Effects of Binge Drinking on Cognitive and Metacognitive Activities of Wistar Rats

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Abstract - This study was designed to examine the effects of alcohol on Cognitive and metacognitive activities of rats. 25 male rats with average weight of 150g were divided into five groups comprising of five rats each. While group 1 acted as the control group, Group 2 were administered with low dose (0.5g/kg) of alcohol, Group 3 received medium dose (1.0g/kg) of alcohol, Group 4 was administered with high dose (1.5g/kg) of alcohol and then group 5 was administered with a reference drug (Donepezil 0.1g/kg). Following 4 weeks of administration after acclimatization of animals, various Neurobehavioral tests were employed to investigate specifically the effect of alcohol at graded dose on metacognitive functions in the rats. These tests include the elevated plus maze, Beam walk test, Barnes maze, Navigational maze and the passive avoidance test. Result on metacognitive assessment showed that the group treated with medium dose and high dose of alcohol demonstrated reduction in metacognitive activities in rats. The result further showed that Cognitive and motor coordination and balance were significantly ($p<0.05$) affected by medium and high doses of alcohol. Conclusively, Alcohol affects the metacognitive ability of rats in a fashion that is dose dependent.

Keywords: Metacognition, Neurobehavioral, Elevated Plus Maze, Beam Walk, Barnes Maze, Navigational Maze and Passive Avoidance.

Introduction

Alcohol is the most widely consumed addictive substance worldwide (Gunzerath et al., 2004). The presence is felt in almost all the activities of African customs and traditions ranging from burials, rituals, marriages, oath takings, covenant establishments, meetings, hospitalities, evening relaxation to all forms of other daily activities (Ekwe, 2000). Apart from water and wind, alcohol is another integral and indispensible part of African life and living (Ekwe, 2000). Alcohol is undoubtedly consumed because it has a pleasant subjective effect. It positively reinforces or rewards drinking by producing a mild euphoria (Michael, 1996). Although it is debatable whether moderate drinking offers any health benefits (Gunzerath et al., 2004). The deleterious effects of excessive alcohol use are well recognized. (Oscar-Berman & Marinkovic, 2007).

The term metacognition refers to the awareness, management, monitoring and control of one's own learning and thought processes (Kuhn & Dean, 2004; Martinez, 2006). Metacognition is a form of executive control involving monitoring and self-regulation (Scneider & Lockl, 2002). Metacognitive skills are seen as something that enables learners to self-manage and evaluate their own thinking and learning (Peters, 2000). Rivers (2001) reports that students' self-directed learning behaviour is associated with students' regular estimation of their academic performance, their approach to learning, and how this compares with that of other learners and with the teaching styles used.

MATERIALS & METHODS

Animal Preparation

All animals were housed in wooden cages in the animal house, College of Basic Medical Sciences, University of Port Harcourt, Nigeria. The wistar rats averagely weighing 150g were maintained under standard conditions of temperature, humidity and light. They received food and drinking water ad libitum and were allowed to acclimatize for two (2) weeks.

Alcohol and Donepezil

48% Alcoholic wine and Donepezil manufactured by Wuhan Grand Pharm. Group, co, Ltd, China were purchased ready to use.

Administration of Alcohol

Grouping Design and Treatment

The animals were divided into five groups. Each group comprise of five male Albino wistar rats.

The first group (control group) was given normal chow. The second group had 0.5g/kg of 48% Alcohol; the third group was given 1.0g/kg of 48% Alcohol. The fourth group was given 1.5g/kg of 48% Alcohol while the fifth group was administered 0.1g/kg donepezil.

Metacognitive Tests

Metacognitive tests were carried out on the experimental animals with the following tests;

- Elevated Plus Maze Task
- Beam Walking Test
- Barnes Maze Test
- Navigational Maze Test
- Passive Avoidance Test

Statistics

Statistical analysis was done using SPSS version 20.0 and the results were expressed as mean ±SEM and relative percent change. One way Analysis of Variance (ANOVA) and Post Hoc Test was used to compare the mean and P-Value ≤ 0.05 was accepted as statistically significant. Results were presented in tables and bar charts.

CHAPTER FOUR

RESULT

TABLE 4 Pattern of time spent on the open arm of EPM at different trials on exposure to various doses of Alcohol and Donepezil drug of test groups.

