THE RELATION BETWEEN PREFERENCE AND DEMAND IN THE DOMESTIC HEN: DOES PREFERENCE VARY WITH PRICE?

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ABSTRACT

Six hens responded under an increasing Fixed Ratio schedule of reinforcement to assess demand separately for two different food types: wheat and puffed wheat. Demand curves generated showed the least preferred food, puffed wheat, yielded a higher initial (ln L) demand than the more preferred food, wheat. While responding for the more preferred food, wheat, produced lower initial (ln L) demand functions, responding for wheat was maintained to higher increasing FR schedules of reinforcement than was that for puffed wheat. This phenomenon occurred across all six hens. To assess preference between the two food types the hens responded under a two-link concurrent-chain schedule of reinforcement. Under the concurrent-chain schedule of reinforcement there were three conditions, each consisted of a initial link with VI 90-s VI 90-s in effect, and terminal links of FR1, FR8 and FR32. The concurrent-chain schedule was used to examine if or how preference may relate to demand. Preference measures obtained showed wheat was generally preferred to puffed wheat across all prices throughout the preference assessment. As price increased in the terminal link during the preference assessment, preference for wheat became more extreme as did the hens responding. The results suggest that while there is a systematic relation between preference and demand, in that at higher FR values food with higher demand levels is preferred. This does not seem to hold, however, at FR1.

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Thorndike (1911) formulated a general theory called the Law of Effect in which he stated; a reinforcer is something that increases the probability of behaviour occurring again in the future. Reinforcers affect behaviour in greater or lesser degrees. However, Thorndike (1911) did not discuss reinforcer value directly. If a reinforcer has an effect on behaviour then is it reasonable to assume that different reinforcers would have differing effects on that behaviour, and the reinforcers would also have different values. There have been many approaches to assigning reinforcer value or strength and the two discussed here come through the consideration of the preference between, and the demand for, reinforcers.

The terms preference and demand are often used to describe separately occurring phenomena within experimental and applied psychology. Preference refers to the choice made by an organism in a given situation, or when given the choice of two alternatives, and is suggested to be means of measuring reinforcer value (Tustin, 1994). Preference assessments have been carried out with both humans and non-humans (Baum, 1974; Hughes, 1976; Pace, Ivancic, Edwards, Iwata, & Page, 1985; Matthews & Temple, 1979). Demand refers to the amount of work an organism will do for a particular commodity and has also been used as a measure of reinforcer value (Tustin, 1994). Researchers have investigated the demand for a number of different commodities; for example, food (Hursh, Raslear, Shurtleff, Bauman & Simmons, 1988), environments (Matthews & Ladewig, 1994) and drugs (Hursh & Winger, 1995) again using both humans and non-humans.

The assessment of an animal's demand requires the organism to respond on a manipulandum to gain access to a reinforcer or an event (commodity) at differing prices (Hursh, 1980). A demand function plots the amount of a commodity purchased against the price of that commodity (Lea, 1978), typically in logarithmic terms. In animal experiments, price is usually analogous to the number of responses required from the animal (Lea, 1978). Fixed Ratio (FR used typically) schedules require the animal to respond a predetermined number of times before a reinforcer is made available. For example, a FR 20 schedule would deliver a reinforcer after every 20^{th} response is made (Ferster & Skinner, 1957). This is also considered to be a price of '20'.

The initial slope, intensity (steep or flat) and shape of the demand function shows the elasticity of the commodity, which can be used to determine how valuable that commodity is (Lea, 1979). Hursh (1980) describes three types of elasticity of the demand function which he says are necessary to characterise the allocation of behaviour in demand assessment: inelasticity, unit elasticity, and elasticity. When consumption is plotted against price (both in logarithmic terms), this gives a function with a slope more negative than -1.0. This shows elastic demand, which is thought to indicate the commodity, is a non-essential item because the animal does not maintain its response rate across price increases, and so consumption decreases across price. .

Alternatively, a demand curve with a slope less negative than -1.0, is said to be inelastic (Hursh, 1980). When demand is inelastic the animals' response rate increases as the price increases so consumption remains relatively stable across price increases. However the consumption rate may still decrease. Inelastic demand curves show that the item being worked for is of some 'value' to the animal (Hursh & Winger, 1995) and is thought to indicate that the commodity being worked for is a 'need' rather than a 'luxury'.

Unit elasticity, the third type of elasticity described by Hursh (1980), occurs in situations where the animal maintains a constant response rate across price increases. There is a “precise balance” (Hursh, 1980, p.227) between consumption and price, with the decreases in consumption matching the price increases (i.e. a doubling in ‘price’ leads exactly to a halving of consumption). For example, someone may spend $100 a week on petrol and if the price of petrol doubled but he or she still spent only $100 a week on petrol, then their consumption of petrol would be halved. Unit elasticity would then be seen by the shape and slope of the demand curve, which is equal to -1.

It is also possible to have a demand curve that indicates mixed elasticity. Mixed elasticity is shown by demand curves that concave downwards and contain portions of inelasticity, unit elasticity and elasticity. A demand curve that shows mixed elasticity is inelastic at low FR prices, has at least one point of unit elasticity (maximal response output), and as the price increases to high FR values the response rate decreases quickly, showing elasticity. Demand curves of mixed elasticity have been described by the equation:

$$\text{Log } Q = \log L + b\,(\log P) - a\,P \qquad (1),$$

which describes consumption and price in logarithmic terms (Hursh et al., 1988). In this equation, Q refers to total consumption (e.g. reinforcers or amount consumed per session), and P is the price (e.g. FR size). The parameter log L is the estimate of the initial level of consumption obtained at the lowest price. The initial slope of the demand function is described by parameter b, and parameter a reflects the change in the slope of the function as the price increases. From this equation Hursh et al. (1988) established that it was possible to identify the FR or price at which maximal response output occurs, or the price at which demand changes from inelastic to elastic. This point is termed P_{max}, and is described by the equation:

$$P_{max} = (1 + b) / a \quad (2),$$

where the parameters *a* and *b* are as previously described.

Assessing demand for a commodity gives an indication of just how hard an animal will work for the commodity being offered, or how 'valuable' that commodity is to the animal. Hursh et al. (1988) stated that reinforcer 'value' is an important factor when measuring demand. Demand functions are a way of investigating the sensitivity of consumption of a commodity as the price changes (Hursh & Winger, 1995). The changes in consumption according to price could be another indication of how 'valued' the commodity is by the animal. As different commodities produce different demand curves, it is possible to quantitatively assess these differences by fitting Hursh et al.'s (1988) equation to the demand functions. Demand functions can be compared in a number of ways. Firstly, two curves may differ in initial intensity of demand (log *L* in Equation 1). They may also differ in the degree of initial elasticity (*b* value in Equation 1), and also in the rate at which this elasticity changes (*a* value in Equation 1). Finally, P_{max} (the point of maximal output and unit elasticity) may also vary and allow comparison of the commodities.

Unfortunately, comparisons of the parameters of the fitted lines are not entirely straightforward. Consider two commodities both showing mixed elasticity. One demand curve reflects a higher initial consumption rate (higher log *L* value) but falls quickly, producing a demand curve that has a steeper (more negative) initial slope or a lower *b* value, and a bigger change in the slope (higher *a* value) of the demand curve. The other demand curve starts lower (lower log *L* value) but remains inelastic for longer, and consumption declines more slowly (higher *b* and lower *a* values). Comparison of initial demand would suggest the first commodity was most valued, but consideration of inelasticity and P_{max} would ‘favour’ the second commodity. Clearly under some circumstances consideration of demand curves could be ambiguous.

Alternatively it has also been suggested that preference measures can be used to assess reinforcer value (Tustin, 1994). According to Tustin (1994), demand curves can predict preference, with a flatter demand curve reflecting a “more highly valued or preferred reinforcer” (p. 598). This occurs because the more ‘valued’ reinforcer maintains the rate of responding as the ‘price’ increases. It is not clear however, whether preference derived from consideration of demand levels will necessarily be the same as that assessed by more usual methods (i.e. concurrent schedules of reinforcement).

Concurrent schedules have been used to assess various aspects of reinforcer preference, including, between rates (Fantino & Davison, 1983), amounts (Grant, 2005) and types (Flevill, 2002) of food. Commonly, preference is assessed using concurrent schedules of reinforcement. Under concurrent schedules of reinforcement an animal is required to respond on one of two (or more) simultaneously available but incompatible manipulanda, such as levers that can be pressed or keys that can be pecked (Catania, 1966). Each manipulandum has a corresponding consequence or reinforcer, such as a different food type. Preference measures are usually derived as response ratios or ratios of times spent responding on each of the manipulanda (Baum & Rachlin, 1969).

When investigating an animal’s preference for given commodities it is important to understand that the animal’s preference is only ever relative to the commodities or events available. For example, a child may prefer oranges over apples when asked to choose between these two alternatives, but may prefer apples over pears when given a choice between these two alternatives. This would suggest the child had a preference for oranges compared to the other two alternatives. It is quite possible that the child dislikes all three fruits, but will show a preference relative to the situation.

A schedule of reinforcement determines the number of responses needed, or elapsed time required on the manipulanda, before a reinforcer is permitted. Variable Interval (VI) schedules are commonly used for measuring an animal's preference as it encourages sampling of both alternatives. Under a VI schedule, a reinforcer becomes available after the first response is made following a predetermined interval since the last reinforcer. The intervals vary and have an averaged value which is specified in the schedule (e.g. a VI 60-s schedule will make a reinforcer available on average every 60 seconds after first response on the alternative since the previous reinforcer delivery).

Schedules of reinforcement may be rich or lean, with a rich schedule delivering reinforcers more frequently and at a faster rate compared to the lean schedule (Sumpter, Foster & Temple, 2002). Concurrent schedules can also be programmed to be dependent or independent. If the schedules are programmed to be dependent, each schedule counts down simultaneously, and when one schedule reaches zero (in terms of VI schedules) and a reinforcer becomes available, the opposing schedule stops timing until that reinforcer has been delivered (Catania, 1966). Both schedules then continue timing down once the reinforcer is no longer available. Independently programmed schedules continue to time down regardless of whether the opposing schedule has a reinforcer available (Catania, 1966). Independent schedules face the problem of exclusivity of choice, while dependent schedules guard against exclusivity by ensuring that the animal will experience both alternatives available. Matthews and Temple (1979) suggest, however, that exclusive responding may be maintained by dependent contingencies (i.e. responses required), and preferences observed may actually be smaller than the ‘true’ levels of preference.

Herrnstein (1961) proposed an equation, which allows preferences obtained through concurrent schedules to be quantitatively described or predicted. This equation, the Strict Matching Law (SML), reads as:

$$B_1 / (B_1 + B_2) = R_1 / (R_1 + R_2) \qquad (3),$$

where parameter B refers to the behaviour which includes the number of responses made or the time spent responding to manipulanda. Reinforcers obtained on each alternative are represented by the parameter R, while the numbers 1 and 2 represent the two alternatives available.

