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Wheel running induced by intermittent food schedules

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Sixteen naïve male Wistar rats were exposed to intermittent food delivery to measure the development of schedule-induced wheel running, using fixed time (FT) 30, 60, 120, 240 and 480 s schedules, counterbalanced across animals according to a Latin square design (except under the FT 480 s, which was always presented last to complete the data set). Rats were also exposed to a massed-food control condition. Wheel running was induced in the range of 30-240 s with a gradation as a function of inter-food interval (IFI) length. The temporal distribution of wheel turns was generally presented in the form of an inverted U-shaped as IFIs progressed, showing maximum responding during the first portion of the interval. The introduction of massed-food resulted in an immediate reduction in wheel running. These results support the notion that wheel running can be schedule-induced and categorized into the so-called adjunctive behaviors. These data indicate that IFI length affects the development of schedule-induced wheel running and that the rate of wheel running is maintained by intermittent reinforcement, which are common characteristics of schedule-induced behaviors. Likewise, this idea is supported by the occurrence of a similar temporal pattern to that found with other adjunctive behaviors, such as schedule-induced polydipsia, with its maximum manifestation occurring between the beginning and middle of IFIs.

In 1961, Falk observed that exposure of food-deprived rats to intermittent food reinforcement schedules, with free access to a bottle

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containing water in the experimental chambers, caused the development of excessive drinking (schedule-induced polydipsia, SIP) unrelated to physiological needs or apparent behavior regulation. Other similar behavioral patterns were later studied, such as wheel running (Levitsky & Collier, 1968), air licking (Mendelson & Chillag, 1970), wood chewing (Roper & Crossland, 1982), pica (Villareal, 1967), aggression (Looney & Cohen, 1982), escape (Brown & Flory, 1972), defecation (Rayfield, Segal & Goldiamond, 1982) and a long list of other activities (see reviews by Falk, 1977; Pellón, 1990), all in theory being modulated by the degree of intermittency in the reinforcement. These behavioral patterns have been called adjunctive behaviors (or schedule-induced behaviors) (Falk, 1971; Roper & Posadas-Andrews, 1981; Staddon, 1977; Timberlake, Wahl & King, 1982; Wetherington, 1982), and are characterized primarily by meeting the criteria of significantly higher response rates when exposed to intermittent reinforcement (albeit without an explicitly arranged contingency between behavior and reinforcer occurrence) which are usually observed following the reinforcer in the form of an inverted-U throughout the inter-reinforcement interval.

The meeting of the above mentioned criteria to qualify for categorization as an induced behavior has generated discussion with wheel running in particular, and its comparison to SIP as the referenced prototypical adjunctive behavior. Schedule-induced wheel running (SIWR), where animals deprived of food are exposed to intermittent reinforcement while having free access to a running wheel, was investigated initially by White (1985) and Riley, Wetherington, Delamater, Peele and Dacanay (1985). On the one hand, White (1985) was interested in testing 1) the temporal properties of intermittent reinforcement, and 2) the place occupied by wheel running within the inter-food intervals (IFI), finding that, in sessions with massed-food, the final rate of wheel running decreased in three of the four subjects in comparison with the rate observed under a FT 60-s condition. Wheel running rate increased again after the restoration of the FT 60-s schedule. His results also showed a clear temporal distribution, where wheel running was unlikely to occur after food, increasing until reaching its highest peak above what would correspond to the 24-s bin, and gradually decreasing thereafter towards the end of the IFI. These results led White to conclude that SIWR is an induced behavior. On the other hand, Riley et al. (1985) studied the changes in wheel running (amount, rate and temporal distribution) according to variations in the IFI in three rats. Their results showed that an increase in the IFI increased the total amount of wheel running, but did not increase the rate of wheel running and delayed the appearance of the maximum response peak within the IFI. These results tend to support

Staddon's (1977) approach by which wheel running is not considered to be induced but what he instead called "facultative" behavior.

