INTRODUCTION

Tomie (1995, 1996, 2001) has noted that Pavlovian conditioning of autoshaping conditioned responses (CRs) and prominent symptoms of drug misuse share a number of salient features. The present experiment is designed to elucidate further the properties of drug-taking behaviour induced by Pavlovian autoshaping procedures, by asking if experience with Pavlovian autoshaping procedures induces drinking, and in particular ethanol drinking, in rats. Such procedures provide for the presentation of a localized visual stimulus, conditioned stimulus (CS), that is followed by the response-independent presentation of food US. The present experiment is designed to elucidate further the properties of drug-taking behaviour induced by Pavlovian autoshaping conditioned responses (CRs), consisting of drinking of either 6% ethanol or water from the sipper CS. This study also tests predictions derived from the autoshaping model by asking if sipper CS-directed drinking will be retained, despite the absence of training for several weeks, and, in addition, if drinking rate is a negative function of sipper CS duration.

Methods: Autoshaping procedures, conducted in two daily sessions, consisted of the brief insertion of the sipper tube CS followed by the response-independent presentation of food US. For the Ethanol group (n = 8), the sipper CS contained 6% ethanol, whereas for the Water group (n = 8), the sipper CS contained tap water. Saccharin fading procedures were employed, whereas for both groups, during days 1–19, the sipper CS contained 0.1% saccharin, and thereafter across training days the concentration of saccharin was gradually reduced (0.07, 0.035, 0.0%). Following elimination of saccharin, both groups were maintained in their home cages during a 27-day retention interval, and then re-evaluated for autoshaping of drinking of unsweetened ethanol and water. Thereafter, across days, the duration of access to the sipper CS (5.0, 7.5, 10.0, 15.0 s) during each autoshaping trial was increased. Results: Both groups increased drinking across the first 19 days of training with sipper CS–food US pairings, and, at 0.0% saccharin, the Ethanol group consumed 14.76 ml of 6% ethanol per day, resulting in a daily ethanol consumption of 2.77 g/kg. For both groups, daily levels of drinking before and after the 27-day retention interval were comparable, attesting to the durability of the acquired drinking effects. At each CS duration, the Ethanol group consumed more millilitres of fluid per day than did the Water group, and for the Ethanol group, peak drinking of 24.0 ml of 6% ethanol per day was observed at the 10 s CS duration. For both groups, drinking rate (millilitres of fluid consumed per second of CS duration), was a declining monotonic function of CS duration, resulting in a daily ethanol consumption of ~4.2 g/kg for the Ethanol group. Conclusions: These data reveal that these sipper CS–food US autoshaping procedures induce drinking in rats that is durable and negatively related to increasing CS duration. The effects of both variables are consistent with the hypothesis that drinking from the sipper CS is a Pavlovian autoshaping CR. Autoshaping of drinking in the Water group is observed despite the absence of water deprivation, and even more fluid is consumed by the Ethanol group than by the Water group. The high volumes of ethanol consumed during brief daily sessions suggest that Pavlovian autoshaping procedures may provide an animal learning model of binge drinking.
induce drinking of water from the sipper CS. This is an important consideration, as the drinking of 6% ethanol observed by Tomie et al. (2002a) may be due to the caloric value of the 6% ethanol solution, which would not be a factor when the sipper CS contained tap water. The Pavlovian autoshaping model predicts that the water control group will drink the solution in the sipper CS, even when the sipper CS contains a water solution with no caloric value.

The present study was also designed to assess the durability of the drinking effects established by Pavlovian autoshaping procedures. Groups of rats provided with 6% ethanol (Ethanol group) or tap water (Water group) in the sipper CS were evaluated for changes in sipper CS-directed drinking across a 27-day retention interval. Once acquired, Pavlovian CRs are typically maintained across long retention intervals (Mackintosh, 1974); therefore, the drinking established by these autoshaping procedures is expected to be durable. Finally, the present study will also assess the effects of increasing the mean duration of time that the rat has access to the sipper CS on each autoshaping trial on the rate of drinking from the sipper CS. Autoshaping investigators have reported that the rate of performance of autoshaping CRs declines with longer CS durations (Gibbon and Balsam, 1981; Jenkins et al., 1981; Killeen, 1984); therefore, the autoshaping model predicts that increasing the sipper CS duration will decrease the rate of drinking (millilitres of fluid consumed per second of CS duration), and this effect should be observed in both the Ethanol and Water groups.