The Strict Matching Law states that the distribution of responding will match the distribution of reinforcers that are available on concurrent schedules of reinforcement (Herrnstein, 1961). For example, if one schedule delivers twice as many reinforcers as the other, the Strict Matching Law would predict, that 2/3rd’s of the subjects responding and 2/3rd’s of the subject’s time would be allocated to the richer schedule.

Deviation from the matching law has been known to occur during choice assessment experiments and Baum (1974) concluded that behaviour did not always conform to the Strict Matching Law. From the Strict Matching Law equation, Baum (1974) derived the Generalised Matching Law equation:

$$\text{Log}\,(B_1 / B_2) = a \log (R_1 / R_2) + \log c \qquad (4),$$

where parameters B and R are as previously defined. The sensitivity of the animal's behaviour to changes in the reinforcement rate are described by parameter *a*, and log *c* is the measure of bias the animal has towards one alternative over the other, irrespective of the reinforcer rate differences.

Two types of deviation from strict matching are undermatching and overmatching (Baum, 1974). Undermatching is said to occur when more responding than predicted by the Strict Matching Law occurs on the leaner schedule of reinforcement. In Equation 4 undermatching is associated with *a* values less than 1.0. Overmatching is when more responding than predicted occurs on the richer schedule of reinforcement, and *a* values in Equation 4 are greater than 1.0.

Another form of deviation from strict matching that must be considered has been described by Baum (1974) as inherent or response bias. This can be seen as an unaccounted for preference by the animal toward on of the alternatives when the schedules of reinforcement for each alternative are, in fact equal. Possible reasons for inherent bias may be; one response key in an operant chamber may require more effort to peck than the other, or it may be physically more difficult for the animal to respond to one key over another. However, Baum (1974) states the reason for such a bias may remain unknown to the researcher.

Matthews and Temple (1979) investigated food preference in cows responding under concurrent schedules of reinforcement. To account for the inherent bias outcomes in their study, elaborated on Baum's (1974) generalised matching equation. Matthews and Temple's (1979) equation reads as:

$$\text{Log}\ (B_1/B_2) = a \log (R_1/R_2) + \log b + \log q \qquad (5),$$

where the parameters B, R, and *a* are as previously defined. Log *b* allows for a measure of inherent bias and log *q* is the imposed biases (in their case differences in the two foods offered). Log *b* and log *a* added equal log *c* from Equation 4. Equation 5 allowed Matthews and Temple (1979) to obtain a measure of preference for differing food types excluding any inherent biases.

Tustin (1994) suggests that both preference and demand measure reinforcer 'value' and that they are expected to give equivalent measures of reinforcer 'value'. Preference and demand are often investigated as separate components of the same experimental research, and it is not understood how, or if, they relate to each other. There are very few studies, which have compared preference and demand measures.

One study, which investigated both demand and preference was conducted by Flevill (2002). An assessment of preference for three foods (wheat, puffed wheat, and honey puffed wheat) was obtained in Flevill's (2002) study by requiring the hens' to respond under concurrent Random Interval (RI) schedules of reinforcement, where reinforcement is programmed to occur at random intervals. It was found that wheat was most highly preferred followed by honey puffed wheat, and puffed wheat was least preferred.

Flevill (2002) then investigated hens' demand for the same three different food types by increasing FR requirements. Given the preference rankings, it is reasonable to expect that the hens would show a higher demand for the more preferred commodity over the least preferred commodity across all prices. However, this was not the case. Specifically, Flevill (2002) found higher initial (ln *L*) demand for the least preferred food (puffed wheat) and lower initial (ln *L*) demand for the most preferred food (wheat).

Demand measures found by Flevill (2002) showed that hens will respond at a faster rate for the least preferred commodity at lower prices when only one of the commodities is available. However she found that when two commodities are available concurrently, hens will respond quicker for the most preferred food (Flevill, 2002). These preference results when compared with the findings from the demand measures were not intuitive.

The preferences obtained by Flevill (2002) were assessed on a simple concurrent schedule. From Flevill's (2002) research it can be concluded that when a hen is required to respond under equal concurrent schedules of reinforcement at a 'price' of one wheat is the preferred food.

When using ordinary concurrent schedules to assess preference, the data indicate that clear preferences were found at a low 'price' (Flevill, 2002). Demand curves are generated by plotting responses made over increasing prices, while preference is assessed by time spent and responses made to the manipulanda associated with the preferred alternative. A chained schedule involves an animal responding on a manipulandum while in the presence of one stimulus, which in turn produces a second stimulus, then a third, fourth and so on (Ferster & Skinner, 1957; Kelleher, 1966). Concurrent-chain schedules offer a way to assess preference for reinforcers at higher prices, requiring more than one response. A two-component concurrent-chain schedule consists of an initial link or 'choice phase' and a terminal link or 'outcome phase' only (Kelleher, 1966). During the initial choice phase there are two lit response keys concurrently available, but there is only one lit response key available during the terminal link. The animal responds to a programmed schedule of reinforcement during the initial link, which leads to the terminal link, giving direct access to the reinforcement (Houston, Sumida & McNamara, 1987). During the terminal link, the animal is required to respond on the manipulandum according to a different schedule of reinforcement than that in the initial link. Typically a single food is used as a reinforcer (Davison, 1983), and is termed the primary reinforcer (Kelleher, 1966). The terminal link has been referred to as a conditioned reinforcer, and responding in the initial link is used to estimate the effectiveness of the conditioned reinforcing properties of the terminal link (Kelleher, 1966).

Based on Flevill's (2002) research when the commodities were presented alone (i.e. demand assessment), hens responded faster at low FR's for the less preferred commodity. This less preferred commodity, however, produced lower rates of responding when the two commodities were presented concurrently. In the case of Flevill's research this was done with concurrent RI RI schedules, requiring only one response for access to the reinforcer. It is of interest to investigate whether preference will change accordingly with different methodology, (i.e. if preference will change when assessed at various prices). That is, will the hens' preference change as the price increases?

To investigate if preference does change along with increases in price, a concurrent chain schedule will be used here. This will allow assessments of preference at different terminal link schedules and therefore differing 'prices'. If a concurrent-chain schedule with FR1 in the terminal link, and simple concurrent schedules are equivalent, then, from Flevill (2002) it is reasonable to expect initial link preferences to be in favour of the more preferred of the two foods. However as the terminal link schedule value is increased this seems unlikely to remain consistent. At higher 'prices' the reinforcer value may change. It is reasonable to assume that at the higher FR values, terminal link preference will be towards the most preferred food available. In addition the more preferred food is expected to sustain demand to higher levels.

In light of previous findings (Flevill, 2002) the current experiment has two main objectives. The first is to replicate and extend Flevill's (2002) preference assessment, by employing a concurrent-chain schedule. This will enable the examination of preference for two different reinforcers (wheat and puffed wheat), at prices other than FR1. Secondly, with the use of a concurrent-chain schedule three different 'prices' (i.e. FR1, FR8 and FR32) will be programmed to operate in the terminal link, which will produce three different points at which preference can be assessed, and also allow for comparison to, or prediction from, the demand assessment.

METHOD

Subjects

Six Brown Shaver hens, numbered 11 to 16, were used as subjects. Each hen was individually housed in a wire cage measuring 430-mm high, 310-mm wide and 470-mm long. Water was freely available to every hen, ad libitum, in her home cage. Vitamins and grit were provided on a weekly basis. The hens were maintained at 80% (+/- 5%) of their free feeding body weights, which was calculated through daily weighing through supplementary feeding of NRM Peck'n'Lay, or Commercial Laying Pellets. All hens were approximately 26 months old at the commencement of the experiment. All hens' had previous experience responding on concurrent variable-interval (VI) schedules of reinforcement.

Apparatus

The particleboard experimental chamber was 640-mm long, 540-mm high, 430-mm wide and painted white internally and externally. A covered fan, 80 mm in diameter, was situated on the back wall, 425 mm from the bottom of the chamber and 170 mm from the left side of the chamber. The fan provided ventilation and some masking noise. The floor of the chamber was wooden and lined with a grey artificial grass mat (550 mm by 410 mm).

Within the chamber there were two circular response keys made of semi-translucent Perspex and backlit green by a 1-W bulb. Each key was 30 mm in diameter, situated on the front wall of the chamber. The keys were surrounded by an aluminium plate 130-mm long, 50-mm wide and positioned 215 mm apart, with the left key 55 mm from the left side of the chamber wall and the right key

35 mm from the opposite side. In order for a response to either key to be effective, a force of 0.1 N (10 g) was required. Each effective response was followed by a brief audible feedback beep provided by an electronic beeper, situated centrally behind the keys. Responses made to unlit keys were ineffective.

Situated on the front wall, 150 mm beneath each response key, was an open square 120-mm high and 90-mm wide, which provided 3-s access the reinforcer when the food hopper was raised. The hopper was part of an external magazine, which contained the experimental food: wheat in the left magazine, puffed wheat in the right magazine. Each magazine was manually filled with the appropriate food when required.

During the 3-s reinforcer access period, both key lights were extinguished and the response keys became inoperable. A 1-W white bulb, situated 30 mm above the hopper, illuminated the reinforcer during periods of reinforcement-access. The light from the response keys and the food hopper were the only sources of illumination in the experimental chamber.

Each magazine was placed on a pair of Atrax Compact Precision Balance ™, BH Series Scales, which allowed the magazines to be weighed during the duration of each session. The magazines sat on the scales with an attached aluminium bracket. The brackets provided stability for the magazines to sit on top of the scales, allowing the weights to be read every second, and gave space for a tray to catch any spilt feed.

The magazines, scales, and power supply box were all attached to a Pentium Processor 133 Mhz, GenuineIntel Computer, with 16 Mb ram, running windows 98 and Med PC ^{R} for windows (Med III, 1987-99), version 1.16.

Procedure

Demand assessment. During the demand assessment the hens responded on FR schedules of reinforcement for wheat (Condition 1) and puffed wheat (Condition 2). Before starting the wheat condition preliminary training required the hens to respond on a FR 20 schedule for one week.

Experimental sessions for the wheat condition started with the hen being placed in the chamber and the left key lit green. The right key was inoperable throughout all series of the wheat condition. During the puffed wheat condition the right key was lit green and the left key was inoperable.

Within each condition, three series of increasing FR schedules were conducted. There was a maximum of eight days of responding on FR 20 between each series of the wheat condition, and five days of responding on FR 20 between each series of the puffed wheat condition. This allowed for all hens to reach individual break points, and for all hens to start responding to the new series on the same day. Table 1 presents the highest FR schedules reached where each hen received reinforcers, in Series 2 and 3 of the wheat and puffed wheat conditions of the demand assessment. If the hen failed to receive any reinforcers during a session, that particular FR schedule was presented again during the next session until the hen had completed two consecutive sessions without receiving any reinforcers at which time the schedule of reinforcement would automatically be reset to FR20.