Staddon (1977) distinguished three classes of behaviors based on their temporal location within the IFI, its relationship with the reinforcer and its excessiveness. Induced behaviors (see also Staddon & Simmelhag, 1971) would present a high response rate and would be located either at the beginning of the IFI, that is, activities that occur immediately after the delivery of the reinforcer as a consequence of a low probability of reinforcement in the post-reinforcement period ("interim" behaviors, such as SIP), or at the end of it, occurring consistently before, or just at the moment of, the presentation of the reinforcer, and therefore, in the presence of stimuli related to the release of such a reinforcer ("terminal" behaviors, such as magazine entries). On the other hand, Staddon (1977) used the term "facultative" to refer to those non-induced behaviors that would not increase in frequency as a consequence of exposure to intermittent reinforcement schedules, but that would present a non-null baseline in animals deprived of food (see also Roper, 1981; Staddon and Ayres, 1975). In addition, facultative behaviors would adopt an intermediate position between interim and terminal induced behaviors within the IFI. Among these behaviors, Staddon (1977) included activities such as wheel running or grooming.

Changes in wheel running have been studied according to variations in IFI length. Induced behaviors, particularly SIP, have a bitonic inverted U-shaped relationship with food frequency (Falk, 1966; Flory, 1971; Roper, 1980); while non-induced behaviors increase their rate in parallel with increases in the length of the IFI, as is generally claimed to occur for wheel running (Penney & Schull, 1977; Staddon, 1977; Staddon & Ayres, 1975). Staddon (1977) suggested that changes in wheel running might be due, in part, to temporal competition with drinking or other schedule-induced behaviors. In fact, evidence has been found regarding the interaction between drinking and wheel running (Penney & Schull, 1977; Riley, Peele, Richard & Kulkosky, 1981; Roper, 1978; Staddon, 1977; Staddon & Ayres, 1975). For example, Roper (1978) found that drinking rate declined when competing with wheel running, and recovered when access to the wheel was impeded. This competition between drinking and wheel running might indicate, however, that both behaviors are of the same nature.

Studies that have described the location of behaviors within the IFI when both interim and namely non-induced behaviors occur, usually indicate that interim activities tend to occur first and the overall distribution of activity is multimodal (Roper, 1978; Staddon & Ayres, 1975; Staddon & Simmelhag, 1971), with a first peak representing the activity of interim behavior and, later, the non-induced behavior (Penney & Schull, 1977). However, when

only interim activities occur in the interval, or when only non-induced behaviors occur, the resulting distribution is unimodal, with a shift of the peak to more intermediate or earlier IFI positions, respectively, for one or the other type of behavior (Roper, 1978; Staddon & Ayres, 1975; Wetherington & Riley, 1986). These are the results obtained with wheel running alone, where it presents an almost post-food location (Riley et al., 1985; Segal, 1969; White, 1985), thus resembling an induced behavior such as SIP. The prevention of the occurrence of induced behaviors would trigger the expression of non-induced behaviors (Cook & Singer, 1976); and, similarly, non-induced behaviors would have an effect on interim behaviors when both are issued concurrently (Riley et al., 1981; Roper, 1978; Segal, 1969; Wetherington & Riley, 1986).

Since wheel running under intermittent reinforcement was initially considered induced given its resemblance to SIP [i.e. both do not occur under continuous reinforcement, both depend on reinforcement being intermittent, and both occur immediately after reinforcer delivery (Levitsky & Collier, 1968)], this was later questioned (Staddon, 1977), and there is still an unresolved debate on whether or not it should be regarded as induced. For example, Segal (1969) supported the hypothesis that it was an induced behavior, because in this study it was found that in the face of concurrent access to water and wheel, the quantity of wheel running increased at the same time as SIP developed, although to a lesser extent, whilst the suppression of access to drink produced a temporal wheel running pattern similar to that of SIP. Investigations that have suggested that wheel running might be a non-induced behavior base their conclusions on observations such as: 1) wheel running locates in the middle part of the IFI, after drinking and prior to anticipatory reinforced behavior (e.g., Staddon & Ayres, 1975); 2) wheel running is not constrained to food contexts, contrary to other induced behaviors such as SIP (Penney & Schull, 1977; Staddon, 1977; Staddon & Ayres, 1975; Wetherington, Brownstein & Shull, 1977); 3) an increase in the rate of food release causes an increase in terminal and interim activities, while wheel running decreases (Staddon & Ayres, 1975); 4) wheel running occurs mainly during post-omission intervals regardless of the time elapsed since the last meal (Penney & Schull, 1977), being high even in the total absence of food such as when an extinction procedure is imposed (Staddon, 1977). High rates of wheel running in the absence of food can simply be accounted for by considering the fact that animal subjects are substantially deprived of activity in their limited home cages, thus rendering wheel running a form of reinforcement (e.g., Pierce, Belke & Harris, 2018), while pre-organized patterns of behavior and extended temporal contiguity between events can account for other aspects of SIWR (see Killeen & Pellón, 2013).

