish the psychopharmacological effects of kava. For instance, LaPorte et al. (2011) suggested acute kava use, both significantly impaired visual attention and increased body sway, whereas in another study, it was reported that: "kava significantly enhanced visual attention and working memory" (p. 110). They concluded: "kava has non-deleterious effects on cognition during acute administration or produces reduced visual attention at higher doses during cognitive demand" (p. 110). In a study that used a driving simulator to measure the effects of "an acute medicinal dose of kava (180 mg of kavalactones)" on adult participants, Sarris, LaPorte et al. (2013) found that this "[did] not impair driving ability" (p. 13). However, although LaPorte et al. cautioned that until "a more detailed account of the risk benefit ratio of kava on cognition" has been established, "caution is advised when driving and operating heavy machinery" (p. 110), Sarris et al. (2013) add the need for research focused on high consumption doses as consumed in traditionally influenced settings.

In a recent study from NZ, 20% of drivers reported taking drugs known to interfere with their driver safety within 3 hr of driving (Starkey, Charlton, Malthotra, & Ameratunga, 2016). Drug and alcohol-driving prevalence in NZ is a significant health and safety issue and is estimated to have an annual "social cost" of $564 million (Ministry of Transport, 2017, p. 4). Injury resulting from road traffic accidents is the leading cause of hospitalisation for Pacific men and women (Slack, Nana, Webster, et al., 2009). Hospitalisation as a result of drug use among Pacific people is also higher than the general population and increases significantly with age (Slack et al., 2009). Research focused on Tongan kava drinkers report that it is common for 70% to drive home from kava drinking sites (Maneze, Speizer, Dalton, & Dennis, 2008), which can include travelling from one city to another.[1]

Over the past 5 years, the NZ Police has reported increased numbers of kava "intoxicated" drivers (Morgan, 2014; Welsh, 2017). Further, NZ's Crown Research Institute, The Institute of Environmental Science and Research, report the increased presence of kavalactones in the blood of deceased motor vehicle accident victims (Poulsen, Moar, & Troncoso, 2012). By combining statistics on kava use from the NZ Alcohol and Drug Use Survey, with two ethnographic studies, it is argued that there are now more than 15,000 kava users driving motor vehicles following lengthy traditionally influenced kava drinking sessions on an average Friday or Saturday night in NZ (Aporosa, 2015). It is presumed that the high Pacific hospitalisation rates resulting from road traffic accidents and drug use have an as-yet unrecognised link with kava use and driving. This potentially puts a large number of Pacific people and other road users at high risk of injury.

To date, there has only been one successful kava-driving prosecution in NZ (District Court of New Zealand, 2000) and a small number overseas (Jolly, 2009; Swenson, 1996). Although this subject is of concern to road safety commentators (Berry, Gilbert, & Grodnitzky, 2019; Fu, Perl, Jennings, & Hepburn, 2019; Wainiqolo, Kool, Nosa, &

Ameratunga, 2015), law enforcement, and land transport agencies in NZ and the Pacific Islands,[2] the reality is that very little is known about the effects of kava at traditionally consumed volumes, on cognitive faculties related to driver safety. Additionally, when the comments of LaPorte et al.'s (2011) and Sarris et al. (2013) as discussed above are combined with Bwarenaba et al. (2017) concerns about kava psychopharmacology and neurophysiology following small pharmacologically administered doses of kava, this points to the urgency to undertake research in this field.

4 | STUDY RATIONALE

This study was motivated by a desire to discover what effects prolonged kava drinking would have on selected cognitive faculties associated with driver ability and safety. The study aimed to investigate, in particular, two cognitive performance factors, reaction and divided attention, over the course and immediately following a traditional kava consumption session of 6 hr to access driver safety. It is anticipated that this information will improve road safety and reduce injury and hospitalisation, and related economic and social costs, to positively impact on the health of Pacific people and other road users both in NZ and internationally. Study hypothesis: Kava consumers (active group) show a decrease in reaction response of (a) reaction time and (b) divided attention compared with the control group.