For both the wheat and puffed wheat conditions each experimental session lasted for 40-mins keytime, which comprises the total session time excluding the cumulative reinforcer time. On the first experimental day of each series each hen

Table 1.

The order of experimental conditions, along with the highest FR schedule completed for each series, in both conditions, for each hen.

		Subjects					
Condition	Series	11	12	13	14	15	16
Condition 1: Demand Assessment Wheat (Highest FR)							
	2	256	256	128	256	256	512
	3	256	256	256	256	128	512
Condition 2: Demand Assessment Puffed Wheat (Highest FR)							
	2	128	64	128	256	128	256
	3	128	128	128	128	256	256

was required to respond on a FR 1 schedule and this schedule was increased each session by way of doubling (i.e. FR 2, FR 4, FR 8, FR 16, FR 32, FR 64 etc).

Preference assessment. Throughout the preference assessment the left magazine contained wheat and the right magazine contained puffed wheat, corresponding with the keys/magazines in effect in the wheat/puffed wheat conditions of the demand assessment. Every experimental session lasted for 40 minutes keytime (i.e. total session time excluding the cumulative reinforcer time).

During preference assessment the hens responded on a concurrent-chain schedule of reinforcement. The concurrent-chain schedule consisted of two links, an initial link and a terminal link. At the beginning of the initial link both keys were lit green. The subjects could respond to either key, in any order and at any time during the initial link, consisting of dependent concurrent VI 90-s VI 90-s schedules. Upon completion of the response requirements on the VI 90-s schedule on the left key, the left key colour would change to red, and the right key light was extinguished and became inoperative. When the response requirement of the VI 90-s schedule was completed on the right key, the key colour would change to white, with the left key becoming inoperative. The change of colour on either key signalled the end of the initial link and the beginning of the terminal link. The hen was then required to respond on the operative key a predetermined number of times according to the FR schedule in effect. Upon completion of the response requirement, a reinforcer would be delivered. After a reinforcer, both keys would once again be lit green and the initial link was recommenced.

The preference assessment consisted of three differing terminal link requirements (Conditions 3, 4 and 5) during which the concurrent schedules in the initial link remained at VI 90 s. The terminal link required the hens to respond on a FR schedule, which was different in each of the three conditions. The terminal link during Condition 3 consisted of an FR 1 schedule, Condition 4, a FR 8 schedule, and Condition 5, a FR 32 schedule. The FR schedules were assigned based on the demand data collected prior to the preference assessment. FR 1 was the lowest price at which demand was assessed. FR 8 was chosen as a moderate FR value as this was approximately where the two demand function curves for wheat and puffed wheat crossed. Finally FR 32 was chosen because the demand data showed all subjects would continue responding for both foods at this level, as previously shown in Table 1.

The experimental conditions were changed when the behaviour of all six hens was deemed both statistically and visually stable. Statistical stability was reached when five, not necessarily consecutive, calculated medians of the proportion of responses and time spent on the left key did not differ by more than 0.05. Upon achieving statistical stability, graphical stability was sought. Graphical stability was obtained visually by plotting the log ratio of responses and times spent on the left key across sessions. Graphical stability was achieved when it was agreed, by at least two laboratory members, that the data were visually stable (i.e. not trending in any direction). Table 2 presents the number of days taken to reach stability (statistical and visual) during Conditions 3, 4 and 5 for each hen. The visual stability data is inclusive of the statistical data, as statistical stability always occurred first.

Table 2

The number of days taken to reach statistical and visual stability during Conditions 3, 4 and 5 for each Hen.

	Days to statistical stability			Days to visual stability		
Hen	Cont 3	Cont 4	Cont 5	Cont 3	Cont 4	Cont 5
11	17	15	18	46	33	72
12	17	26	15	47	32	71
13	20	14	16	46	31	71
14	17	14	18	51	32	71
15	17	14	14	46	30	72
16	30	16	15	48	31	69

RESULTS

Demand Assessment

The raw data collected during the demand assessment phase of this experiment, Series 1, 2 and 3 of Condition 1 (wheat), and Condition 2 (puffed wheat), for all hens are given in Appendix A. As there were no consistent differences between the data from Series 1, 2 and 3 for wheat (Condition 1) or puffed wheat (Condition 2), only data from Series 2 and 3 from both conditions are presented and analysed here.

The FR schedule values at which each hen completed Series 2 and 3 for Conditions 1 and 2 are presented in Table 1 (previously presented in the Method section). All subjects maintained responding at larger FR values during the wheat condition, compared to the puffed wheat condition. During the wheat condition, Hens 11, 12 and 14 continued to respond to a FR value of 256 for Series 2 and 3, which was the highest FR value reached for these three hens. Hen 13 responded to FR values of 128 and 256, and Hen 15 to FR 256 and 128 for Series 2 and 3 respectively. Hen 16 continued to respond at FR 512 for both Series, being the highest FR reached during both conditions across series and subjects. Hens 11, 13 and 15 responded for puffed wheat to a FR value of 128 during Series 2, while Hen 12 responded to FR64, and Hens' 14 and 16 continued to respond for puffed wheat to FR 256. During Series 3 Hens' 11, 12, 13, and 14 responded to FR 128 for puffed wheat, while Hens' 15 and 16 continued to respond to FR256 for puffed wheat.

Figures 1, 2 and 3 present the overall response rates, the running response rates and the post-reinforcement pause (PRP) times for each hen, plotted against

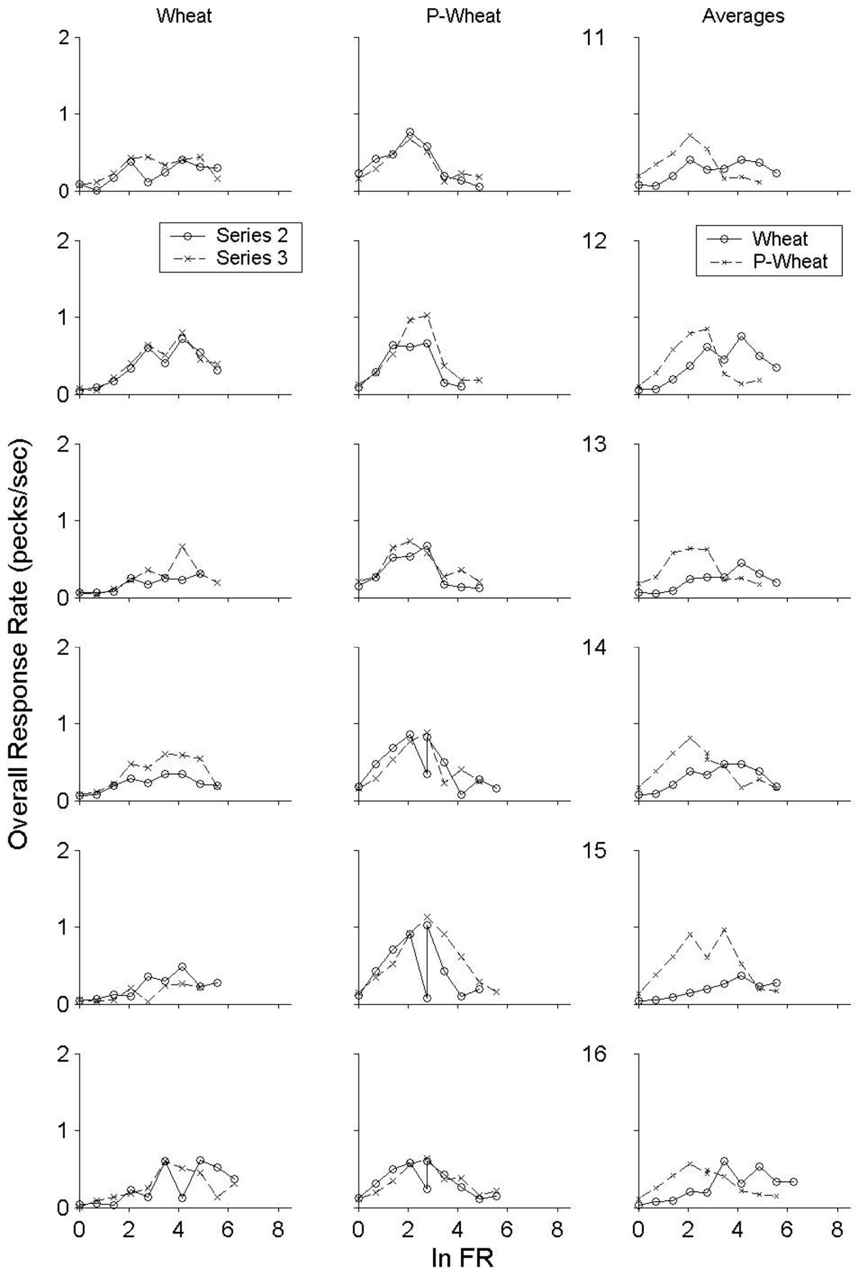

Figure 1. Overall Response Rates and averages for Series 2 and 3 under Conditions 1 (wheat) and 2 (puffed wheat) shown as responses per second against natural logarithmic (ln) FR Schedules.