As a result of the aforementioned background, it seems clear that there is still no unified consensus on wheel running as an induced behavior, and this is an issue that needs to be resolved with further experimentation. Clarifying the nature of wheel running as induced or not is important because if it were induced, it would respond to characteristics related to the reinforcer and thus would be modifiable by environmental variables known to affect other schedule-induced behaviors. Facultative behaviors, in contrast, would not be susceptible to manipulation due to alterations in reinforcement parameters. Consequently, in the present study, we will attempt to clarify the contradictions that have been raised on this issue by reworking previous studies while trying to overcome the criticisms received, and by increasing the sample of subjects, an issue that is extremely necessary for a more thorough analysis and generalization of the results. To address this objective, we will focus on the two criteria that would distinguish an induced from a non-induced behavior: 1) the effect of intermittent reinforcement on wheel running, and 2) the influence of the length of the IFI on the development of wheel running and the location it occupies within the IFI, looking for similarities with SIP.

METHOD

Subjects. Sixteen 10-week-old male Wistar rats were purchased from Charles River Laboratories (Lyon, France). They were experimentally naïve and were housed in groups of four in an environmentally controlled room at 21 °C and 65% relative humidity, with a 12-h light-dark cycle (lights on from 08:00 to 20:00 h). After 1 week of habituation to the animal facility, rats were housed individually in 18 cm × 32.5 cm × 20.5 cm transparent Plexiglas cages, with a metal-grid detachable roof that allowed for food to be deposited and a water bottle to be fitted, with food and water available *ad libitum*. After being maintained for 2 weeks in those conditions, rats were gradually reduced to 80-85% of their free-feeding body weight by controlled feeding and then maintained at this level of food deprivation throughout the experiment, with reference to the standard growth curves provided by the supplier. The animals were weighed daily before experimental sessions, and food was made available by daily feeding of lab chow approximately 30 min after completion of each experimental session. At the start of the experiment, rats were in their 17th week of life and had the following mean body weight: 319.69 g (range: 292–346 g). Water continued to be freely available to all animals in their home cages throughout the experiment. All procedures were in accordance with the Spanish Royal Decree 53/2013 regarding the protection of experimental animals and with the European Union Council Directive

2010/63, and were approved by the Bioethics Committee of Universidad Nacional de Educación a Distancia.

Apparatus. The experiment was conducted in 8 Letica LI-836 conditioning chambers (Cibertec Inc., Madrid, Spain) measuring $29 \times 24.5 \times 35.5$ cm which were enclosed in soundproofed housing, equipped with their own ventilation and a small observation window at the front. The fan produced an ambient noise of approximately 60 dB in each chamber that functioned as masking noise during experimental sessions. The front panel of each conditioning chamber was made of aluminum, the left wall of transparent Plexiglas and the remaining walls of black Plexiglas, with stainless steel grid floors. A dispenser was situated behind the front panel to supply 45-mg of standard rat food pellets (Bio-Serv, Frenchtown, NJ, USA) in a centered aperture in the front wall of the chamber, situated 3.7 cm from the floor. The chambers were lit by two 3-W lamps situated at both upper sides of the front panel, and an indirect 25 W light fitted to the interior of the soundproof housing that insulated each chamber.

On the exterior of the back panel of the chamber, a wheel of stainless steel was fitted, 32 cm in diameter and 9.5 cm wide with spokes distributed at 1 cm intervals around the rim. The rat had access to the wheel from the interior of the chamber, through a 10 cm in diameter circular aperture in the wall, situated 28 cm from the front panel and 1 cm from the floor. A removable metal trapdoor restricted access to the wheel when necessary. An AZ fag magnetic reed switch recorded each entire revolution of each wheel.

The scheduling and recording of experimental events was controlled by Med PC IV[®] software.

Procedure. *Development of schedule-induced wheel running.* When the weights of the animals were stabilized within the criterion-based range, rats were exposed to an adaptation session in the conditioning chambers for 20 min, with 30 food pellets being previously deposited all together in the food magazine, ventilation and illumination provided, but with no experimental contingency in operation. During this session, animals had no access to the wheel.