5 | MATERIALS AND METHODS

5.1 | Participants

Ethics approval was granted for this study by The University of Waikato's (NZ) Human Research Ethics Committee (HREC [Health] #34). Kava-using participants were placed in the "active" or experimental group and were recruited from *kalapu* (traditionally influenced kava drinking venues) in Hamilton and Auckland, NZ. "Control" participants were recruited by word of mouth, notice boards, and online advertisements at The University of Waikato. Participant eligibility was limited to those over 18 years of age who held a full (unrestricted) driver's licence.

5.2 | Participant eligibility

An eligibility screening form played a key role in participant recruitment. This allowed all participants to be screened for good health, the absence of neurological or psychological conditions (concussion, previous head injury, and psychotic disorders), and to identify any participants taking anxiolytic or sleep medications.

The control participants were asked whether they had ever consumed kava and, if so, how recently. In a few cases, where control participants had consumed kava within 6 months of testing, they were made ineligible for inclusion in the study to ensure all control participants were kava free. Nine of the 20 control participants acknowledged previous kava use, most commonly as part of either a cultural experience at The University of Waikato or while on holiday in Fiji. However, none of them had consumed kava within the past 12 months.

Active participants were also questioned about their kava use. This allowed novice kava users to be identified and excluded, as the study required those who could demonstrate regular use of kava at high consumption volumes over multiple hours. Following selection for participation, the active participants were requested not to consume any kava over a 4-day period prior to testing. Drawing on in vivo experiments with mice and rats, Singh (2004b) states that kava has a drug half-life of 9 hr. This suggests that it takes as many as 90 hr, or almost 4 days, for kava to be eliminated from the body (Aporosa, 2008). The use of "suggests" is deliberate in recognition of Bwarenaba et al.'s (2017) observations regarding limited kava psychopharmacology understanding. Due to the increasing use of kava by non-Pacific people, "other" ethnicities in addition to Pacific Island people were also recruited, and included, in both the active and control groups.

Sixty-seven participants were initially screened for recruitment with 40 advancing to the full experiment. The 40 participants tested consisted of 20 active kava drinkers and 20 control non-drinkers. The average age of all participants was 35.2 years old (SD = 9.8), with little difference between the average age of the active (35.3 years, SD = 9.5) and control (35.1 years, SD = 10.4) groups. Participants were male with the exception of two females in both the active and control groups. Individuals who met test eligibility following screening were given a detailed explanation of the research aims, procedures, and expected time commitment and required to refrain from alcohol intake for 24 hr prior to testing. The control participants were also reminded that test eligibility required them to be kava free for 6 months prior to testing, whereas the active participants were asked to abstain from kava use for 4 days prior to testing to comply with the kava washout requirements.

Each of the 40 participants were asked what ethnicity they identified as. Participant ethnicity, together with age and gender, and designation as either a control or active participant are presented in Table 1.

5.3 | Procedure

The participants were tested in two groups of 20, with each of the two subgroups consisting of 10 active (kava drinkers) and 10 control (non-drinkers). The need to break the 40 participants into those two groups was necessitated due to limited cognitive testing equipment. Upon arrival at the test venue, a lecture room at The University of Waikato acting as a *kalapu*, all participants were briefed on the study procedures and signed informed consents. Participants were also reminded that they would undergo computer-based psychometric testing, in the adjacent computer lab, on the hour over the test period. Kava consumption procedures were explained to the active

TABLE 1 Selected research participant characteristics

M/F	Age	Ethnicity
Control (non-drinking) participants		
F	46	Māori
F	56	Māori
M	32	Fijian
M	29	Māori
M	39	Rarotongan
M	59	African
M	29	Papua New Guinea
M	35	NZ European
M	31	Māori
M	32	Papua New Guinea
M	43	NZ European
M	44	Māori
M	44	Samoan
M	25	Māori
M	46	Māori
M	46	Māori
M	30	Samoan
M	34	Māori
M	20	NZ European
M	22	Māori
Active (kava drinking) participants		
F	48	Tongan
F	25	Tongan
M	30	Hawaiian
M	46	Tongan
M	48	Māori
M	38	Tongan
M	42	Fijian
M	28	Samoan
M	52	Māori
M	39	NZ European
M	33	American–Indian
M	23	Māori
M	20	Tongan
M	46	Fijian
M	30	Fijian
M	37	Fijian
M	37	Fijian
M	47	Fijian
M	43	Fijian
M	29	Tongan

participants, reminding them that they would be served kava at precise intervals, six times per hour for 6 hr, and that at each serving they were free to choose their serve quantity, which ranged from decline to 25, 50, 75, and 100 ml (equivalent to 0.2 pints). The participants were advised that their kava intake would be recorded by one of the two research assistants aiding the chief investigator. In addition to this, research assistants were also asked to make notes of any unusual behaviour by the participants, as the test event proceeded.

