Behavioral Sequence of Satiety: A Comparative Approach between Birds and Mammals

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Abstract

This approach on the behavioral satiety sequence (BSS) on the historical point of view, the relationship between behaviors that are part of this sequence, shaped as it is used in mammals and eventually brings a new model of how this sequence is made utilize poultry using experimental animal allowing the use of index's to facilitate the study of the relationship between sequence and behaviors that are part of it.

Keywords: Feeding; Drinking; Sleep; Behavioral satiety sequence

A Behavioral Sequence of Satiety BSS

Behavioral Satiety Sequence we know under that name today is the result of physiological changes resulting eating behavior resulting in an organized and remarkable sequence of behaviors [1,2]. This sequence is composed of two phases, the first phase prandial composed by ingestion of food, and the second postprandial phase, composed by drinking behavior, behavior maintenance (Preening) and sleep behavior or attitude being typical sleep [1,2]. As can be seen in the Figure 1 below.

History

The discovery and description of the sequence of behaviors was only possible because of work, such as Barnet(1956) [3], Grant and Mackintosh (1963) [4] E Scott (1966) [5]. These works brought a new look at behavioral pharmacology criticized the studies in the 50s and 60s abide by if only because no consequence to what happened, what behavior the animal had during the time of the experiment. From this new look, there was a substantial change on this type of experiment behavioral pharmacology including the study of food intake, by passing to observe and give more importance to behavior than just the total consumption of food after applying a drug. An example is the work of Bolles (1960) [6], studying the self-cleaning behavior in rats after ingestion of food.

In the year 1960, Richterend Bolles, first observed a sequence of behaviors performed by rodents that were presented to the food after being fasted for 24 hours. This sequence of behaviors was composed by drinking, then for a short period of preening and finished with a long period of inactivity with typical sleep posture. In 1974 arises, the work of Smith et al, the idea that cholecystokinin could be a natural satiety signal and triggering behavior of this sequence. Based on this idea and using behavioral observation and assessment tool, Antin and his colleagues came to confirmation that satiety was reflected through a sequence of behaviors [1,7].

Relationship Between the Behaviors that Make Up the BSS

Food intake

The intake has a direct relation to intake water in many species such as, for example, rodent, 70% of water consumption consumption occurs 24 hours from ten to thirty minutes after the feed intake. Already in pigeons, 70% of water consumption takes three minutes after the meal. In these species, a positive correlation between the size of the meal and the amount of water intake [8-14] is observed. The interdependence between the intake of feed and water intake becomes more evident when their consumption are evaluated in the absence of one or the other [11]. This leads to reduction in both feed intake and water in many species, and in invertebrates [15] in rodents [6] and birds [8,10]. This variety of species with similar responses suggests that the mechanisms of interdependence among 27 eating and drinking are preserved phylogenetically.

Preening

The preening behavior is part of a set of stereotyped behaviors that are related to the body and are phylogenetically conserved maintenance, since being found in arthropods up in birds and mammals [16,17]. What differentiates this behavior between species is its function. While in arthropods has the primary function of care of legs and antennae, in mammals plays an important role, in addition to hygiene in the establishment of social relationships, such as tolerance to feed along with another individual, mutual assistance regarding the aggressive behavior of other groups [18,19]. Besides the functions mentioned, the wiper has been implicated as a marker of low levels of stress in primates and rodents, and birds [18,20-22].

Typical sleep behavior

The sleep behavior after the meal appears at the end of the BSS is a competitor behavior and food intake, or both can not happen at the same time. Like other components of the BSS, the relationship...
between sleep after a meal seems to be evolutionarily preserved. This is because its occurrence is reported in both invertebrate (C. elegans) as in vertebrates such as rodents, for example. In C. elegans, sleep after the meal is characterized by a total period of immobility after the consumption of food, and there is a relationship between sleep time with the nutritional value of the food [23]. Already in rodents, this postprandial sleep does not seem to be so dependent on the nutritional value but the amount of food ingested, as shown by the work of [24,25]. Pigeons Columba livia, which were reared after fasting for 96 hours, showed an increase of three times the duration of slow-wave sleep and the emergence of paradoxical sleep [26]. Such a relationship between eating and sleep was also observed in humans and appears to result from a combination involving stimulation of vagal afferent pathways, increased body temperature, glucose concentration, the more the hormones that are released by the gastric system, for example, cholecystokinin (CCK), which acts on the central nervous system areas involved in control of sleep [27-29].