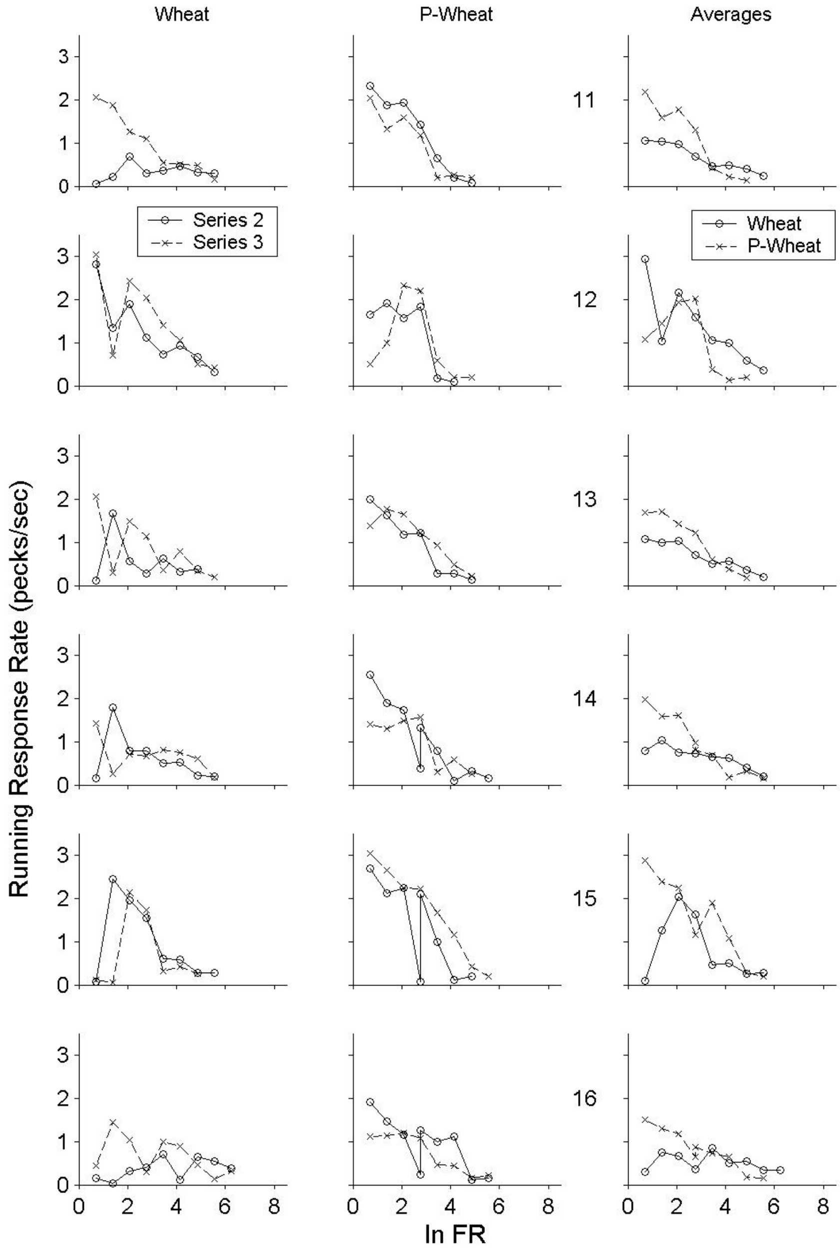

Figure 2. Running Response Rates and averages for Series 2 and 3, under Conditions 1 (wheat) and 2 (puffed wheat) shown as responses per second (run time without PRP time) against (ln) FR Schedules.

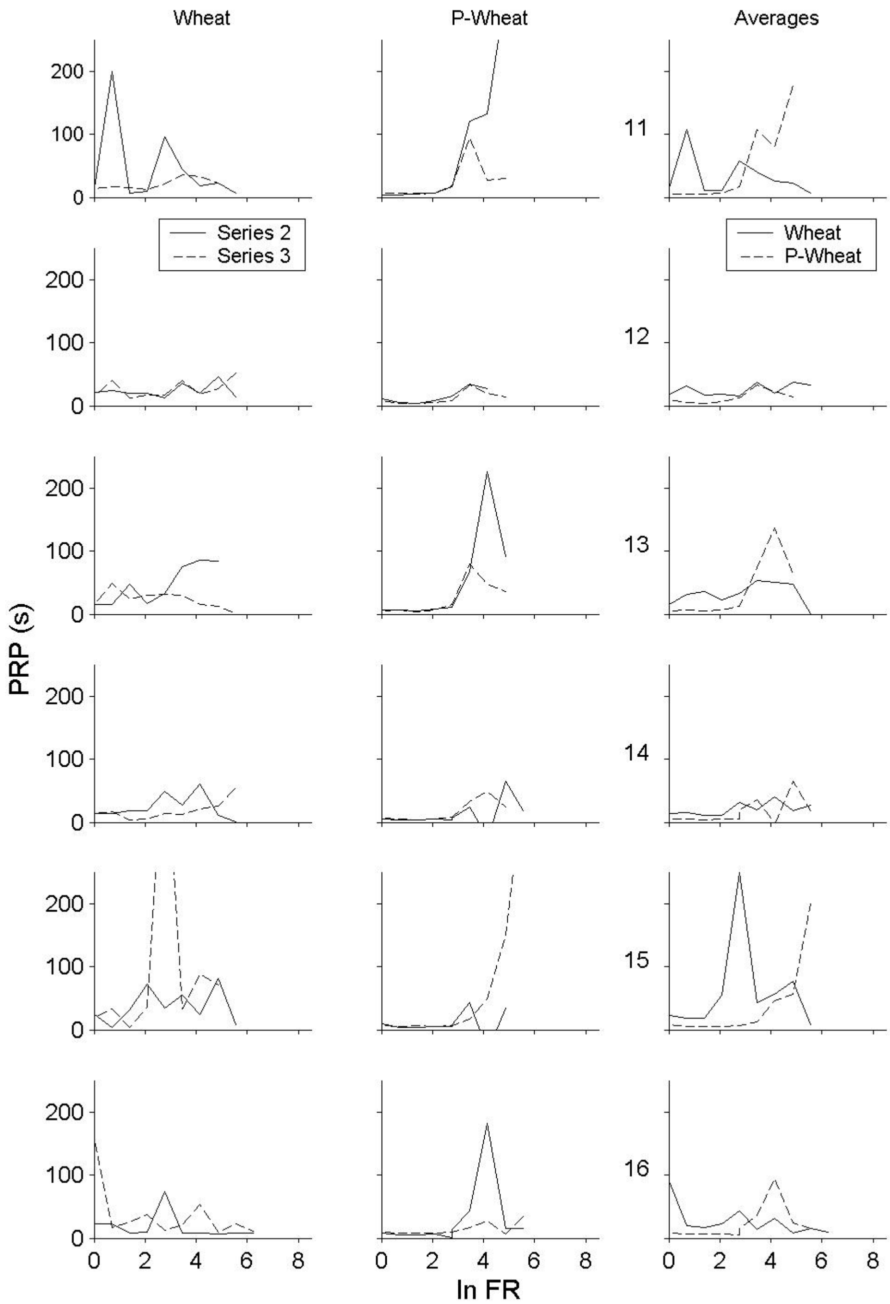

Figure 3. The Post Reinforcement Pause (PRP) Times and averages for Series 2 and 3 under Conditions 1 (wheat) and 2 (puffed wheat). Pauses (seconds) in responding after reinforcement shown as functions of (ln) FR Schedules.

log FR size. In each Figure the left panel represents Series 2 and 3 of Condition 1 (wheat), the middle panel represents Series 2 and 3 of Condition 2 (puffed wheat), and the right panel represents the averaged values of Series 2 and 3 under both the wheat and puffed wheat conditions.

Overall response rates, shown in Figure 1, were calculated as the total number of responses made divided by the key time (session time excluding the time the magazine was operative). Figure 1 shows that there were no consistent differences in the overall response rates between Series 2 and 3 of Conditions 1 (wheat) and 2 (puffed wheat) across Hens. However, there were differences seen between the averaged overall response rates of the two conditions: wheat and puffed wheat. Responding under Condition 1 increased gradually, with averaged overall response rates consistently higher as FR schedules increased, while the averaged overall response rates under Condition 2 increased rapidly during smaller FR sizes but decreased quickly as the FR size increased. This effect is present in Figure 1 with the data presented being bitonic; that is an inverted u-shape curve was produced when the data was analysed.

The running response rates, shown in Figure 2, were calculated by dividing the total number of responses by run time. It is not possible to calculate running response rates at FR1 as run time is the same as key time. Post-reinforcement pauses are excluded from run time. Generally the running response rates decreased as FR schedules increased for all hens across both conditions. Each panel indicates that all hens were responding consistently under both conditions, with little variance between series for each hen.

A comparison of the two conditions shows that during Condition 2 (puffed wheat) all Hens, except Hen 12, showed higher running response rates during the small FR schedules when compared to Condition 1 (wheat). Hen 12, however, has a higher running response rate during Condition 1 (wheat) at low FR sizes. During Series 2 of Condition 1 (wheat), Hen 11 responded at a much slower rate than during Series 3, but her responding decreased during Series 3 and was at a consistent level of responding at the end of both Series. Generally the running response rates decrease as the FR sizes increase across both Series and Conditions for all Hens.

Figure 3 presents the average PRP time, which was calculated by dividing the total post reinforcement pause time by the number of reinforcers obtained at each FR size. The y axis was taken to 200 seconds to allow for trends in the data to be seen. Hens 12, 13, 14 and 16 show no consistent differences between series or conditions. Hen 11 has longer PRPs during Series 2 for Conditions 1 and 2. The PRPs are very small during Series 3 of both conditions for Hen 11. Hen 15 responded in a similar manner, with large pauses during Series 3 of both conditions, and smaller PRPs during Series 2 under Conditions 1 and 2.

Figure 4 presents consumption rate calculated by dividing the reinforcers gained by total keytime (reinforcers per second) plotted against FR schedules, both on natural logarithms. The left panel presents the demand curves for Series 2 and 3 of the wheat condition, while the middle panel presents demand curves for Series 2 and 3 of the puffed wheat condition. The right panel presents the data averaged across Series 2 and 3 for both the wheat and puffed wheat conditions for each hen, overlayed for ease of comparison. The lines shown were fitted to the data using Hursh et al.'s (1988) nonlinear equation (Equation 1) with the parameters of the lines displayed in Table 3 for the wheat condition and Table 4