MATERIALS AND METHODS

Animals and treatment

Adult male Long–Evans (Blue Spruce strain) rats (n = 16) obtained from Harlan–Sprague–Dawley (Almont, NY, USA), initially weighing 260–280 g at the beginning of the experiment, were used. Rats were housed individually in suspended steel cages in a colony room with a 12-h light:12-h dark cycle (lights on 04:00). Continuous access to water in their home cages was supplied while the rats were maintained at 80–85% of their free-feeding body weights by providing supplemental rat chow after each daily session. Principles of laboratory animal care (Institute of Laboratory Animal Resources, 1996) were followed.

Apparatus

Autoshaping chambers were four Plexiglas cubicles (24 × 24 × 26 cm) with a stainless steel grid floor all enclosed in sound-attenuating, ventilated outer casings. One house light (GE 1821) was mounted directly above the operant chamber on the ceiling of the outer hull. The front panel of each chamber was equipped with a retractable stainless steel sipper tube containing a stainless steel ball-bearing with an inserted rubber stopper holding the fluid in a 50 ml Plexiglas graduated tube (model 58320; Kimble–Kontes, Vineland, NJ, USA). The Plexiglas tube was mounted on a mechanical bottle insertion mechanism (BCS Machine, South Plainfield, NJ, USA), which inserted the stainless steel sipper tube 3.5 cm above the grid floor and 3 cm to the left of the centreline. The bottle insertion mechanism moved the sipper tube a total of 2.75 cm from fully retracted to fully inserted. In the fully retracted position, the sipper tube was 2.0 cm removed from the chamber. A contact lickometer recorded licks (model ENV-250; Med Associates, St Albans, VT, USA). A metal food pellet receptacle was mounted 3 cm to the right of the centreline, and 4 cm above the floor. The food pellet dispenser (model PDC/PPD, BRS/LVE) delivered 45 mg food pellets (#F0165, BioServ, Frenchtown, NJ, USA). Masking noise (88 dB, linear scale) was provided by the operation of ventilating exhaust fans mounted on the outer hull. IBM PCs controlled session events.

Drugs

Bulk ethanol (95%) was obtained from Rutgers University Chemical Stores. Saccharin sodium was obtained from Sigma Chemical Co., St Louis, MO, USA.

Autoshaping procedure

Rats were run 5 days per week and received two autoshaping sessions per day. Morning sessions were conducted between 09:00 and 12:00, whereas afternoon sessions were conducted between 13:00 and 16:00. Prior to each autoshaping session, rats were weighed and then immediately placed in the autoshaping chamber. Eight rats were randomly assigned to the Ethanol group, and eight rats were assigned to the Water group. For both groups, the sipper tube (CS) was inserted for 5 s, followed immediately by the response-independent operation of the pellet dispenser (US). For both the Ethanol and Water groups, the delivery of the food pellet US occurred regardless of whether the subject contacted the sipper CS. Both groups received a total of 25 trials per autoshaping session. The mean inter-trial interval (ITI) duration was 60 s, with a minimum of 45 s and a maximum of 75 s. The session duration was ~30 min. Volume of fluid consumed (ml) during each autoshaping session was determined by recording the volume in the tube immediately before and after each session.

For the first 19 days of autoshaping, the Ethanol group received 6% ethanol in 0.1% saccharin solution. During days 20–31, the Ethanol group received 6% ethanol in 0.07% saccharin solution. During days 32–35, the Ethanol group received 6% ethanol in 0.035% saccharin solution. During days 36–40, the Ethanol group received 6% ethanol in 0% saccharin (tap water) solution. The water group received identical training (i.e. the same saccharin fading procedure) with 0% ethanol (tap water) rather than 6% ethanol.