The experiment commenced the day after the adaptation session. Rats were exposed to four FT schedules of different lengths (FT 30-, 60-, 120- and 240-s), such that food pellets were dispensed at these regular intervals regardless of the rats' behavior. Sessions were run daily, with a rest interval of two days between successive FT schedules, with each session being composed of a total of 30 food deliveries. All animals underwent all FT schedules, the order of which was established by pairs of rats using a Latin square design. While exposure to the first FT schedule lasted 20 sessions, the

remaining schedules were held over 15 sessions due to the stability observed in behavior. On completion of the first four schedules, all animals were exposed to 15 sessions under an FT 480-s schedule for the purpose of completing the data set.

The following measures were recorded for each rat each session: total number of wheel turns, along with the number of responses given at each IFI and every 1-s in each interval.

Massed-food control condition. When exposure to the different FT schedules had been completed, rats were exposed to a single session of 240 min of massed-food presentation; 30 food pellets were presented together in the food magazine at the start of the session, and the total number of wheel turns was recorded every 15 min in order to compare it with the data obtained under the different FT schedules, so as to assess the influence of intermittent food delivery on the development of SIWR.

Statistical analysis. SIWR development was analyzed using a one-way repeated measures analysis of variance (ANOVA), with FT schedules (FT 30-, FT 60-, FT 120-, FT 240- and FT 480-s) as the within-subject factor. When appropriate, post hoc comparisons were carried out using pairwise comparisons with a Bonferroni correction for p values.

Comparisons of each FT schedule with its corresponding massed-control were carried out using paired t -tests for related samples.

Statistical analyses were conducted using data on each respective subject's last three sessions under each FT schedule, with the minimum level of significance set at $p < 0.05$. Effect sizes were estimated by η^2 (ANOVAs) or Cohen d (t -tests). All analyses were computed using the SPSS software package (Version 24).

RESULTS

Figure 1 shows the mean (\pm Standard Error of the Mean - SEM) number of wheel turns per minute, as well as the mean (\pm SEM) number of wheel turns per food pellet, given by rats under the different FT schedules and for the massed-food control condition, taking the average of the last three sessions for each FT schedule.

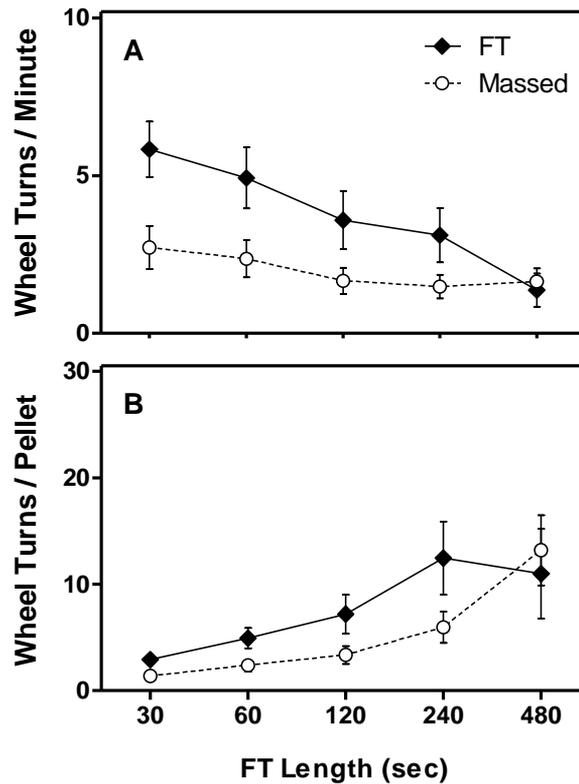


Figure 1. (A) Mean (\pm S.E.M.) number of wheel turns per minute under each FT schedule and for the massed-food control condition; and (B) mean (\pm S.E.M.) number of wheel turns per food pellet under each FT schedules and for the massed-food control condition.