All research participants were invited to partake of snack foods and non-alcoholic drinks at their leisure during the test period. These consisted of typical kava *chasers* or food items consumed during a regular kava session. These included salted potato chips and peanuts, apples and pears, and lollipops (a boiled sweet on the end of a stick). Drinks consisted of water, sports rehydration drinks, and lemonade. Participants were asked not to consume energy drinks or caffeine. Additionally, the participants were informed that they were free to move about and leave the *kalapu* to use the toilet, although the active group members were to be present in the *kalapu* at kava serving times, and all participants were to be available on the hour for testing in the computer lab. Although the study adhered to some strict conditions (such as driver's licence requirements, a health screening check, kava serving times, and psychometric testing procedures), flexibility around kava serving portions, the consumption of *chasers*, and the freedom to move about was allowed, with this contributing to a "naturalised" setting of kava consumption.

Two short videos explaining the cognitive tests were shown to the participants with time given for questions and answers. Once all participants were familiar with the test procedures, the participants then underwent baseline testing in the adjacent computer lab.

Following baseline testing, all of the participants were returned to the *kalapu* and invited to sit on woven mats where *iSevusevu* was presented. This is a Fijian influenced respect-based cultural acknowledgement in which the participants were thanked for their time and participation. All Pacific people have cultural practices similar to *iSevusevu*, including Māori (indigenous New Zealanders) who call their equivalent a *pōwhiri* or *whakatau* (Aporosa & Forde, 2019). Additionally, this aided the "naturalised" kava consumption setting and complied with Pacific cultural expectations and obligations guided by Aporosa's (2014a) Post-Development Pasifika methodological framework. *iSevusevu* also initiated the first serving of kava to the active participants. The kava was served from the *kumete* in *bilo*/*ipu* (cups made from coconut shells) using measured quantities as directed by the active participants (see Figure 1). A time chart ensured that the kava was served at the appointed times. The control participants did not consume kava during the *iSevusevu* or at any point during the testing phase. Over the following 6 hr, the participants engaged in *talanoa*, consuming *chasers* and drank kava (if part of the active participant group), and occasionally left the room to use the toilet, with these factors complementing and necessitating a "naturalised" kava test environment.

5.4 | Measures

Two traffic psychology research psychometric assessments were drawn from the Vienna Test System (VTS) test battery (VTS, 2016): the WAFA Alertness (intrinsic visual) test that measures reaction and

attention intensity (Sturm, 2016a) and the WAFG Divided Attention (unimodal visual) test that measures parallel processing and selectivity of attention (Sturm, 2016b). The WAFA Alertness test requires the participant to react as quickly as possible by pressing a "green" button (on the computer keyboard) following each presentation of a stimuli (a large black circle on a white computer screen) without a cue. In total, 50 stimuli are presented of which 25 were randomly selected for "mean reaction time" assessment (Aschenbrenner, Kaiser, Pfüller, Roesch-Ely & Weisbrod, 2012, p. 15).

In the WAFG Divided Attention test, participants were required to monitor two visual stimuli (a black square and a circle on a white computer screen). If one of the stimuli "becomes lighter [in colour] twice in succession," the participant must register this change as quickly as possible by pressing a "green" button (on the computer keyboard; Sturm, 2016b, p. 37). In total, 85 sets of stimuli are presented of which 21 were randomly selected for "mean reaction time" assessment (Aschenbrenner et al., 2012, p. 15). To assist participants with recognition of colour change in the WAFG test, lighting within the test lab was reduced.