Use of the Behavioral Satiety Sequence as Pharmacological Research Tool

With the advent of new technologies, especially linked to registration by means of cameras, it became possible refinement studies on the BSS to the point of being able to better observe the behaviors - how they are expressed and the links between them. What made possible the experiments calibration of BSS. Among them, the experiments involving pre-charging of feed offered to the animal before the start of observation, experiment involving the tampering of the palatability of the diet with added quinine or lithium that are used to help differentiate making part of the natural process of satiation eating interrupting the unpleasant taste because of nausea or because of tampering with rations. BSS calibration with the use of drugs as a tool to better understand the sequence of attributes, such as whether or not BSS is sensitive to changes in food intake, and perhaps most importantly, allow it was possible to discern what is really a satiety caused by a decrease in drug intake because of its side effects such as, nausea, dizziness, increased locomotion that are caused by certain drugs. Finally, the pharmacological experiments have shown the participation of some neurotransmitters the control of satiety sequence, such as serotonin and NPY [1,2,30,31] this sense, the attributes of the BSS, as the onset, duration, frequency of feeding behavior and its microstructure, have been repeatedly used as safer hipofagiantes drug effects in rodents [2,7,32,33] pre-clinical model. In addition, measures of changes in the temporal and sequential between components of BSS relations can dissect functional interactions between the systems related to energy homeostasis, hidrossalino balance and sleep-wake states.

In mammals, the methods used to cause SCS lay hold of prolonged food deprivation (24-48 hours) or systematic dietary restriction, followed by reintroduction of food. The intake and postprandial behavior caused by the fast switching are recorded separately into small segments (five minutes) in order to describe the temporal behavior of each route in detail over 30-40 minutes after meal. The effects of drugs applied before the restatement of food or test diets of varying palatability with different nutritional and sensory properties, are examined by comparing the resulting curves of different behaviors simultaneously in a qualitative way [2].

However the use of this model has been used in mammals in a way that may be affecting the results, for example when neglecting the drinking behavior as can be seen from the work [1,7]. The neglect of this behavior can lead to less reliable results of the composition of the sequence, since there is a relationship between the intake of food and drink so that the drink is part of the food intake as stated by [14]. Furthermore, it is worth noting that from the beginnings to the present day the results of experiments in which the employee is SCS are evaluated in a qualitative way down a line where it crosses a line to eat and sleep as we can see in Figure 2.

This form of evaluation is somewhat poor form and this can hide important data on the effects of the studied drugs, such as increased or decreased thirst or hunger.

Furthermore, it should be noted that although food deprivation is a common factor in the animal in its natural habitat, in experimental conditions it may introduce uncontrollable variables in the expression of the SCS, the impact of changing phenomenon in the post-ingestive sleep prandial. This fact occurs because food deprivation leads to modification of sleep patterns in both rodents as in birds. The difference between birds and rodents is that prolonged fasting in rodents increases wakefulness and reduces time spent in REM sleep, and increase the time spent on motor activities and to contribute to a substantial delay in circadian rhythms. Birds already in the starvation leads to increased as in vertebrates such as rodents, for example. In C. elegans, sleep after the meal is characterized by a total period of immobility after the consumption of food, and there is a relationship between sleep time with the nutritional value of the food [23]. Already in rodents, this postprandial sleep does not seem to be so dependent on the nutritional value but the amount of food ingested, as shown by the work of [24,25]. Pigeons Columba livia, which were reared after fasting for 96 hours, showed an increase of three times the duration of slow-wave sleep and the emergence of paradoxical sleep [26]. Such a relationship between eating and sleep was also observed in humans and appears to result from a combination involving stimulation of vagal afferent pathways, increased body temperature, glucose concentration, the more the hormones that are released by the gastric system, for example, cholecystokinin (CCK), which acts on the central nervous system areas involved in control of sleep [27-29].

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However the use of this model has been used in mammals in a way that may be affecting the results, for example when neglecting the drinking behavior as can be seen from the work [1,7]. The neglect of this behavior can lead to less reliable results of the composition of the sequence, since there is a relationship between the intake of food
the time that the animal needs to go without food so you can unleash the BSS. This reduction was 24 pm for 1h. That was enough to add a mixture of seeds (see for composition see [35]) that the animal likes to order the return of normal chow and water. This is an important finding because it avoids the effects of prolonged fasting. This reduction in fasting time increased with this mix of seeds not only triggered the BSS as not married significant changes when compared with animals that were fasted for 24 hours as we can see by the Table 1 below.

Having such data note the importance the search for a palatable food that can add to food intake so that rodents can trigger BSS without the animal needs to undergo long periods of fasting.