Following the 40th day, autoshaping procedures were suspended for the next 27 days (41–67). All rats were placed on free-feed for 20 days, and during days 60–67 all rats were food-deprived to 80–85% of their ad libitum weights. Following the completion of the 27-day retention interval, the effects of increasing the duration of access to the sipper CS were evaluated. During days 68–78, all rats received 11 days of autoshaping procedures identical to those given on day 40, with the CS duration of 5 s. During days 79–88, the CS duration was 7.5 s. During days 89–93, the CS duration was 10 s, and during days 94–115, the CS duration was 15 s.

Blood-ethanol assay

Immediately after the second autoshaping session of day 103, each rat was manually restrained and a scalpel was used to remove the last 5–10 mm of the tip of the tail. Samples of tail blood were collected to assay blood ethanol. For all rats,
latency to collect the tail blood samples following the incision was ~1–2 min. Tail blood samples were assayed for blood-ethanol levels using Sigma Diagnostics Enzymatic Alcohol Assay Kit (Product #332-C).

Statistics

For each subject, for each autoshaping session, the following data were obtained: ml of fluid consumed, total number of sipper tube licks, body weight, and g/kg of ethanol consumed. For each group, effects of autoshaping sessions on mean ml of fluid consumed, mean number of licks, and mean g/kg were assessed by one-way repeated-measures analysis of variance using ANOVA (Systat). For all of these measures, for each subject in each group we derived the mean of the last 4 days of autoshaping for each saccharin concentration (0.1, 0.07, 0.035, 0.0%) and each CS duration (5, 7.5, 10, 15 s). The mean of the last 4 days of training under each condition provided a stable estimate of asymptotic drinking for each group that did not vary by >10% between consecutive days. Effects of groups and saccharin concentration and effects of groups and CS duration were assessed by two-way repeated-measures multivariate analysis of variance using MANOVA (Systat). The forms of the functions (linear or quadratic) relating drinking to CS duration were evaluated using orthogonal polynomial contrasts (Systat). Statistical adjustments were made to maintain family-wise $P$ values at an alpha level of 0.05 by dividing 0.05 by the number of effects reported in the family-wise analysis.

RESULTS

Acquisition of autoshaping of drinking

Both groups showed systematic increases in mean ml of fluid consumed per day (two autoshaping sessions per day) during the first 19 days of autoshaping. For the Ethanol group, analysis of the effects of autoshaping sessions on mean ml of fluid consumed per day (Fig. 1, upper panel) revealed a statistically significant main effect of days [$F(18,126) = 9.671, P = 0.000$]. A similar analysis for the Water group also revealed a statistically significant main effect of days [$F(18,126) = 4.608, P = 0.000$]. In comparing the two groups across the first 19 days of autoshaping, there was no significant main effect of groups [$F(1,14) = 1.870, P = 0.193$], a significant main effect of days [$F(18,252) = 14.088, P < 0.000$], and no significant interaction effect between groups and days [$F(18,252) = 1.614, P = 0.057$]. The groups differed reliably on mean ml of fluid consumed on day 19 (two sessions) which was the last day of training with the 0.1% saccharin solution [$F(1,14) = 5.525, P = 0.034$]. For the Ethanol group, analysis of the effects of autoshaping days on mean g/kg of ethanol consumed per day (two sessions/day) during the first 19 days of autoshaping (Fig. 1, middle panel) revealed a statistically significant main effect of days [$F(18,126) = 8.370, P = 0.000$]. Both groups also showed systematic increases in mean number of licks on the sipper tube per day during the first 19 days of autoshaping (Fig. 1, lower panel). For the Ethanol group, analysis revealed a statistically significant main effect of days, [$F(18,126) = 4.349, P = 0.000$]. A similar analysis for the Water group also revealed a statistically significant main effect of days [$F(18,126) = 2.800, P = 0.000$].