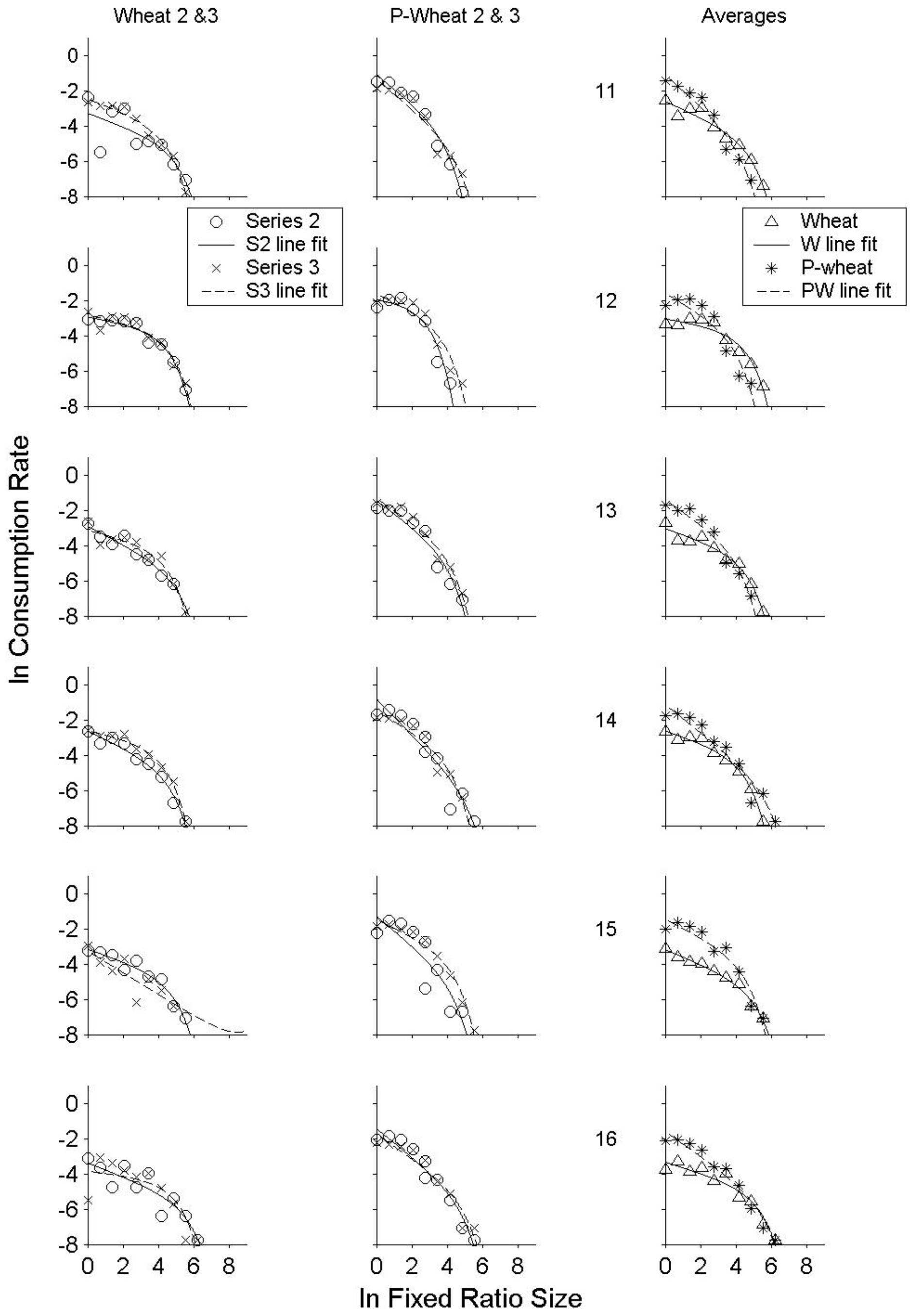

Figure 4: Demand curves and averages generated for Series 2 and 3 under Conditions 1, Wheat, and 2, Puffed Wheat, are shown as (ln) consumption rate plotted against increasing ln FR ratio sizes.

Table 3.

The parameters ln L, b and a for Hursh et al.'s (1988) equation (Equation 1) fitted to the ln consumption across ln FR data points from Series 2 and 3, and the averaged data of Series 2 and 3 of the wheat condition (Condition 1). The Hen number (H), standard errors of the estimates (se), the percentages of variance accounted for by the lines (%VAC) and the FR value at which the fitted functions predict maximal responding (P_{max}) are also shown. The Astrisk indicates the P_{max} value which was unable to be calculated due to negative a values.

H	Series	ln *L*	*b*	*a*	se	%VAC	P_{max}
11	2	-3.27745	-0.37048	0.00712	0.84	66.053	88.416
11	3	-2.45528	-0.38462	0.0124	0.23	97.915	49.627
11	Average	-2.60373	-0.44303	0.00916	0.30	95.951	60.805
12	2	-2.93629	-0.1785	0.01259	0.20	97.441	65.25
12	3	-2.81793	-0.21151	0.01128	0.35	92.432	69.902
12	Average	-3.03425	-0.17514	0.01187	0.31	93.838	69.491
13	2	-2.8907	-0.51609	0.00679	0.26	94.154	71.268
13	3	-3.12272	-0.25308	0.01282	0.34	94.598	58.262
13	Average	-3.02457	-0.34968	0.011	0.24	97.227	59.12
14	2	-2.61832	-0.47333	0.01062	0.25	97.666	49.592
14	3	-2.59636	-0.23406	0.01504	0.16	98.857	50.927
14	Average	-2.61623	-0.33549	0.01302	0.16	98.889	51.038
15	2	-3.14885	-0.34717	0.00853	0.27	95.236	76.533
15	3	-3.25653	-0.61461	-0.00012	0.59	73.063	*
15	Average	-3.17353	-0.4153	0.00676	0.15	98.442	86.494
16	2	-3.36636	-0.39692	0.00367	0.59	82.657	164.327
16	3	-3.84156	-0.12428	0.00753	0.81	74.302	116.297
16	Average	-3.32405	-0.31507	0.00531	0.33	94.45	128.988

Table 4.

The parameters ln L, b and a for Hursh et al.'s (1988) equation (Equation 1) fitted to the ln consumption across ln FR data points from Series 2 and 3, and the averaged data of Series 2 and 3 of the puffed wheat condition (Condition 2). The Hen number (H), standard errors of the estimates (se), the percentages of variance accounted for by the lines (%VAC) and the FR value at which the fitted functions predict maximal responding (P_{max}) are also shown.

H	Series	ln *L*	*b*	*a*	se	%VAC	P_{max}
11	2	-1.07712	-0.77407	0.02477	0.36	97.29	9.121
11	3	-1.33507	-0.82567	0.01228	0.51	92.216	14.196
11	Average	-1.07634	-0.86687	0.01579	0.40	95.856	8.431
12	2	-1.89641	-0.10765	0.07319	0.44	93.453	12.192
12	3	-1.60663	-0.44529	0.02625	0.52	91.666	21.132
12	Average	-1.56907	-0.56818	0.02229	0.59	89.547	19.373
13	2	-1.42788	-0.71798	0.01953	0.45	94.359	14.44
13	3	-1.31747	-0.6488	0.01826	0.32	96.455	19.233
13	Average	-1.3801	-0.66857	0.01904	0.36	95.966	17.407
14	2	-0.82677	-0.99089	0.00645	0.71	89.569	1.412
14	3	-1.47345	-0.57127	0.01814	0.43	92.989	23.634
14	Average	-1.11514	-0.79195	0.00363	0.52	93.983	57.31
15	2	-1.28414	-0.79939	0.01565	0.90	78.773	12.818
15	3	-1.45542	-0.46281	0.01573	0.29	97.863	34.151
15	Average	-1.44878	-0.50131	0.01276	0.46	94.043	39.082
16	2	-1.42248	-0.78642	0.00919	0.44	95.044	23.24
16	3	-1.73411	-0.68142	0.00806	0.49	92.994	39.526
16	Average	-1.5878	-0.69605	0.00429	0.37	96.417	70.85

for the puffed wheat condition. The variances accounted for by the lines (%VAC), the standard errors of the estimates (se), along with the FR value predicted to generate maximal responding (P_{max}), as calculated by Equation 2, are also presented in Tables 3 and 4 respectively. Table 3 shows that the lines fitted to the consumption data of the wheat condition accounted for over 90% of the data variance in 8 of the 12 cases, with se measures ranging between 0.16 and 0.84. The lines fitted to the consumption data of the puffed wheat condition accounted for over 90% of the data variance in 9 of the 12 cases, and se measures range between 0.29 and 0.90, as seen in Table 4.

The left panel of Figure 4 shows that, for each subject, there were no consistent differences in the demand functions from Series 2 and 3 of the wheat condition. Consumption of wheat generally decreased as the FR size increased. The generated demand curves for the wheat condition begin at approximately the same initial level, with the ln *L* values (initial demand levels) ranging between -2.455 and -3.841 across series and subjects. The initial slopes (*b* values) of the demand curves ranged between -0.178 and -0.614, with no consistent differences observable across Series 2 and 3 for all hens. All of the demand functions for the wheat condition, with the exception of Hen 15, Series 3 are curvilinear. The *a* values presented in Table 3 are positive, indicating elastic demand for wheat as the FR size increased. One demand function (Hen 15, Series 3) curves upwards beyond the last data point proving difficulty in assessing elasticity due to a negative *a* value, resulting in a meaningless P_{max} value. In the remaining 11 cases where P_{max} was calculated for the wheat condition, the P_{max} values ranged between 49.59 and 164.32.

There were no consistent differences in the shapes of the demand functions describing the data from Series 2 and 3 of the puffed wheat condition, as shown in the middle panel of Figure 4. The initial levels of demand (ln *L*) for the puffed wheat condition ranged between -0.826 and -1.896. Table 4 presents the initial slopes, or *b* values, which fall in between -0.107 and -0.990. All demand functions are fit with slightly curvilinear lines, with all *a* values (Table 4) being positive and ranging from 0.008 to 0.073, suggesting demand for puffed wheat became more elastic as the FR size increased. As all *a* values were positive, P_{max} was calculated for all demand curves of the puffed wheat condition, and the ranged between 1.41 and 39.52.

Table 5 presents for each hen the parameters of the demand functions fitted to the data, averaged over Series 2 and 3 of both conditions. There were consistent differences found between the averaged demand functions for wheat and puffed wheat. In all instances initial demand levels (ln *L*) were higher for puffed wheat than for wheat. The ln *L* parameters of puffed wheat ranged between -1.07 and -1.58, while initial levels of demand for wheat fell between -2.60 and -3.32. The initial slopes for puffed wheat (*b* values) are more negative across all subjects (-0.501 to -0.866) compared to those of wheat, which range from -0.415 to -0.443. This indicates that initial levels of demand (ln *L*) for wheat are more inelastic compared to puffed wheat.

In Table 5 the averaged *a* values of both conditions show that in four of the six cases the *a* values for puffed wheat were higher (0.012 to 0.022) compared to those of wheat (0.006 to 0.011). In the remaining two cases the *a* values for wheat are higher (0.013 and 0.005) compared to those of puffed wheat (0.003 and 0.004). This indicates that in four of the six subjects the rate of change in

Table 5.

The parameters ln L, b and a for Hursh et al.'s (1988) equation (Equation 1) fitted to the ln consumption across ln FR data points averaged across Series 2 and 3 of the wheat and puffed wheat conditions (Conditions 1 and 2). The standard errors of the estimates (se), the percentages of variance accounted for by the lines (%VAC) and the FR value at which the fitted functions predict maximal responding (P_{max}) are also shown.