Figure 1A compares wheel turns per minute under the five FT schedules. The analysis yielded a main effect of FT [$F(3,41) = 22.79$, $p < 0.001$, $\eta^2 = 0.603$], with a reduction in response rate as IFI length increased. Post hoc comparisons showed that: FT 30-s produced more responses per minute than FT 120-s, FT 240-s and FT 480-s schedules ($p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively), FT 60-s produced more responses per minute than FT 120-s, FT 240-s and FT 480-s schedules ($p < 0.01$, $p < 0.05$ and $p < 0.001$, respectively), and FT 120-s and FT 240-s produced more responses per minute than the FT 480-s schedule ($p < 0.01$ in both cases). Paired t -tests showed that, when the data of the different FT schedules were compared separately with the data obtained in the massed-food condition, significant differences between means were observed (except for FT 480-s [$t(15) = -1.76$, $p = 0.099$, $d = 0.44$]) as shown by a higher rate of wheel turns with the

intermittent delivery of food (FT 30-s [$t(15) = 4.10, p=0.001, d=1.03$]; FT 60-s [$t(15) = 4.43, p<0.001, d=1.11$]; FT 120-s [$t(15) = 4.11, p=0.001, d=1.03$] and FT 240-s [$t(15) = 5.03, p<0.001, d=1.26$]).

Figure 1B depicts wheel turns per food pellet under the five FT schedules. A main effect of FT was found [$F(4,60) = 5.29, p=0.001, \eta^2=0.260$], with an increase in the number of responses as the length of the interval increased, and therefore the session. Post hoc comparisons showed no statistically significant differences, with only a tendency for FT 30-s to result in fewer responses per pellet than FT 60-s and FT 240-s schedules ($p=0.06$ and $p=0.07$, respectively). Identical results to those found in wheel turns per minute, but for wheel turns per pellet, were obtained in the separate comparisons through paired t -tests of the means of the different FT schedules between the intermittent-food condition and the massed condition ($p=0.001$ in FT 30-s and FT 120-s, and $p<0.001$ in FT 60-s and FT 240-s; see detailed results above).

Figure 2 depicts the mean (\pm SEM) of total wheel turns made every second (bin) during the IFI for each FT schedule (represented in separate panels from top to bottom as a function of increasing FT length), averaged over the last three sessions of exposure to each schedule.

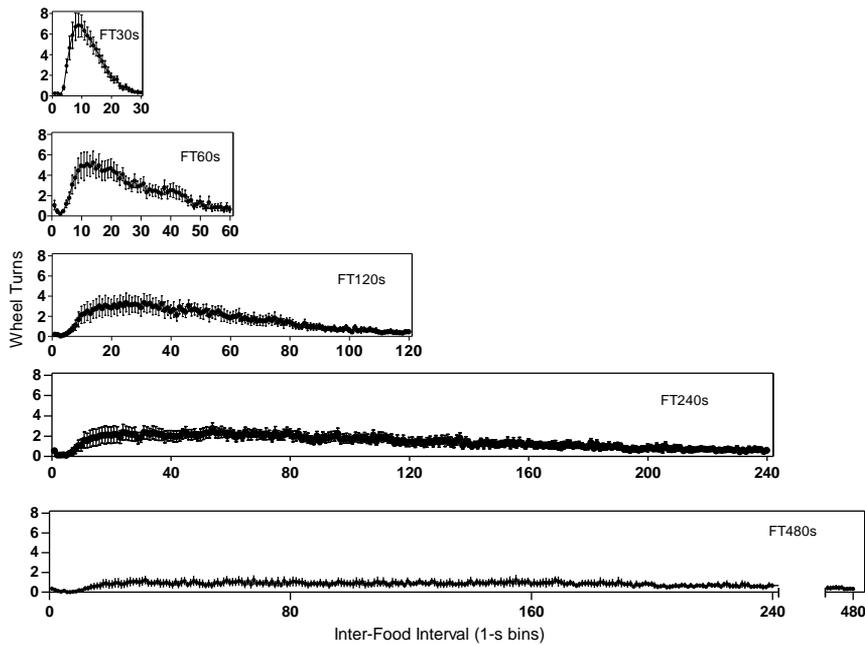


Figure 2. Mean (\pm S.E.M.) wheel turns given every second (bin) during the inter-food intervals for each FT schedule (represented in separate panels from top to bottom as a function of increasing FT length).

Wheel turns were generally distributed in the form of an inverted U-shape as IFIs progressed, showing maximum responding during the first portion of the interval and peaking at bins 9 in FT 30-s, 14 in FT 60-s, 25 in FT 120-s, 54 in FT 240-s, and 32 or 168 in FT 480-s. Rats barely ran towards the end of the IFI. It can be observed that wheel running was more concentrated in the first 3/4 parts of the IFI, except for FT 480-s, where the distribution was flat and low throughout the entire IFI. There was also a tendency towards a shift to the right of the wheel running curve and a "flattening" thereof as a result of the increase in IFI length.