Effects of saccharin fading procedures

Mean ml of fluid consumed during the last 4 days of training (days 16–19) with 0.10% saccharin was 15.352 for the Ethanol group and 12.078 for the Water group. For the Ethanol group, mean ml of fluid consumed during the last 4 days of training with the 0.07, 0.035 and 0.0% saccharin concentrations were 14.547, 14.273 and 14.758, respectively, whereas for the Water group, these values were 11.031, 12.520 and 11.172, respectively. With the 0.0% saccharin concentration, the group mean difference was statistically significant [$F(1,14) = 4.869,$
P = 0.045], indicating that, without saccharin, the Ethanol group drank more than the Water group.

Effects of the retention interval

The levels of drinking for both the Ethanol and Water groups were virtually unaffected by the 27-day retention interval, suggesting robust long-term retention of sipper CS-directed autoshaping CRs. The maintenance of autoshaping CRs across the retention interval was evaluated for each group in two ways. Comparing a group’s mean drinking during the last 4 days immediately prior to the retention interval (days 37–40) to that group’s mean drinking during the first day immediately following the retention interval (day 68) allows for assessment of the immediate impact of the retention interval on drinking. The longer-term maintenance of post-retention interval drinking was assessed by comparing a group’s mean drinking during the last 4 days immediately prior to the retention interval (days 37–40) to that group’s mean drinking during the first 4 days immediately following the retention interval (days 68–71).

The results are shown in Fig. 2. For the Ethanol group, analysis of the effect of the retention interval on mean ml of 6% ethanol solution consumed during the first day following the retention interval (days 37–40 vs day 68) revealed no significant main effect of the retention interval (F < 1). A similar analysis for the Water group also revealed no significant main effect of the retention interval (F < 1). For the Ethanol group, analysis of the effects of the retention interval on mean ml of 6% ethanol solution consumed during the first 4 days following the retention interval (days 37–40 vs days 68–71) also revealed no significant main effect of the retention interval (F < 1). In addition, a similar analysis for the Water group also revealed no significant main effect of the retention interval (F < 1).

Effects of CS duration

Increasing the duration of access to the sipper CS had a biphasic effect on drinking, and this relationship was observed in both groups, where the maximum mean ml of volume consumed per day was observed with the 10 s CS duration (Fig. 3). In addition, at each of the four different CS durations employed, the Ethanol group drank more than the Water group. Analysis of the effects of groups and CS duration on
mean ml of fluid consumed per day during the last 4 days at each CS duration (5, 7.5, 10, 15 s) revealed a significant main effect of groups \([F(1, 14) = 9.339, P = 0.009]\), a significant main effect of CS duration \([F(3, 42) = 32.201, P = 0.000]\), but no significant interaction effect between groups and CS duration \([F < 1 (Fig. 3, upper panel)]\). Analysis of the form of the function relating CS duration to groups using orthogonal polynomial contrasts revealed a significant quadratic component \([F(1, 14) = 32.441, P = 0.000]\). ANOVA for the Ethanol group revealed a significant main effect of CS duration \([F(3, 21) = 14.747, P = 0.000]\), and orthogonal polynomial contrasts revealed a significant quadratic component \([F(1, 17) = 16.851, P = 0.005]\). This analysis for the Water group also revealed a significant main effect of CS duration \([F(3, 21) = 17.842, P = 0.000]\), and orthogonal polynomial contrasts also revealed a significant quadratic component \([F(1, 17) = 15.590, P = 0.006]\).