In addition to VTS's almost 60 years' experience in providing reliable and valid measures of driver fitness (Trinkl, 2012), additional factors influencing the use of this test battery included repeated use without compromising retest validity, test ethno-friendliness and not marginalising participants with English as their second language, and a full test administration time of less than 10 min, a period that did not disrupt the kava serving time rate/pace (Kallweit & Träxler, 2012; Sturm, 2016a, 2016b). The tests were administered on a suite of Dell OptiPlex (9020) desktop computers in a computer laboratory at The University of Waikato. At each testing session, the WAFA presented first followed by the WAFG.

5.5 | Materials—Kava

Dried powdered kava root/basal stump, originating in Tonga, was purchased from a reputable and well-patronised retailer in Hamilton, NZ. Approximately 1 hr before testing, 36 L (9.51 gal) of kava was mixed to a kava strength reflecting that consumed at average *kalapu* in NZ (see Footnote 1). That mixing used a standardised procedure ("recipe"), which was easily duplicated to ensure kava strength consistency across the two test sessions. Kava powder retained for later testing was compressed into heavy-duty plastic bags and stored in an airtight container in a dry dark cupboard at approximately 18°C to maintain freshness (AECOM-Kalang, 2017). Two hundred grams (7.05 oz) of sample of the dried kava powder, together with the recipe, was couriered to T. K. Group Laboratories in Iowa, USA, for kavalactone strength analysis.

5.6 | Procedure

All participants underwent WAFA and WAFG testing at hourly intervals with the final testing done following the sixth hour of kava consumption. At the conclusion of testing, all participants were provided with a substantial meal, given a $100 gift voucher to thank them for their participation and provided with a ride home. The test session took approximately 7.5 hr to complete.

5.7 | Data analysis

Analysis of the psychometric test data was conducted comparing person-to-person with between-group change. Statistical analysis was based on analysis of variance (ANOVA), independent *t* tests, and Bayesian inference. Bayesian analysis produces a "Bayes factor," which is used for comparative analysis. A Bayes factor is a ratio of the likelihood of a specified hypothesis (e.g., effect of a treatment) to another hypothesis (e.g., no effect).

6 | RESULTS

6.1 | Kava analysis

Following the receipt of the 200 g (7.05 oz) of kava powder by T. K. Group Laboratories, this was subsequently analysed, and a certificate of analysis was issued. The certificate explains that kava residue from multiple samples had been evaporated at 40°C and extracted for analysis. The kava was found to contain no adulterants, with a strength rating of 9.26% total kavalactones by dry weight, a chemotype of 423,651, and a mean kavalactone content of 145 mg per 100 ml of kava beverage.

6.2 | Kava consumption

Only seven of the 20 active participants consumed the maximum average of 3.6 L of kava over the 6-hr test period, drinking the full 100 ml of kava at each serving. Active participant average kava consumption was 3.059 L (*SD* = 0.713 L). This average calculated to 4,426.145 mg of kavalactones or approximately 15 times greater than the pharmacologically recommended daily dose of no more than 300 mg.

6.3 | Test data

The mean reaction time at baseline for all participants (active and control), as measured by the WAFA Alertness (intrinsic visual) test, was 249.95 ms (*SD* = 37.57). Divided attention at baseline, as assessed by the WAFG Divided Attention (unimodal visual) test, was 583.58 ms (*SD* = 226.62).

Figure 3a shows the mean reaction and attention intensity time (WAFA test) for the control participants, at hourly test intervals. After 6 hr, the mean reaction and attention intensity time was 256.70 ms (*SD* = 36.86). Similarly, Figure 3b shows the mean reaction and