DISCUSSION

The purpose of the present study was to assess whether wheel running can be considered as schedule-induced behavior beyond previous demonstrations, using different FT food schedules and a massed-food control condition. Animals developed SIWR for most of the FT schedules, in a range of 30-240 s (SIWR was not developed under FT 480 s), with a gradation depending on the length of the IFI (Riley et al., 1985) and a decrease in wheel running rate as the IFI increased.

Figure 1 showed a linear downward function as the IFI increased for wheel turns per minute, this being coincident with the results found for other induced behaviors such as SIP, where a fixed duration of the session for different IFIs showed a decreasing monotonic function of the total volume of water ingested with the increase in the length of the IFI (Bond, 1973; Hawkins, Schrot, Githens & Everett, 1972). More precisely, this resembles the transformation in water ingestion rate carried out by Pellón (2012; see a more detailed analysis in Pellón, 1992) on the original data published by Falk (1966, 1967) and Flory (1971), in which the same function was obtained as that found for wheel running rate in the present study. Furthermore, the data on wheel turns per food pellet presented a bitonic relation as a function of an increase in the IFI, although it did not present an inverted U-shape as clearly as is usually observed with other induced behaviors such as SIP. The inverted U-shaped function is characteristic of induced behaviors recorded in conditions where the number of food pellets remains constant for the different IFIs (Falk, 1966; Flory, 1971; Roper, 1980) (for more information see Pellón, 1992, 2012). Altogether, the present data support the idea that wheel running is schedule-induced and cannot be seen as a non-induced behavior, for which the response rate should increase in parallel with increases in IFI length (Penney & Schull, 1977; Staddon, 1977; Staddon & Ayres, 1975).

The results obtained here run counter to those reported by Riley et al. (1985) because their findings pointed towards a doubtless bitonic rather than linear function, relating the rate of wheel running to IFI length. However, this is more apparent than real. Total wheel turns increased as IFI increased both in Riley et al.'s study and in the present study (here reported as wheel turns per pellet) up to the range of common values tested (30 to 240 s), and then decreased or stabilized at FT 480 s in the present study (a value that was longer than the longest 360 s tested by Riley et al). Differences in the reported results on rate of wheel running are not fully clear but the impression is that Riley et al did not find clear effects of FT length on rate of responding because they first trained all rats on the same FT 60-s food schedule, leading to a lower rate of responding than in any of the other subsequent FT schedules tested, which may then have captured some initial lower level of acquisition than subsequently seen under continuation of repeated and extensive sessions of intermittent reinforcement through different FT values without returning at the end to the initial baseline of FT 60 s. Perhaps more important for discrepancies between Riley et al.'s and our results is the use of a different apparatus, in which the main space was the one with the wheel for Riley et al.'s study (they used a single apparatus consisting of a running wheel with an attached chamber to one of its walls) whilst a side wheel attached to a main chamber was used in our case (see Apparatus section above). The rats' stay in the wheel in Riley et al.'s procedure surely instigated a much higher level of running than in the case of the present study where rats stayed mainly in the open area of the conditioning chambers, crossing to the wheel only to run.

The presentation of a massed-food test allowed us to verify the first criterion (outlined in the Introduction) that must be met in order to consider a behavior as schedule-induced, i.e. an increase in response rate when reinforcers are delivered intermittently. Massed-food presentations caused an immediate reduction in wheel running, and we found significant differences in wheel running rate, this being higher when food pellets were delivered intermittently than when they were all deposited together, thus reinforcing the results previously obtained by White (1985) and extending them to a wider range of FT schedules. This conclusion is further supported by the exception of the data of FT 480 s with a similar rate in massed than intermittent conditions after not having developed high wheel running when food was scheduled intermittently. This reduction in behavior suggests that wheel running itself would be induced by intermittent reinforcement schedules, this being one of the main criteria for the categorization of a behavior as adjunctive (Falk, 1971), and, therefore, contradicting the results obtained by other authors claiming that wheel running was not induced by intermittent reinforcement (Penney & Schull, 1977; Wetherington et al.,

1977). For example, Penney and Schull (1977) found that animals drank less and ran more when exposed to a massed-reinforcement schedule than when an intermittent schedule was presented. Their data could be due to the fact that the comparison of the wheel running rate was made under conditions where a bottle of water was concurrently present with the wheel during the different experimental conditions, thus potentially contaminating the results. Drinking could compete with wheel running, presenting itself as a "stronger" behavior, and therefore limiting the expression of wheel running. The apparent increase in wheel turns per food pellet under the massed control of FT 480 s in comparison with other massed-food tests (see open circles in Figure 1B) is simply due to the larger opportunity to run, given the significant increase in session duration as the number of total food pellets was kept constant across the different FT conditions.