ELEVATED PLUS MAZE (OPEN ARM)					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Group 1 (Saline)	23.50±9.7	33.83±4.25	38.31±2.82	23.71±9.78	26.84±4.25
Group 2 (0.5g/kg)	20.42±8.50*	13.21±4.33*	24.42±2.78	26.47±8.50	30.13±4.33*
Group 3 (1.0g/kg)	35.22±9.92*	43.09±9.23	44.25±5.42*	55.14±.10.0	46.44±9.23*
Group 4 (1.5g/kg)	86.71±5.40	75.33±12.1	94.88±2.26*	77.76±9.56	85.62±10.3
Group 5 (Donepezil)	51.85±9.78	36.80±4.25	38.61±2.82	53.83±9.78	42.86±4.25

Values are presented in mean ± sem, n= 5. * means values are statistically significant when compared to the control.

Key; **group 1** control **Group 2** (0.5g/kg Alcohol), **Group 3** (0.25g/kg Alcohol), **Group 4** (1.0g/kg Alcohol), **Group 5** (Donepezil 0.1g/kg only)

TABLE 5 Pattern of time spent on the closed arm of EPM at different trials on exposure to various doses of Alcohol and Donepezil drug of test groups.

ELEVATED PLUS MAZE (CLOSED ARM)					
Groups	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Group 1 (Saline)	276.50±2.69	266.12±9.50	261.69±2.69	276.29±2.69	273.16±9.50
Group 2 (0.5g/kg)	279.59±48.7*	286.79±12.23	275.58±2.97	273.53±1.01	269.87±1.93
Group 3 (1.0g/kg)	264.78±5.22	256.91±10.0*	255.75±14.7	244.86±19.3	253.56±52.3
Group 4 (1.5g/kg)	213.29±51.7	224.67±51.7	205.12±7.95	222.24±8.89	214.38±16.1
Group 5 (Donepezil)	248.15±2.69	263.20±9.50	261.39±2.69	246.17±2.69	257.14±9.50

Values are presented in mean ± sem, n= 5. * means values are statistically significant when compared to the control.

Key; **group 1** control **Group 2** (0.5g/kg Alcohol), **Group 3** (1.0g/kg Alcohol), **Group 4** (1.5g/kg Alcohol), **Group 5** (Donepezil 0.1g/kg only)

Table 6 Pattern of results from the beam walk test after administration of various doses of Alcohol in the test groups and control

BEAM WALK TEST					
Groups	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Group 1 (saline)	34.65±6.74	51.42±18.2	52.22±2.69	66.86±2.69	60.13±9.50
Group 2 (0.5g/kg)	92.30±11.0	101.21±13.4	71.61±11.0	95.47±48.7	70.43±12.3
Group 3 (1.0g/kg)	161.33±34.8*	154.31±18.8*	205.12±43.9*	157±7.34	168±17.7*
Group 4 (1.5g/kg)	212±25.0*	274±14.8*	284±7.95*	270±8.89*	300±16.1
Group 5 (Donepezil)	32.6±6.72	41.4±18.2	42.2±2.69	63.8±2.69*	58±9.50

Values are presented in mean ± sem, n= 5. * means values are statistically significant when compared to the control.

Key; **group 1** control **Group 2** (0.5g/kg Alcohol), **Group 3** (1.0g/kg Alcohol), **Group 4** (1.5g/kg Alcohol), **Group 5** (Donepezil 0.1g/kg only)