These data were expressed as rate of drinking by correcting for the differential opportunity to drink at different CS durations. This was done by dividing the ml of fluid consumed per day by the duration of the CS. Across CS durations, the Ethanol group drank at a higher rate than did the Water group, and for both groups the functions relating drinking rate to CS duration were descending and monotonic in form (Fig. 3, lower panel). Analysis of the effects of groups and CS duration on mean ml of fluid consumed per second of CS duration for the Ethanol and Water groups revealed a significant main effect of groups \([F(1, 14) = 9.207, P = 0.009]\), a significant main effect of CS duration \([F(3, 42) = 49.582, P = 0.000]\), but no significant interaction effect between groups and CS duration \([F(3, 42) = 3.164, P = 0.034]\). Analysis of the form of the function relating CS duration to groups using orthogonal polynomial contrasts revealed a significant linear component \([F(1, 14) = 66.394, P = 0.000]\). ANOVA for the Ethanol group revealed a significant main effect of CS duration \([F(3, 21) = 26.813, P = 0.000]\), and orthogonal polynomial contrasts revealed a significant linear component \([F(1, 17) = 32.664, P = 0.001]\). This analysis for the Water group revealed a significant main effect of CS duration \([F(3, 21) = 25.416, P = 0.000]\), and orthogonal polynomial contrasts revealed a significant linear component \([F(1, 17) = 47.122, P = 0.000]\).

For the Ethanol group, the function relating g/kg ethanol consumed per day to CS duration was biphasic in form. Analysis revealed a significant main effect of CS duration \([F(3, 21) = 13.004, P = 0.000]\) (Fig. 4, upper panel), and orthogonal polynomial contrasts revealed a significant quadratic component \([F(1, 17) = 21.914, P = 0.002]\). Pairwise comparison of g/kg ethanol consumed per day at the 10 s CS duration vs the 15 s CS duration revealed that the difference was significant \([F(1,15) = 7.053, P = 0.018]\). When these data were expressed as rate of drinking, the function relating g/kg ethanol consumed per second of CS duration was descending and monotonic in form (Fig. 4, lower panel). Analysis revealed a significant main effect of CS duration \([F(3, 21) = 15.481, P = 0.000]\) and orthogonal polynomial contrasts revealed a significant linear component \([F(1, 17) = 18.281, P = 0.004]\).

**Blood-ethanol levels**

For the Ethanol group, mean blood-ethanol levels in samples collected during the tail cut procedure, after the second autoshaping session of day 103, were 59.8 mg/dl (range: 16.1–119.1).

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**DISCUSSION**

For both the Ethanol and Water groups, experience with sipper CS–food US pairings induced initiation of drinking from the sipper CS, and, across autoshaping sessions, systematic increases in daily drinking volume, such that, for both groups, drinking functions resembled Pavlovian autoshaping CR acquisition curves. Saccharin fading procedures (Weiss et al., 1990) were successfully employed, in conjunction with autoshaping procedures, to initiate substantial drinking of 6% ethanol solutions, and following initiation of ethanol drinking by saccharin fading, consumption of substantial volumes of 6% ethanol was maintained, even when saccharin was eliminated. While it remains unclear whether sweeteners, such
as saccharin, are necessary to initiate acceptance of the 6% ethanol solution, it is nevertheless encouraging that these autoshaping procedures are effective in maintaining substantial levels of ethanol drinking even after the saccharin was eliminated.

This is the first report of autoshaping of drinking of water. The data of the Water group show that these Pavlovian autoshaping procedures induced drinking when the sipper CS contained tap water, even though the rats were maintained in their home cages with unrestricted access to water, making it unlikely that the rats drank to alleviate a condition of fluid deprivation. In addition, drinking in the Water group cannot be attributed to foraging for calories by hungry rats, as water has no caloric value. The autoshaping hypothesis suggests that the drinking of water is due to the reflexive and involuntary expression of sipper CS-directed autoshaping CR performance.