H	Condt	ln *L*	*b*	*a*	se	%VAC	P_{max}
11	Wheat	-2.60373	-0.44303	0.00916	0.30	95.951	60.805
11	P-Wheat	-1.07634	-0.86687	0.01579	0.40	95.856	8.431
12	Wheat	-3.03425	-0.17514	0.01187	0.31	93.838	69.491
12	P-Wheat	-1.56907	-0.56818	0.02229	0.59	89.547	19.373
13	Wheat	-3.02457	-0.34968	0.011	0.24	97.227	59.12
13	P-Wheat	-1.3801	-0.66857	0.01904	0.36	95.966	17.407
14	Wheat	-2.61623	-0.33549	0.01302	0.16	98.889	51.038
14	P-Wheat	-1.11514	-0.79195	0.00363	0.52	93.983	57.31
15	Wheat	-3.17353	-0.4153	0.00676	0.15	98.442	86.494
15	P-Wheat	-1.44878	-0.50131	0.01276	0.46	94.043	39.082
16	Wheat	-3.32405	-0.31507	0.00531	0.33	94.45	128.988
16	P-Wheat	-1.5878	-0.69605	0.00429	0.37	96.417	70.85

elasticity was greater for puffed wheat compared to wheat. However in the remaining two subjects (Hens 14 and 16) the rate of change in elasticity was greater for wheat, meaning puffed wheat changed elasticity more slowly. All hens with the exception of Hen 14, had higher P_{max} values for wheat (59.12 to 128.98) compared to puffed wheat (8.43 to 70.85). Hen 14 had a higher P_{max} value for puffed wheat (57.31) compared to wheat (51.03) indicating that puffed wheat had a higher estimated point of maximal responding.

Preference Assessment

The raw data collected for all hens during Conditions 3, 4 and 5 (FR1, FR8 and FR32 in the terminal link) of the preference assessment phase of this experiment are given in Appendix B. For the purpose of data analysis of the preference assessment phase, data from only the last five sessions of Conditions 3, 4 and 5 were analysed, and have been presented here.

Figure 5 presents the log ratios of responses (circles) and times (asterisks) spent on each schedule in the initial links for the last five sessions of each condition (FR1, FR8, FR32). Data points above zero on the y axis indicate more responding and more time spent on the left key for the delivery of wheat in the terminal link, while all data points below zero on the y axis represent more responding and more time spent on the right key for the delivery of puffed wheat in the terminal link. Data presented in Figure 5 show that responding was relatively stable and did not vary much between sessions on a daily basis, therefore the averaging of data is legitimate.

Figure 6 presents the averaged data from the last five sessions during the initial link of the concurrent-chain schedules of Conditions 3, 4 and 5. These are

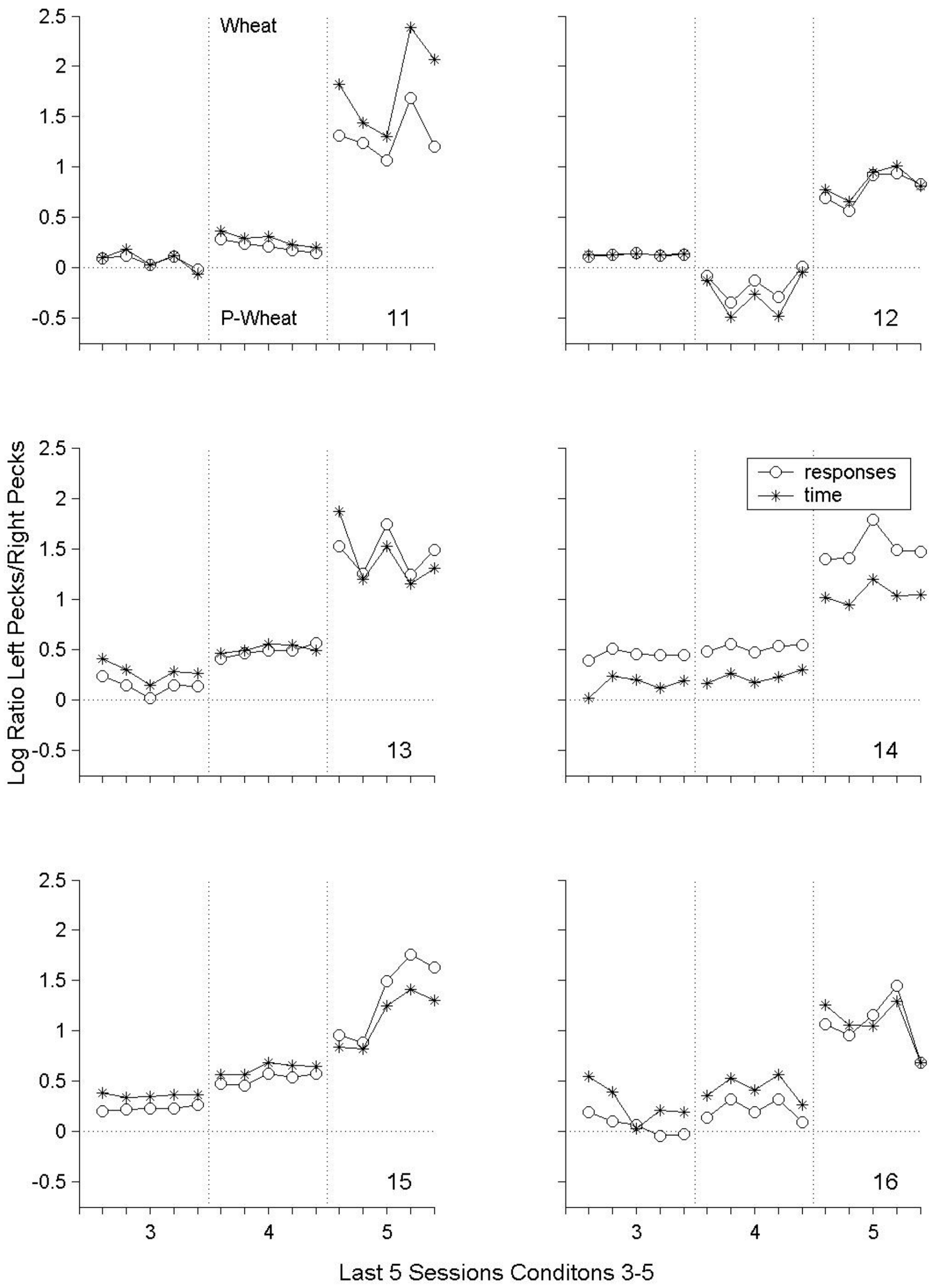

Figure 5. Log ratio's of responses and times plotted against Conditions 3 (FR1), 4 (FR8) and 5 (FR32) for the last 5 Sessions for each hen.

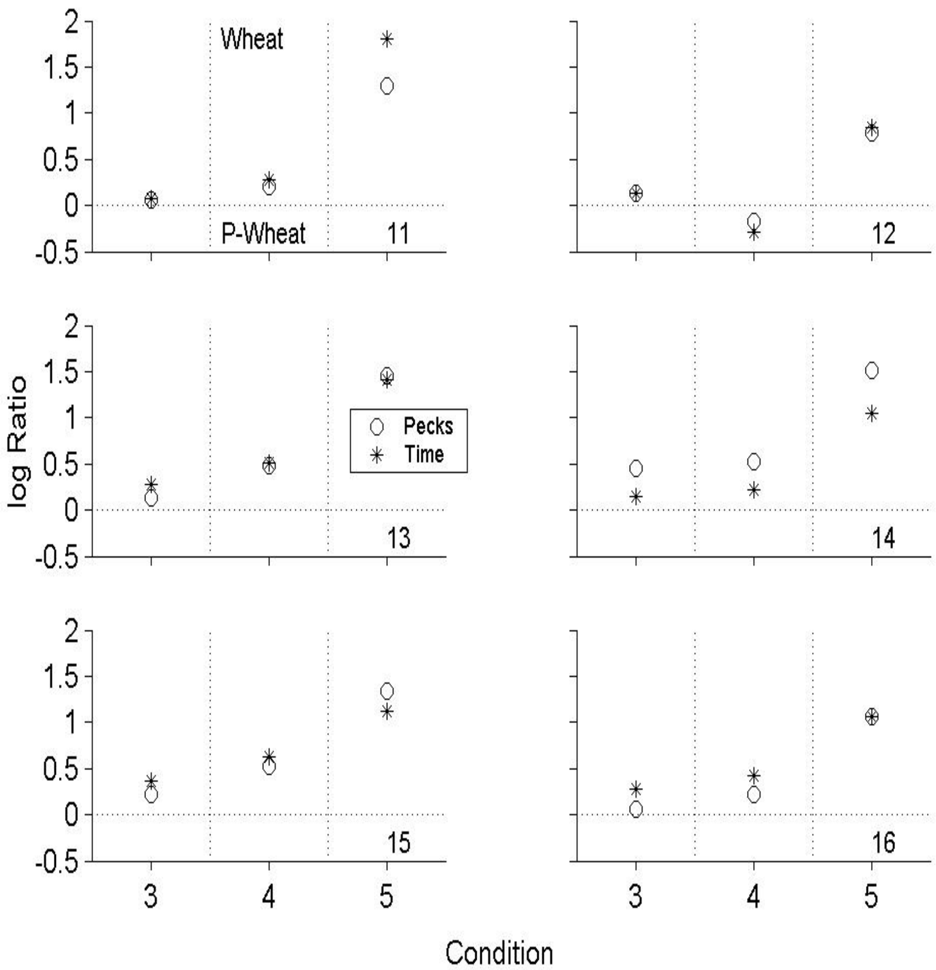

Figure 6. The point estimates of log *c* (Equation 4) of Conditions 3 (FR1), 4 (FR8) and 5 (FR32) for responses (circles) and times responding (asterisks) during the initial link of the last 5 Sessions for each hen.

presented as log ratio point estimates of responses made and time spent on each alternative. The data from each hen are plotted on a logarithmic scale and give the averaged point estimates of log *c* (Equation 4). The point estimates of log *c* show the bias the hen has towards one alternative over the other. This does not include any differences in reinforcer rate, however as the schedule of reinforcement operating in the concurrent-chain schedule was equal, the reinforcers were close to equal also.

Figures 5 and 6 show that during each condition (FR1, FR8 and FR32) all hens (with the exception of Hen 12 in one condition), responded more and spent more time responding to the left (wheat) key, showing a preference towards wheat. During Condition 4 (FR8), Hen 12 responded and spent more time on the right or puffed wheat alternative compared to the wheat (left) alternative. However, her bias returned to the left (wheat) alternative during Condition 5 (FR32) as the 'price', analogous to the terminal link FR, increased.

Table 6 presents the ranges of the values of the log ratios of left/right responses, and the ranges of the log ratio left/right times responding from data presented in Figure 5. The preferences found were the smallest with FR1 in the terminal link, ranging between -0.046 and 0.123 (responses) and -0.06 and 0.548 (time), with means of 0.164 (responses) and 0.208 (time). As the conditions changed and the 'price' increased in the terminal link, the preferences became more extreme towards the left (wheat) key. The preferences towards wheat found at FR8 ranged between -0.343 and 0.579 (responses), and -0.491 and 0.681 (time), with means of 0.294 (responses) and 0.299 (time), while the preferences found at FR32 ranged between 0.562 and 1.789 (responses) and 0.661 and 2.382 (time),

Table 6.