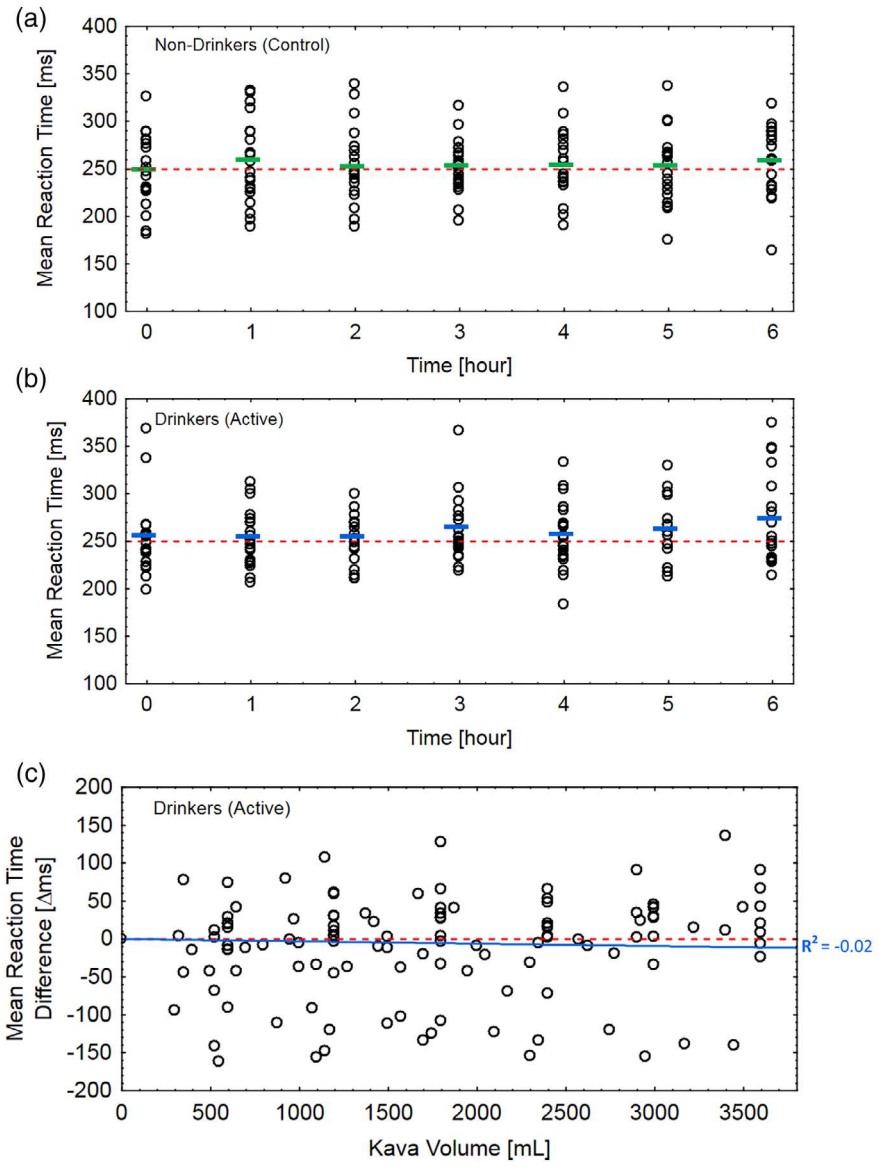

FIGURE 3 (a–c) WAFA Alertness (intrinsic visual) test results. (a) Control participant hourly reaction time. (b) Active participant hourly reaction time. (c) Change in individual mean reaction time from baseline kava consumption

attention intensity time for the kava-consuming active participant groups at hourly test intervals. After 6 hr, the mean reaction and attention intensity time was 271.8 ms (*SD* = 46.32). Finally, Figure 3c shows the change in an individual's mean reaction time from baseline correlated with volume of kava consumed. Positive values indicate slower reaction time and negative values faster reaction time.

Contrary to hypothesis, the WAFA Alertness test results revealed no statistically significant ($p > .05$) difference in reaction time and attention intensity, $F(13, 264)$, 0.582, $p = .868$, both within person or between groups at any measurement point over the 6-hr testing period. Bayesian analysis corroborated the ANOVA and independent *t*-test analysis results. This showed that at baseline, the *p* value for all participants was .280 and at the end of testing at sixth hour, when the active and control participants were compared, .585. Bayesian comparative analysis between baseline and final test at the sixth hour for the control participants was $p = .627$ and for the active participants, $p = .983$. Bayesian comparative analysis between the control participants and the active participants at the sixth hour of testing yielded a Bayes factor of 0.472. This Bayes factor suggests no meaningful difference between the active and control participants.