The Ethanol group drank more than the Water group, and this difference was evident at all saccharin concentrations and was most pronounced when the sipper CS contained no saccharin. It is possible that the elevated drinking in the Ethanol group is due to differences in the caloric content of the solutions offered to the food-deprived rats (Heyman, 1993, 1997; Samson et al., 2000). An alternative account of the enhanced drinking in the Ethanol group was based on the effects of ethanol on autoshaping CR performance. There is evidence that pre-session intraperitoneal (i.p.) injections of ethanol enhance performance of lever-press autoshaping CRs in rats receiving lever-CS–food US pairings (Tomie et al., 1998). Moreover, ethanol’s effects were dose-dependent, such that increasing i.p. doses of ethanol up to 1.0 g/kg were associated with higher levels of autoshaping CR performance. This suggests that, in the present study, the drinking of ethanol would be expected to augment autoshaping CR performance, resulting in more sipper CS-directed autoshaping CRs and more drinking in the Ethanol group than the Water group. This analysis speaks to the issue of why ethanol intake is likely to be exaggerated within a drinking episode. If ethanol’s pharmacological effect is to augment autoshaping of ethanol drinking, then the ethanol–autoshaping interaction provides a positive feedback loop mechanism that will promote the exaggerated expression of ethanol intake (Tomie et al., 2002a).

These data provide evidence of long-term retention of sipper CS-directed drinking, suggesting that drinking established by autoshaping procedures is quite durable. Relative to the pre-retention baseline, there were virtually no effects of the 27-day retention interval on mean ml of fluid consumed for the Ethanol group, and this was true on the first day following the retention interval as well as on the first 4 days following the retention interval. Based on similar comparisons, the Water group also showed virtually no effects of the retention interval.

There are several possible interpretations of the maintenance of drinking in the Ethanol group across the 27-day retention interval. One possibility is based on an alcohol deprivation effect (ADE) (Sinclair and Senter, 1968; Agabio et al., 2000; Samson and Chappell, 2001; for review, see Li, 2000). The ADE is well-documented as an increase in ethanol drinking following a period of abstinence; however, the ADE interpretation does not provide an account of the maintenance of CS-directed drinking observed in the Water group. These subjects were never shifted from alcohol drinking to alcohol abstinence during the retention interval, yet these rats behaved in exactly the same manner as the Ethanol group during the pre- and post-retention intervals.

An alternative view is that autoshaping of sipper CS-directed drinking is durable and well-retained. This view is consistent with the autoshaping analysis, because Pavlovian investigators have extensively documented that Pavlovian CRs are retained across long retention intervals with little or no degradation of CR performance (Mackintosh, 1974). Long-term retention of autoshaping CR performance has been reported in Pavlovian feature learning in pigeons (Nakajima, 1997), and food-getting autoshaping in carp (Aoki, 1985), as well as in other Pavlovian conditioning procedures (Coulter et al., 1976; Marcant et al., 1985; Schreurs, 1993; Solomon et al., 1995; Rosas and Alonso, 1997; Solomon et al., 1998).

In the present study, for both groups, rate of drinking was negatively related to CS duration, and this relationship between CR performance and CS duration has been widely reported by Pavlovian investigators (for reviews, see Mackintosh, 1974; Kilee, 1984) employing a wide range of procedures, including fear conditioning (Odling-Smee, 1975; Burkhardt and Ayres, 1979; Ishii, 1991; Rosas and Alonso, 1997), conditioned enhancement and positive conditioned suppression (Meltzer, 1986), conditioned odour aversion in rats (Rudy and Chee, 1978), and conditioning of heart rate and body temperature with morphine (Schwarz-Stevens and Cunningham, 1994). In addition, the negative relationship between CR performance and CS duration (for reviews, see Gibbon and Balsam, 1981; Jenkins et al., 1981; Kilee, 1984) has also been reported by numerous autoshaping investigators employing pigeons (Balsam et al., 1978; Gibbon and Balsam, 1981; Balsam and Gibbon, 1982; Balsam, 1984; Hennies and Brown, 1990) and rats (Locurto et al., 1981; Kirkpatrick and Church, 2000).