The ranges of the minimum and maximum log ratio left/right responses, and the ranges of the minimum and maximum log ratio left/right times in Conditions 3 (FR1), 4 (FR8) and 5 (FR32) for all Hens

		log Ratio Resp		log Ratio Times	
Hen	FR	Min	Max	Min	Max
11	1	-0.02	0.123	-0.06	0.185
12	1	0.109	0.147	0.129	0.138
13	1	0.017	0.236	0.14	0.409
14	1	0.385	0.506	0.015	0.231
15	1	0.199	0.262	0.342	0.383
16	1	-0.046	0.19	0.026	0.548
11	8	0.145	0.285	0.2	0.37
12	8	-0.343	0.007	-0.491	-0.045
13	8	0.404	0.564	0.466	0.55
14	8	0.476	0.552	0.161	0.301
15	8	0.454	0.579	0.565	0.681
16	8	0.088	0.324	0.263	0.566
11	32	1.066	1.681	1.299	2.382
12	32	0.562	0.938	0.661	1.008
13	32	1.242	1.74	1.149	1.866
14	32	1.394	1.789	0.941	1.2
15	32	0.885	1.759	0.824	1.413
16	32	0.68	1.446	0.68	1.29

with means of 1.265 (responses) and 1.226 (time). All preferences found (with the exception of Hen 12 at FR8) were monotonic, that is, all the preferences increased towards wheat with increased terminal link ratio values (as seen in Table 6). The most variance in the data occurred with FR32 in the terminal link across all Hens. There were no systematic differences between log ratio responding and time components across conditions or hens.

Overall response rates (left panel) and running response rates (right panel) of each hen during the terminal link are presented in Figure 7. The overall response rates were calculated by dividing the total number of responses made in the terminal link by the total key-time spent in the terminal link, excluding any time the magazine was operative. The running response rates for the preference assessment were calculated by dividing the total number of responses in the terminal link by the run time. The running response rates do not include terminal link pauses (i.e. time from when the terminal link is entered until the first response is made in the terminal link). As with the running response rates calculated in the demand assessment, it is not possible to calculate running response rates at FR1. Response rates (responses/sec) are plotted against natural logarithmic FR values and responding for wheat (circles) and puffed wheat (asterisks) are shown across the three conditions.

The overall response rate data show that there are no overall patterns of responding on the puffed wheat alternative compared to wheat at the price of FR1, across all hens. When the condition changed and the ‘price’ was increased from FR1 to FR8 in the terminal link, the Hens’ responding changed. The overall response rates of each Hen at FR8 (terminal link) increased in comparison to data

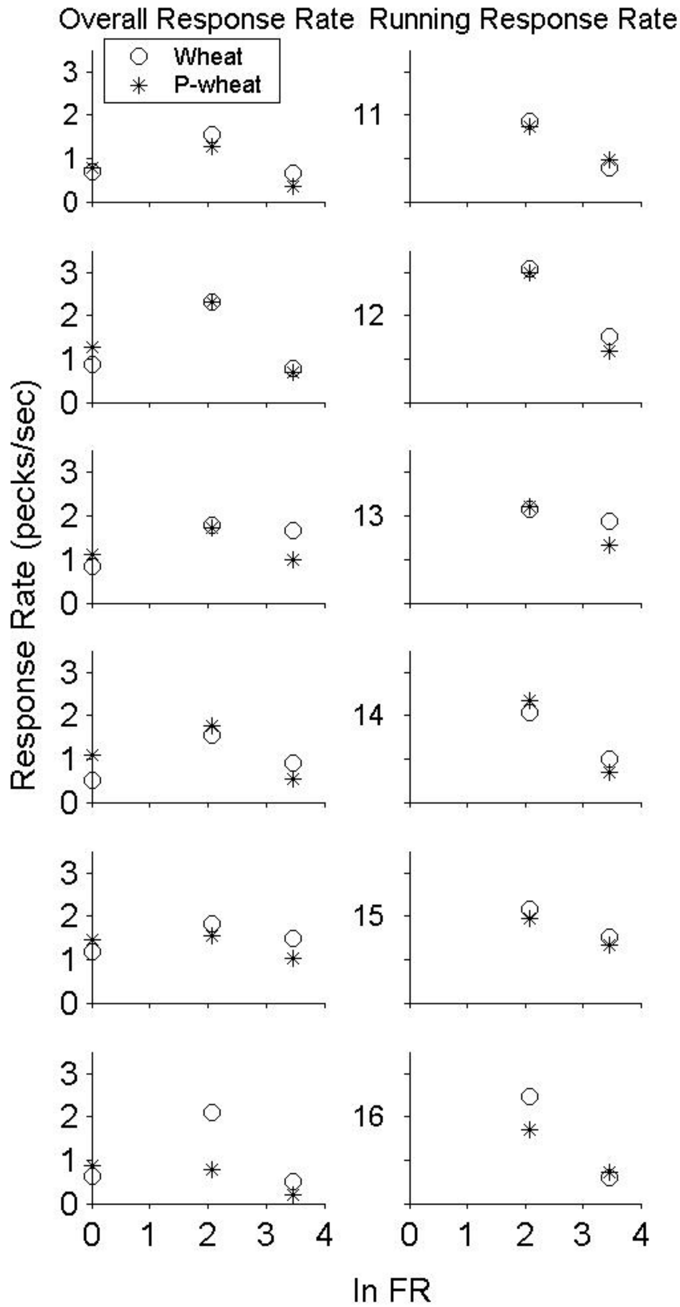

Figure 7. The overall response rates and running response rates generated by responding in the terminal link of the last 5 Sessions of Conditions 3, 4 and 5 for each hen plotted as responses per second against (ln) FR Schedules.

from FR1. Response rates for each alternative across hens, however, remained relatively equal with the exception of Hen 16, with an overall response rate much faster for wheat compared to puffed wheat at the same reinforcer value: FR8. The overall response rates of each hen decreased as the terminal link FR value increased from FR8 to FR32 during the third condition and, all six hens responded at a faster rate for wheat at FR32, compared to puffed wheat at FR32.

The running response rates are similar to those of the overall response rates; there is no general pattern occurring across hens. The running response rates are faster at FR8 compared to running response rates at FR32, which is similar to the overall response rates. However the running response rates are higher at both FR8 and FR32 than the overall response rates. The running response rates for each alternative are relatively equal at both FR8 and FR32. Figure 7 shows that there is a slight difference between running response rates for wheat and puffed wheat at FR8 for Hen 16, with the running response rates being higher for wheat.

Data collected from the terminal link of Conditions 3 (FR1), 4 (FR8) and 5 (FR32) are shown in Figure 8, which presents consumption rate plotted as natural logarithmic values against logarithmic FR sizes. Equation 1 was used to generate demand functions that allow comparison between the conceptual demand functions from the terminal link data and the full demand curves generated from whole sessions. The consumption of wheat (circles) and puffed wheat (asterisks) are presented, along with the best-fit lines for both commodities.

Figure 8 shows the parameter ln L is higher for puffed wheat across all hens, that is, the initial consumption rate of all six hens is slightly higher for

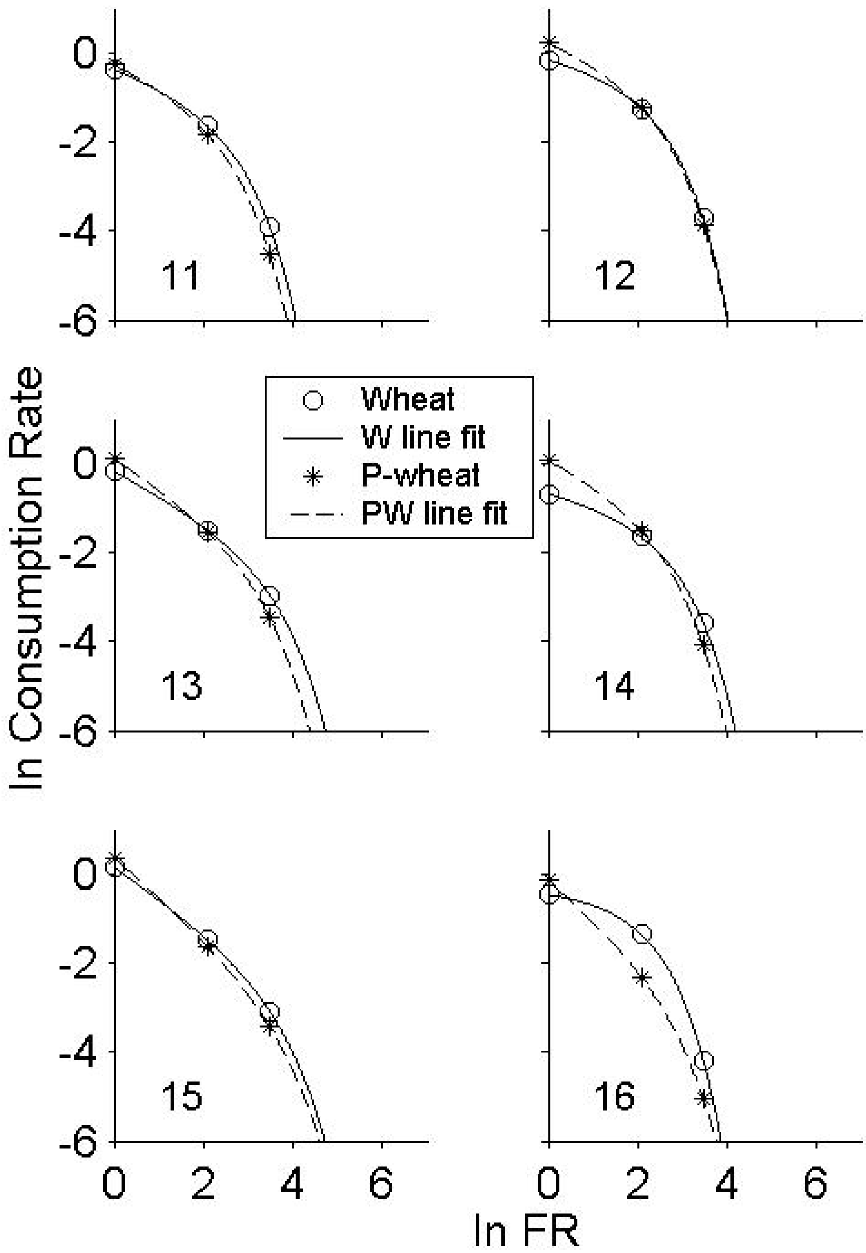

Figure 8. Demand curves generated from the terminal link data from the last 5 Sessions of Conditions 3 (FR1), 4 (FR8), and 5 (FR32) for each hen, plotted against ln FR.

puffed wheat at the lowest price, FR1. The initial slopes (*b* values) of the demand curves generated in Figure 8 for both commodities are negative, however wheat has a less negative initial slope compared to puffed wheat across all hens. The demand curves generated using the terminal link data from Hens 11, 13, 14, 15 and 16 show that the demand curves for wheat and puffed wheat cross at some point showing a larger demand for wheat at higher ‘prices’ especially at FR 32. This is despite the fact that demand for puffed wheat is higher initially, at FR1, compared to wheat at the same ‘price’.