Figure 4a shows the mean divided attention time (WAFG test) for the control participant groups, at hourly test intervals. After 6 hr, the mean divided attention time was 499.75 ms (*SD* = 167.62). Similarly, Figure 4b shows the mean divided attention time for the kava-consuming active participant groups at hourly test intervals. After 6 hr, the mean divided attention time for the active participant groups was 568.32 ms (*SD* = 217.71). Figure 4c shows the change in an individual's mean reaction time from baseline correlated with volume of kava consumed. The positive values indicate slower reaction time and negative values faster.

Again, discordant with hypothesis, the WAFG Divided Attention test results indicated no statistically significant ($p > .05$) difference in parallel processing and selectivity of attention, $F(13, 264)$, 0.834, $p = .624$, both within person and between groups at any measurement

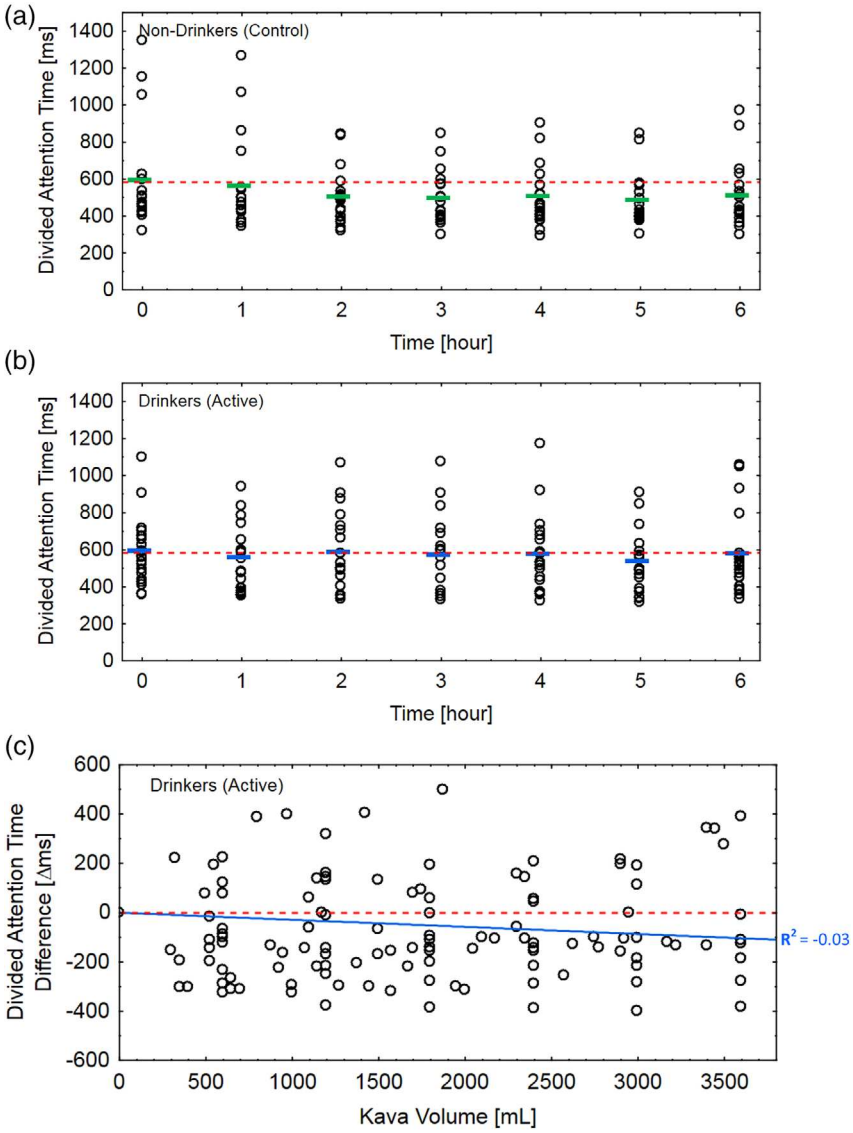

FIGURE 4 (a–c) The WAFG Divided Attention (unimodal visual) test results. (a) Control participant hourly divided attention time. (b) Active participant hourly divided attention time. (c) Change in individual mean divided attention time from baseline with kava consumption

point over the 6-hr testing period. Bayesian inference analysis corroborated the ANOVA and independent *t*-test analysis results. This showed that at baseline, the *p* value for all participants was .385 and at the end of testing at sixth hour, when the active and control participants were compared, .607. Bayesian comparative analysis between baseline and final test at the sixth hour for the control participants was $p = .965$ and for the active participants, $p = .783$. Bayesian comparative analysis between the control participants and the active participants at the sixth hour of testing yielded a Bayes factor of 0.492. This Bayes factor suggests no meaningful difference between the active and control, and the findings show no correlation between consuming kava at traditional volumes and response latency or impairment on divided attention tasks.