These procedures reveal induction of drinking by Pavlovian autoshaping procedures that employ food US. It is notable that several other models of ethanol drinking in rats also arrange for the drinking of ethanol to be accompanied by the presence of food. For example, prandial drinking models of ethanol drinking provide for ethanol availability following the eating of large amounts of food (Meisch and Thompson, 1974; Neill et al., 1994; Cunningham and Niehus, 1997) and schedule-induced polydipsia (SIP) models of ethanol drinking provide for intermittent schedules of food presentations in a situation where ethanol is also available (Falk et al., 1972; Hymowitz and Freed, 1974; Colotla and Keehn, 1975; McMillan et al., 1976; Riley et al., 1979).

It is appropriate to ask, therefore, if the drinking observed here may be due to either post-ingestive prandial drinking or schedule induction effects. While it is possible that either or both of these factors contributed to drinking in this study, it is unlikely that they account for a substantial portion of it. This is because all of the drinking in these Pavlovian autoshaping procedures occurs only in the brief intervals of time just prior to the ingestion of food, whereas the vast majority of drinking induced by prandial drinking or SIP procedures occurs during the post-ingestive intervals after the food has been consumed. It should also be noted that the effects of eating on drinking are estimated by pseudoconditioning controls that receive sipper CS and food US, but randomly with respect to one another. Tomie et al. (2002a,b) provided data from two studies showing that when the sipper CS contains 6% ethanol but the sipper CS is presented randomly with respect to the food US,
there is reliably less drinking than when the sipper CS and the food US are paired in the autoshaping procedure experienced by the ethanol group in the present study.

It is appropriate to justify the use of food-deprived rats in these studies. First, it should be noted that their use is typical of traditional autoshaping studies employing food as the US (Tomie et al., 1989). Presumably, this is to ensure that the rat is hungry enough to eat the food US and experience the CS–US pairing. For this reason, it seems appropriate to initiate the testing of the autoshaping model of ethanol drinking by using the food deprivation procedures typically employed in autoshaping studies. With regard to the issue of the appropriateness of employing food deprivation in studies of ethanol drinking, it is important to note that the autoshaping model of ethanol drinking is a Pavlovian conditioning model, rather than an operant or instrumental model of ethanol self-administration. The autoshaping model is intended to evaluate the effects of non-contingent pairings of ethanol sipper and food on ethanol drinking. The drinking induced by the autoshaping technique, therefore, is due solely to the experience of ethanol sipper than food, and does not necessarily reflect on the positively reinforcing effects of ethanol. The present studies were not designed to effectively isolate ethanol’s positively reinforcing effect, or to provide information as to the environmental conditions most conducive to the expression of the positively reinforcing effects of ethanol (Samson et al., 2000). While the assessment and analysis of the positively reinforcing effects of ethanol is an extremely important and complex issue, it remains orthogonal to the purpose of this study, which was to characterize the effects on ethanol drinking of experiencing the ethanol sipper just before eating.

These Pavlovian autoshaping procedures induced relatively high volumes of consumption of unsweetened 6% ethanol solutions in very brief periods of time, and therefore these procedures may provide an animal learning model of binge drinking. The rapid drinking of large volumes of ethanol, characteristic of binge drinking in humans, is observed in this study where the rats in the Ethanol group consumed ~4.19 g/kg ethanol per day, even though the sipper CS was available for only a total of 500 s (8 min and 20 s) per day.

These autoshaping procedures induce binge-like drinking and do so merely by providing for repeated pairings of the ethanol sipper with food reward. The obvious suggestion is that pairings of the ethanol sipper with other types of rewards may also induce high levels of ethanol drinking. In humans, the ethanol sipper is likely to be differentially paired not only with the eating of favourite foods, but also with other rewarding and preferred activities, including social interactions, entertainment, or romance. It is likely beyond coincidence that, in humans, such circumstances appear to be highly conducive to the induction of binge-like episodes of excessive and uncontrollable ethanol intake. The intriguing possibility is that binge-like episodes of ethanol drinking are mediated by the performance of sipper CS-directed Pavlovian autoshaping CRs, and this hypothesis is supported by data, such as those presented here, showing that binge-like drinking co-varies with autoshaping CR performance (Tomie, 1995, 1996, 2001).

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