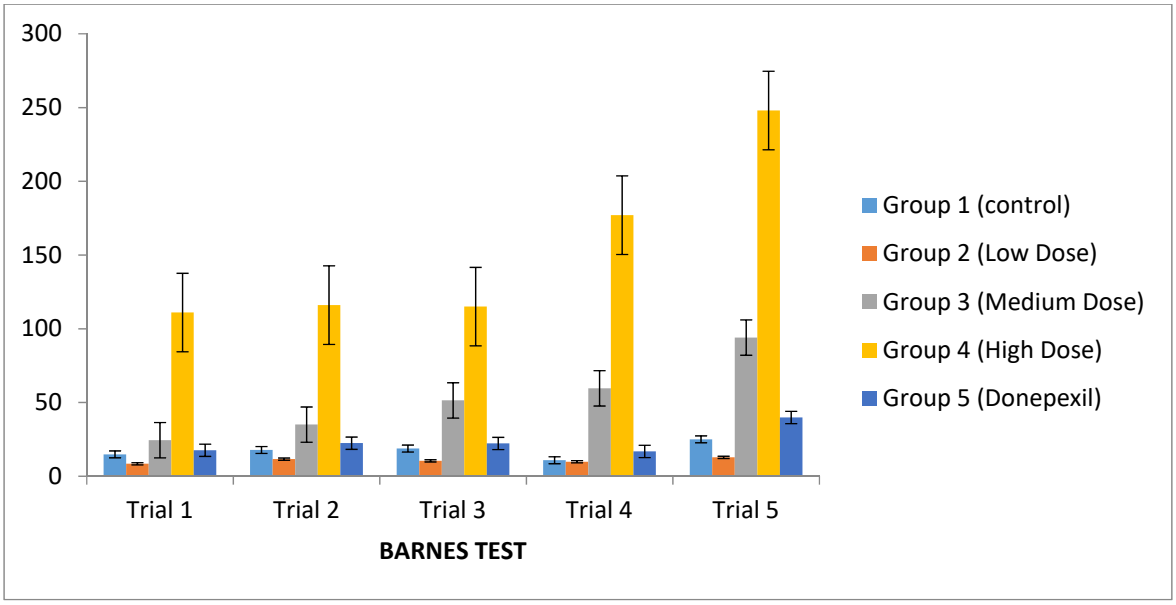

Fig 1 Bars showing result from the Barnes test after administration of alcohol

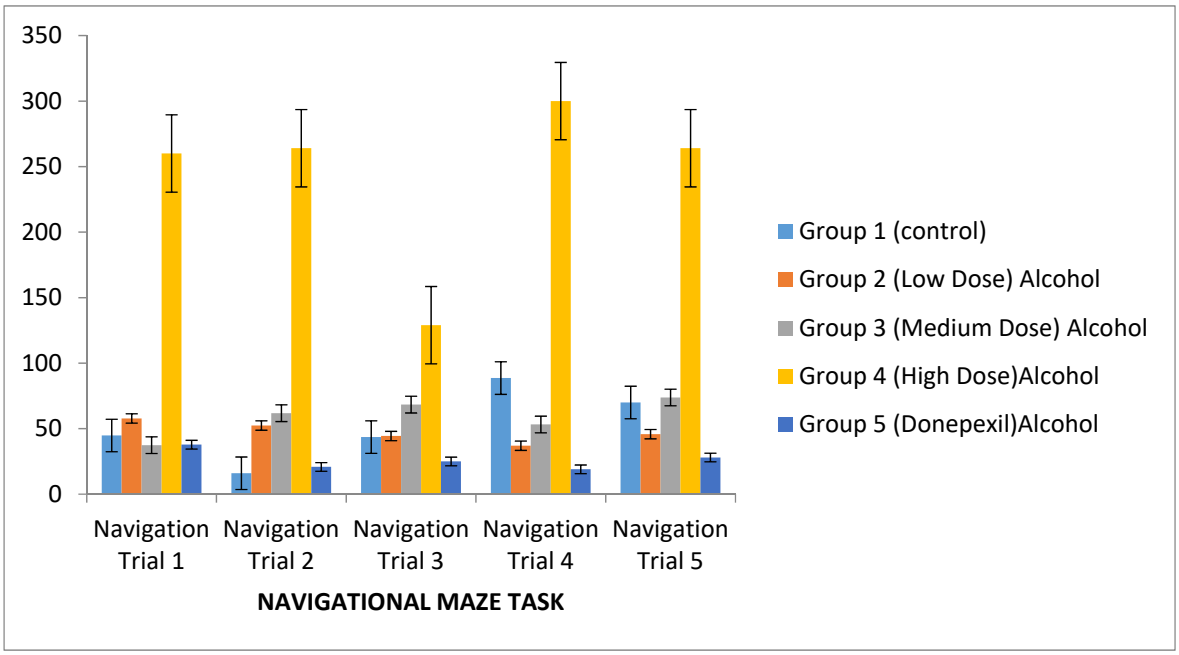

Figure 2 bars showing results from navigational maze test across the test groups and the control