With regard to the second criterion for schedule induction as post-reinforcer location of the behavior (see Introduction), the temporal distribution of wheel running showed a similar function to that normally seen in SIP, i.e. an inverted U-shaped post-pellet location, presenting a maximum peak during the first part of the IFI (Falk, 1971; Segal, 1969) (except for FT 480 s, which showed a flat distribution throughout the entire IFI, and failed to generate SIWR), followed by a gradual decrease towards the end of the IFI. This well-defined response pattern has been reported by White (1985), and is strong evidence that wheel running constitutes schedule-induced behavior. Similarly, White (1985) concluded that the results, often disparate, that had been obtained by different authors depended on the configuration of the apparatus used. For example, the possibility of access from the wheel to the food receptacle resulted in a pattern of wheel running that barely diminished until the arrival of the next reinforcer (Roper & Crossland, 1982), or the possibility of engaging in alternative behaviors, where for example the presence of a bottle containing water displaced the peak of wheel running to more central positions in the IFI (Penney & Schull, 1977; Staddon & Ayres, 1975). The curve tended to shift to the right and flatten as a consequence of increases in the length of IFI, conditions that have been observed previously in SIP (Íbias & Pellón, 2011). Results reported by Riley et al. (1985) are very similar to those observed here for temporal distributions, and although they preferred to be more conservative and consider running as a non-induced behavior, they also suggested a temporal modulating effect of the food schedule, thus agreeing with the criteria that must be met to regard running as another schedule-induced behavior.

In conclusion, the results found in the present study support the idea that wheel running may be classified within the so-called adjunctive behaviors, as well as acquiring an induced character. According to Staddon

(1977), wheel running might be considered an adjunctive behavior but not an induced behavior, as it does not comply with the characteristics of induction, since when exposed to an intermittent reinforcement schedule it would not present excessive rates and it would adopt an intermediate position within the IFI, thus not having a direct relationship with the reinforcer. However, our data indicate that wheel running is a schedule-induced behavior that develops at excessive rates when animals are exposed to an intermittent reinforcement schedule, while under massed control, the rate drops considerably, contrary to Staddon's suggestion that wheel running should be maintained even in the absence of intermittency. Furthermore, the temporal distribution of wheel running within the IFI presents a pattern similar to that found with other induced behaviors such as SIP, that is, when only the wheel is available during the experimental session, wheel running reaches its maximum between the beginning and the middle of the interval between meals, adopting a post-food position within the IFI.

Even though the present data appear to be conclusive, they also encourage us to further continue investigating the characteristics and interactions of wheel running as a schedule-induced behavior and as a behavior that can be maintained in its own right.

RESUMEN

Se expuso a 16 ratas macho Wistar a la administración intermitente de comida para medir el desarrollo de carrera inducida por programa, utilizando programas de tiempo fijo (TF) 30, 60, 120, 180 y 240 s, contrabalanceados entre animales de acuerdo a un diseño de cuadrado latino (excepto el programa de TF 480 s que se presentó siempre el último). Se expuso también a las ratas a una condición de control de comida masiva. Se indujo carrera en el rango de 30-240 s con una gradación que estuvo en función de la longitud del intervalo entre comidas. La distribución temporal de las vueltas fue por lo general en forma de U invertida a medida que aumentó el intervalo entre comidas, con un máximo de respuestas en la primera parte. La introducción de comida masiva resultó en una reducción inmediata de la carrera. Estos resultados apoyan que el correr en la rueda puede ser una conducta inducida y que se puede categorizar en las denominadas conductas adjuntivas. Estos datos indican que la duración del intervalo entre comidas afecta el desarrollo de la carrera inducida por programa y que la tasa de carrera es mantenida por reforzamiento intermitente, características que son comunes a todas las conductas inducidas por programa. Esta conclusión se apoya también en la ocurrencia de un patrón temporal semejante al de otras conductas adjuntivas,

como la polidipsia inducida por programa, con su máxima manifestación entre el principio y el medio de los intervalos entre comidas.

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