6.4 | Observations

At the conclusion of each test event, the chief investigator and research assistants discussed observations they had made regarding participant changes over the duration of the test period. The research team unanimously agreed that as the 6 hr progressed, subtle changes were observed in many of the kava drinkers, namely, slowing psychomotor response, a somnolent-like state, altered word pronunciation, and a slowing of speech rate.

7 | DISCUSSION, LIMITATIONS, AND CONCLUSION

In this study, we were interested in the effects of kava drinking, during and following high traditional influenced consumption volumes (greater than 2,000 mg of kavalactones), on reaction and divided attention to understand impacts on driver ability and safety. This novel study combined a "naturalised" approach with quantitative assessment. The outcomes from testing with both the VTS WAFA Alertness (intrinsic visual) and WAFG Divided Attention (unimodal visual) tests produced results discordant to hypothesis. This was unexpected considering the change observed in active participants as the

test sessions progressed. These observations align with reports from both NZ and Pacific-based Police (see Footnote 2) who describe suspected kava "drink-drivers" at road-side stops as exhibiting decelerated body movement and slurred or slowed speech.

The WAFG Divided Attention results for the control participants at the sixth hour (499.75 ms) showed a small decrease (i.e., improvement) of 83.83 ms when compared with baseline. Although that slight improvement could be explained by practice effect, VTS report test repeatability without compromising validity. More importantly are the active participants. Following 6 hr of kava consumption at a dose approximately 15 times greater than pharmaceutical recommendations, the active group also had a slight average decrease (i.e., improvement) in response time (568.32 ms) of 15.26 ms.

Countering the WAFG Divided Attention increase response times was the WAFA reaction time results. At the sixth hour (256.70 ms), the control participants were fractionally slower by 7 ms when compared with baseline participants, whereas the average active participants were slightly slower (271.8 ms) than baseline participants by 22.10 ms. The nonsignificance of that active participant WAFA reaction time result is demonstrated when compared with the effects of alcohol consumption on driver reaction time. Grant, Millar, and Kenny (2000) showed that consuming 50 mg of alcohol (equivalent to the current 0.05 NZ driver blood alcohol limit), slowed driver reaction time by 70 ms, and this increased to 120 ms at 0.08 (the previous limit).

It is tempting to speculate as to the reasons for the minor changes in WAFG and WAFA responses and why the initial hypothesis was not confirmed by the data. However, it is important to reiterate that there is very limited understanding regarding the psychopharmacological effects and neurophysiological mechanisms associated with kavalactone metabolism (Bwarenaba et al., 2017). Many factors, including plant cultivar and chemotype (i.e., ratio of kavalactones), effects of individual kavalactones and interactions between different kavalactones and between other compounds, and external factors, may have separately or collectively influence the effects on the kava user.

There were a number of limitations to the current study. Aporosa and Tomlinson (2014) explain the challenge of conducting "randomized controlled trials … considered the 'gold standard' for health research … [when] such testing is next to impossible under the conditions in which kava is normally consumed" (p. 164). That impossibility includes fluctuations in kava strength, whether due to the age of the kava plant at time of harvest or the type of kava cultivar (as previously mentioned) that, together with kava mixing based on kava powder and water ratio estimates and preference, prevents kava from being prepared to a strict standardised concentration.