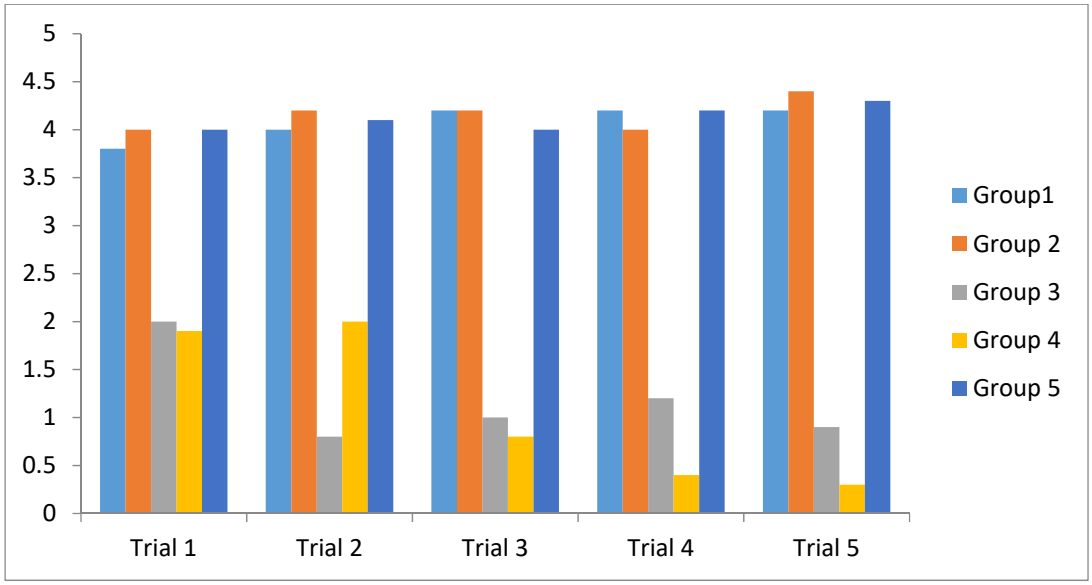

Fig. 3 Bars showing pattern of avoidance during the passive avoidance test

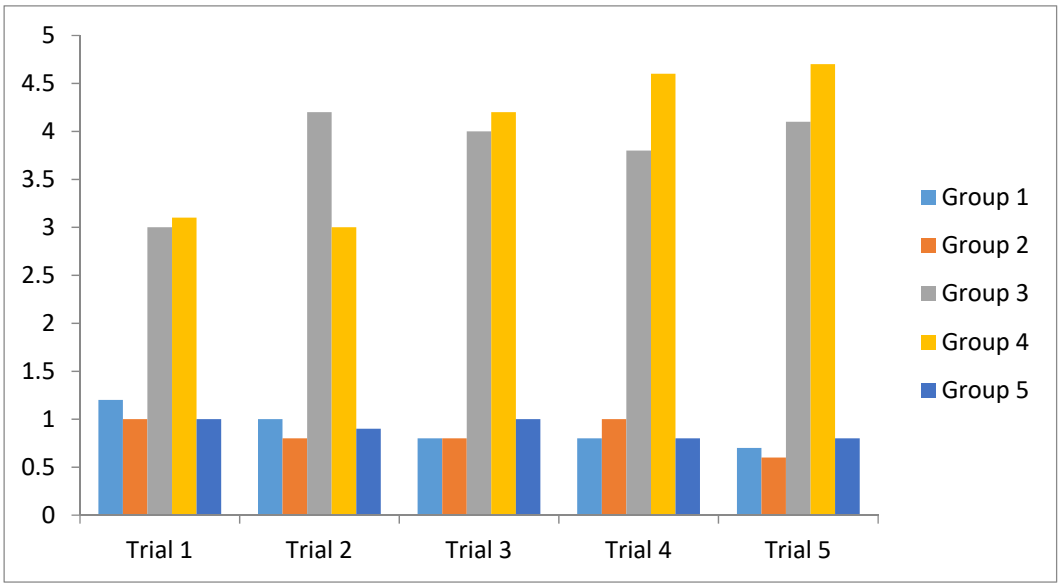

Fig. 4 Bars showing results for the Number of shocks during the passive avoidance test

DISCUSSION

The results of the elevated plus maize as shown in tables 1 and 2 revealed that in all the test groups, rats spent more time in the closed arm than in the open arm, exhibiting innate behavior of preference for protected and dark arrears (eg closed arm), an indication that these animals are aversive to light and unknown environments. The phylogenetics of rodents has been conditioned to see light and unknown environments as dangerous (Michael & Michael, 2015).