Another innovation was the use of indexes that have made it possible to study the relationship between behaviors that are part of the sequence as well as determine precisely when the BSS and ends. Developed index were the peak time (TTP) which is the time it takes to reach each behavior at its maximum and is determined by the number of bins (bins - dividing the total time observed in interval of 4 minutes), the interval between peaks (IPI) shows that as the treatment may influence the distances between maximum durations, which is already an idea of stretching or acceleration of BSS and given by subtracting the values of the peak bins of eating for peak drinking, of eating for peak autolimpeza and peak to peak eat and sleep behaviors intersection (ItS), which demonstrates the exact time at which a sleep behavior becomes more important than another and thus determines the end of the BSS can be better visualized in the Figures 3 and 4 below Table 2.

<table>
<thead>
<tr>
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<th>MS-BSS (n=6)</th>
<th>24-h Food deprivation (n=6)</th>
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<tbody>
<tr>
<td>Food Intake (g/100g bw)</td>
<td>3.65±0.64</td>
<td>3.99±1.17</td>
</tr>
<tr>
<td>Feeding (duration, s)</td>
<td>1601±335</td>
<td>818±349</td>
</tr>
<tr>
<td>Latency (s)</td>
<td>51±13</td>
<td>50±165</td>
</tr>
<tr>
<td>TTP (bins)</td>
<td>3(2,3)</td>
<td>2(1,3)</td>
</tr>
<tr>
<td>Water Intake (ml/100 g bw)</td>
<td>1.85±0.73</td>
<td>1.89±1.05</td>
</tr>
<tr>
<td>Drinking (duration, s)</td>
<td>35.88±18.97</td>
<td>43.74±24.99</td>
</tr>
<tr>
<td>Latency (s)</td>
<td>1342(941, 1709)</td>
<td>822 (580, 3065)</td>
</tr>
<tr>
<td>TTP (bins)</td>
<td>17 (8,22)</td>
<td>5 (4,6)</td>
</tr>
<tr>
<td>Preening (duration, s)</td>
<td>229.16±97.81</td>
<td>608±772</td>
</tr>
<tr>
<td>Latency (s)</td>
<td>1989 (1152,2436)</td>
<td>986 (863,1025)</td>
</tr>
<tr>
<td>TTP (bins)</td>
<td>19 (17,21)</td>
<td>9.5 (7.12)</td>
</tr>
<tr>
<td>Sleep (duration, s)</td>
<td>1675±881</td>
<td>520±405</td>
</tr>
<tr>
<td>Latency (s)</td>
<td>2290 (1668,2916)</td>
<td>1854 (1263,2131)</td>
</tr>
<tr>
<td>TTP (bins)</td>
<td>18 (13,20)</td>
<td>10 (7,14)</td>
</tr>
<tr>
<td>IPI feeding/drinking (bins)</td>
<td>5 (2,20)</td>
<td>2.5 (1.4)</td>
</tr>
<tr>
<td>IPI feeding/preening (bins)</td>
<td>9 (8,9)</td>
<td>6.5 (5.10)</td>
</tr>
<tr>
<td>IPI feeding/sleep (bins)</td>
<td>15 (10,16)</td>
<td>8.5 (6.11)</td>
</tr>
<tr>
<td>IPI feeding/preening (bins)</td>
<td>6.5 (3,9)</td>
<td>4 (3.4)</td>
</tr>
<tr>
<td>IPI feeding/sleep (bins)</td>
<td>11 (9,12)</td>
<td>8.5 (7.9)</td>
</tr>
<tr>
<td>IPI feeding/preening (bins)</td>
<td>10 (8, 13)</td>
<td>9.5 (7.14)</td>
</tr>
</tbody>
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Table 1: Values of latency, inter-peak interval (IPI), time-to-peak (TTP) and intersections (ItS) are expressed as medians (minus 25% and plus 75%), while food/water intake and duration of behaviors as expressed as mean ± SEM.

It can be shown graphically as follows:

![Figure 3](image_url) Demonstration of the indices evaluated in the MS-BSS protocol.

![Figure 4](image_url) Latency to the first occurrence (A), time-to-peak (B), intersection point (C), and inter-peak intervals (D) of ingestive and non-ingestive behaviors in free-feeding pigeons (FF) in free-feeding pigeons after food presentation to the seed mixture (FF + SM) and in 24-h food deprived animals presented to the seed mixture and regular chow (FD24h + SM). Data were expressed as the median (symbols) plus the 75th percentile and minus the 25th percentile (whiskers). (*) pb0.05 compared to the FF data and (#) pb0.05 compared to the feedingscore in the same experimental condition.
of interest including any financial, personal or other relationships with other people or organizations that could inappropriately influence the work here submitted

Role of the Funding Source

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References