Kava's union with cultural values and respect creates several additional limitations. For instance, cultural respect factors prohibit ingestion volume requirements, the limiting of movement in and out of kava venues, and limitations on food consumption while drinking kava beverage. Cultural values also prevent a kava substitute or placebo from being represented as "real" kava, particularly when the kava is presented as part of *iSevusevu*. Further, because this present study required experienced kava use participants who were capable of drinking large volumes of kava (up to 3.6 L [6.33 pints]) over 6 hr, this also negated the possibility of using a kava placebo to drive "gold standard" testing. This is because kava produces a tingling in the mouth as selected kavalactones interact with oral sensory nerves (Aalbersberg & Sotheeswaran, 1991), a sensation an experienced kava drinker would immediately recognise and question if absent. Finally, also mentioned above is the lack of understanding regarding kavalactone "modes of action" and how kava metabolises (Bwarenaba et al., 2017), together with kava's drug half-life. Such limitations prevented a double-blind placebo-driven "gold standard" testing regime, influencing the use of the naturalised methodology in this study, an approach used in other drug studies.

Nichter, Quintero, Nichter, Mock, and Shakib (2004) explain that although drug research is "largely dominated" by studies utilising statistical data collected though quantitative measures (p. 1908), such rigid approaches fail to provide scope for "space and time" associated with drug substance use (p. 1919). They argue the importance of combining quantitative and qualitative methodological approaches, with the latter including "naturalistic inquiry," particularly when drug use is associated with cultural and traditional substance use and settings (pp. 1912, 1925). Reporting on their study that assessed emotion related to the use of MDMA: "ecstasy," Kamboj et al. (2018) explain their methodology as including a "naturalistic (non-laboratory), within-subjects design" due to their participants supplying their own ecstasy during stage one of testing (p. 1136). In a similar manner to Aporosa and Tomlinson, Kamboj et al. acknowledge that this "imposes some limits on the strength of conclusions … obviously lacking the high levels of experimental control afforded by double-blind laboratory studies, 'naturalistic studies' … [however] are nonetheless potentially valuable in allowing efficient preliminary hypothesis testing on, as yet, poorly characterised drug effects. These can then pave the way for more tightly controlled studies if promising effects are observed" (p. 1135).

Ideally, the use of a driving simulator would have provided a true representation of the actual impact of kava use at traditional consumption volumes on driving. However, time constraints related to simulator test procedures and the use of a naturalistic test setting did not allow for this, contributing to yet another study limitation. Following the analysis of the test data, and the conflict between the lack of results and observations of impairment among the active participants by the researchers, it is acknowledged that the study would have benefited from a validated assessment for observing general behaviour, mood, speech, and appearance. Finally, due to the lack of statistical significance difference between the control and active participants following data analysis, no subanalysis or covariant was undertaken to assess differential kava amounts on the consumption of food and drink items or personal characteristics of the active participants.

Although this first of its kind experimental study—aimed at high kava consumption users—did not reveal significant data, it has assisted in "pav[ing] the way for [a] more tightly controlled stud[y]" (Kamboj et al., 2018, p. 1135), particularly in light of the participant observations during the test sessions. When those observations are combined

with the anecdotal reports from police who continue to stop drivers who appear intoxicated while showing negative results from breath tests, this demonstrates an urgent need for more research in this field. A new more tightly controlled study is currently underway.

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CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ENDNOTES

[1] The kava strength was estimated by Aporosa (author). He has more than 20 years' experience in drinking and mixing kava and attended kalapu in NZ, the Pacific Islands, and Europe. Concerning his level of experience, Associate Professor Matt Tomlinson (2016, written communication), Australian National University, stated: "Dr Aporosa must now be considered the world's leading researcher on the social use of kava (Piper methysticum)."

[2] Over the past 5 years, Aporosa has discussed concerns regarding kava drink-driving with Police and Road Safety in NZ and the Pacific. They include Sergeant Michael Morgan (2014, 2017, November 4/May 4) of the Counties—Manaukau, Prosecutions Section, Auckland, NZ; Ms Sally Fletcher (2017, May 4), Otahuhu Police Prosecutions Office, Auckland, NZ; Inspector Gini Welsh (2017, June 26), Officer in Charge, Road Safety, New Zealand Police National Headquarters, NZ; Senior Superintendent Mahesh Mishra (2018, September 25), Police Traffic Division, Fiji; Executive Office Leasi Vainalepa Galuvao (2018, October 2), Land Transport Samoa; Deputy Commissioner Sālote Grewe (2018, October 11), Tonga Police; and Sergeant Edward Kalura (2018, November 8), Road Safety Division, Vanuatu Police.

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