Furthermore, examination of the results in table 1 and 2 also showed a pattern of increased time spent on the open arm of the elevated plus maze proportional with the dose of alcohol (48% v/v) administered. Increased open arm time and/or open arm entries relates to anti-anxiety behaviour like reduced fear and risk taking. The result showed that alcohol consumption enhances anxiolytic-like (anti-anxiety) activities. Studies carried out by Longo and Johnson, 2000; Tasman et al., 2008 suggests that the anti- anxiolytic like effects of alcohol is temporary, but in this case we are of the opinion that the rats in these groups have experienced greatly reduced or loss of function of the amygdala. The amygdala regulates fear and anxiety. Studies have shown that exclusive alcohol has noticeable mental consequences which can lead to loss of memory and even brain damage (Gilman et al., 2008; Moberg & Curtin, 2009).Hull, 1981 attributes alcohol-induced reduction in anxiety and the accompanying increase in social behavior, risk-taking, aggression, and euphoria to reduced self-consciousness (Hull, 1981).

The result of the beam walk test revealed a pattern of increased task duration which followed a sequential order as the dosage of alcohol (48% v/v) administered increased. The result is in line with the study carried out by Fuster

et al., 1982 on monkeys who reported that alcohol selectively affects cerebral substrate association with visual attention and spatial bearing ability. This effect was in a dose dependent fashion.

Navigation is the ability of organisms to learn to find their way through the environment without getting lost, a characteristic that requires spatial learning and memory for locations and routes. This is a function of the hippocampus. The results of the navigational tests as shown in tables 4 and 5 revealed a pattern of marked retention/memory deficit. The observed deficit followed a sequential order that was dose dependent. Significant retention/memory deficit was observed in groups 3 and 4 animals that were administered 1.0g/kg and 1.5g/kg of alcohol respectively. We suggest that the observed deficit could be as a result of hippocampal impairment by alcohol. Many authors have shown that lesions, pharmacological inhibition, long-term potentiation (LTP) saturation, and loss-of-function of signalling molecules or receptors within the hippocampus result in impaired spatial learning and memory.(Brandeis et al., 1989; Burgess et al., 2002; Buzsaki & Moser, 2013; McNamara & Skelton, 1993; Moser et al., 1998; Penner & Mizumori, 2012; Suh et al., 2011; Whitlock et al., 2006).

The amygdala, the hippocampus and the prefrontal cortex are part of the neural network that control passive avoidance learning (Bearendse et al., 2008; Burwell et al., 2004; McGaogh, 2004; Ogren et al., 2008). The results of the passive avoidance, an animal paradigm used for studying learning and memory revealed that there was a dose dependent impairment of avoidance. When compared with the control in fig 3, groups 3 and 4 showed significant difference in avoidance which also translates to the number of shocks received as shown in fig 4. The implication of this is that at concentrations of 1.0g/kg and 1.5g/kg, the neural network (Amygdala, Hippocampus and the Prefrontal Cortex) that controls learning and memory is progressively impaired. This could be as a result of the irregular release of serotonin occasioned by alcohol intake. Alcohol temporarily boosts serotonin levels but in the long term, excess alcohol decreases serotonin levels (Tasman et al., 2008).Increases and decreases in brain serotonin have resulted in passive avoidance deficit, probably reflecting the involvement of multiple serotonin receptors in this task (Ogreen et al., 2000). We also suggest that the passive avoidance deficit observed could be as result of excitotoxicity, since alcohol exposure is known to enhance activation of glutamatergic synapses. Excitotoxicity is considered a chief mechanism for brain damage in acquired insults/models such as stroke, trauma, status epilepticus, hypoglycaemia, and hyperglycaemia (Michael & Edward, 2016).

Conclusion

In conclusion, the results showed that Alcohol affects metacognitive functions and behavior in rats. The various tests employed in the study clearly demonstrate the direct interference which alcohol could have in cognitive awareness and motor activities. The impact of medium and high dose of alcohol(48% v/v) on learning, memory, cognito-motor behavior and coordination is evidently negative. Hence, Alcohol has modulatory effect on metacognitive functions and motor coordination.

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