Table 7 presents the parameters of Hursh et al.’s (1988) equation (Equation 1) for the averaged consumption rate data for each hen during the terminal link of the concurrent chain schedules of Conditions 3, 4 and 5. The standard errors of estimates (se), percentage of variances accounted for (%VAC) and the FR value, which predicts the maximal response output (P_{max}), as calculated by Equation 2, are also presented.

The initial consumption levels (ln *L*) were higher for puffed wheat across all six hens. The *b* values, or initial slope of the demand functions for all hens are curvilinear. All *b* values presented in Table 7 are negative, however, the *b* values for puffed wheat are more negative than for wheat. This indicates a steeper initial slope for puffed wheat compared to wheat. The *a* values for three hens (11, 13 and 14) are all slightly smaller for wheat than those of puffed wheat, meaning that for these three hens wheat is the more inelastic commodity of the two. The remaining three hens (12, 15 and 16) have higher *a* values for wheat compared to puffed wheat, indicating puffed wheat is more inelastic for these three hens.

Figure 9 presents the terminal link pauses in seconds plotted against natural logarithmic FR schedules. The terminal link pause was calculated by

Table 7.

The parameters b, a and ln L from Hursh et al.'s (1988) equation (Equation 1) fitted to the ln consumption plotted against the ln FR data across the three conditions of the terminal link during the concurrent-chain schedules (Conditions 3, 4 and 5). The standard error of the estimates (se), the percentages of variance accounted for by the lines (% VAC) and the FR value at which the fitted curves predict maximal responding (P_{max}) are also shown.

Hen	Alt	*Ln L*	*b*	a	P_{max}	se	%VAC
11	Wheat	-0.293	-0.362	0.074	8.62	0.0000442	99.995
11	P-Wheat	-0.159	-0.473	0.085	6.2	0.0000438	99.999
12	Wheat	-0.054	-0.224	0.090	8.62	0.0000190	99.997
12	P-Wheat	0.323	-0.426	0.084	6.83	0.0000120	100
13	Wheat	-0.141	-0.537	0.030	15.43	0.0000311	100
13	P-Wheat	0.157	-0.655	0.042	8.21	0.0000305	99.997
14	Wheat	-0.605	-0.242	0.066	11.49	0.0000251	99.996
14	P-Wheat	0.175	-0.514	0.077	6.31	0.0000165	99.999
15	Wheat	0.187	-0.700	0.026	11.54	0.0000446	99.998
15	P-Wheat	0.404	-0.887	0.024	4.71	0.0000306	100
16	Wheat	-0.338	-0.039	0.116	8.28	0.0000132	100
16	P-Wheat	-0.070	-0.820	0.066	2.73	0.0000186	100

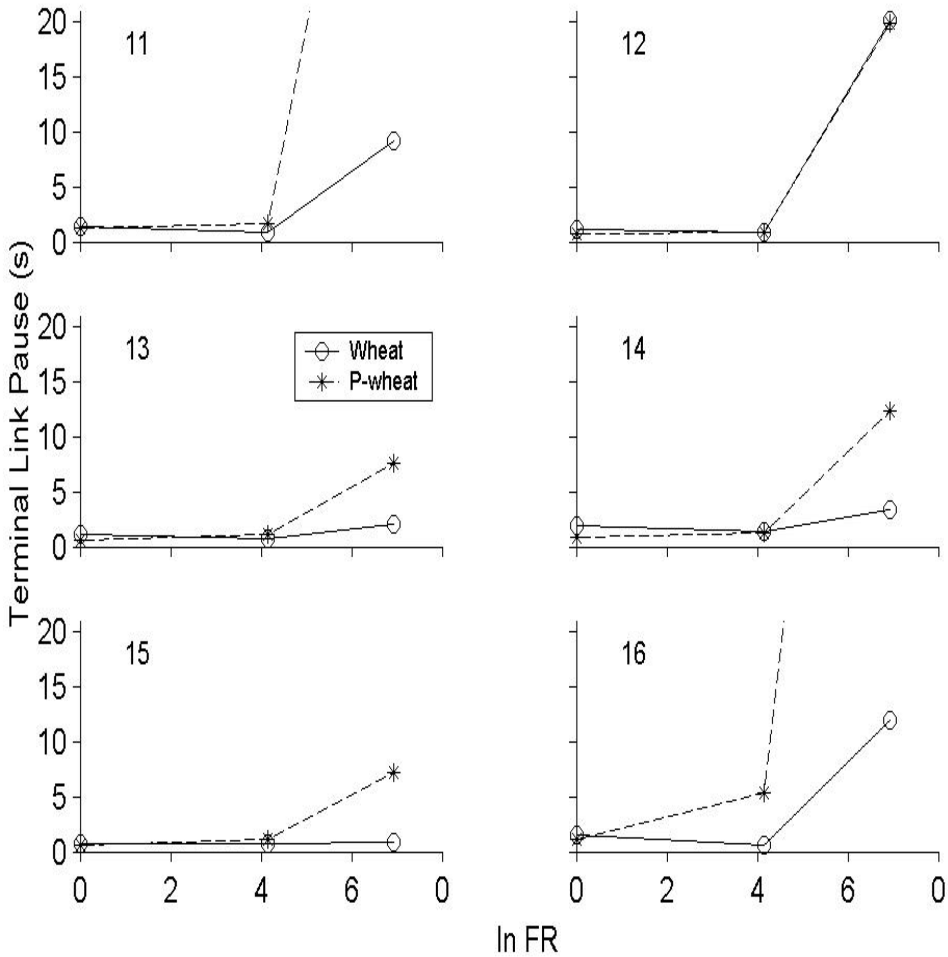

Figure 9. The averaged terminal link pauses (seconds) plotted against ln FR schedules for each hen during Conditions 3 (FR1), 4 (FR8) and 5 (FR32).

counting the seconds from the time the terminal link was entered to the first response made in the terminal link, divided by the number of reinforcers gained during each session. All hens except Hen 12 continued to respond for wheat to the highest FR schedule of the preference assessment. Hen 12 stopped responding during the terminal link at a 'price' of FR32. The terminal link pause at FR1 ranged from 0.791s to 1.904s for wheat and 0.573s to 1.229s for puffed wheat. Responding for puffed wheat was commenced before wheat for all hens at FR1. That is, all six hens started responding faster for puffed wheat compared to wheat. As the FR increased the terminal link pauses increased for both wheat and puffed wheat. Pauses taken during Condition 4 (FR8 in the terminal link) ranged from 0.652s to 1.344s for wheat, and 0.802s to 5.372s for puffed wheat. The terminal link pauses made by Hens 13, 14 and 15 remained relatively stable when responding for wheat as the terminal link increased from FR8 to FR32. The remaining hens (11, 12 and 16) took longer to respond at FR32 compared to FR8 on the wheat alternative once entering the terminal link. The pauses made across all hens ranged from 0.800s to 20.081s for wheat and 7.150s to 107.745s for puffed wheat. There are slight differences in the terminal link pauses between wheat and puffed wheat at prices of FR1 and FR8, while there is a considerable difference between the terminal link pauses taken when responding for wheat and puffed wheat at the increased price of FR32.

Table 8 presents the terminal link pause values for all the data points displayed in Figure 9. Table 8 also makes for ease of comparison of terminal link pauses between the alternatives. It becomes clearer that pauses before responding for puffed wheat are noticeably smaller at the low FR value compared to wheat,

Table 8.

The averaged terminal link pauses, counted in seconds, divided by reinforcers gained during the terminal link phase of Conditions 3 (FR1), 4 (FR8) and 5 (FR32) for each alternative: wheat and puffed wheat, for each hen.

		Hen					
		11	12	13	14	15	16
Wheat	FR1	1.392	1.104	1.129	1.904	0.791	1.52
	FR8	0.855	0.894	0.787	1.344	0.759	0.652
	FR32	9.235	20.081	2.026	3.359	0.8	11.985
P Wheat	FR1	1.229	0.734	0.573	0.853	0.633	1.086
	FR8	1.67	0.802	1.078	1.189	1.067	5.372
	FR32	60.019	19.909	7.578	12.39	7.15	107.745

but the puffed wheat pauses are considerably larger at the high FR value compared to wheat.

DISCUSSION

The aim of this research was to investigate the relation between hens' preference and demand for two different food commodities: wheat and puffed wheat. The experiment was designed firstly to determine if demand could predict preference, and secondly whether preference would change as the price of the commodities increased as assessed by a concurrent chain schedule of reinforcement with increasing FR schedules of reinforcement in the terminal links.

The demand assessment phase of this experiment was a replication of Flevill's (2002) research, and based on that research it was expected that puffed wheat would yield higher initial (ln *L*) demand, while wheat would yield a lower initial (ln *L*) level of demand. This was found throughout the present research. While the results from Flevill's (2002) research were counter intuitive, the replication of those findings in this piece of research, suggests that the findings are, in fact, reliable. Similar findings to those of Flevill (2002) and the present experiment, were also found in research conducted by Grant (2005). Grant (2005) found lower initial levels of demand for the more preferred reinforcer but in her experiment this was a larger (longer magazine time) reinforcer rather than a qualitatively different one. In both Flevill (2002) and Grant's (2005) research the preferred reinforcer gave lower ln *L* values: one preference was for quality (Flevill, 2002) and one was for quantity (Grant, 2005), yet the results were similar.

The parameters of the demand curves generated in the present study indicate a generality of findings with all ln *L* values being higher for puffed wheat across all hens. However this does not imply a generality of parameters, that is, all hens have individually different ln *L* values for both puffed wheat and wheat. The average ln *L* values for puffed wheat ranged between -1.076 and -1.587, while the average ln *L* values for wheat ranged between -2.603 and -3.324. Although initial demand (ln *L*) values were higher for puffed wheat, other parameters, such as *b* values and P_{max} values were higher for wheat. In all cases the averaged *b* values were negative for both wheat and puffed wheat, however, the *b* values for puffed wheat were more negative, indicating a steeper initial slope of the demand curves. The averaged P_{max} values were higher for wheat in five of the six cases as shown in Table 5. This indicates that the ‘price’ at which responding for wheat shifts from inelastic to elastic is higher than that of puffed wheat. One suggestion for this occurrence might be that wheat is the more valued commodity of the two at higher prices. The demand functions for wheat and puffed wheat, do however, show mixed elasticity across all hens, but the hens will respond longer at higher prices (FR schedules of reinforcement) for wheat compared to puffed wheat.

A generality of findings is also evident in the terminal link demand curves; that is all ln *L* (initial demand) values were higher for puffed wheat than for wheat. A generality of parameters is not evident (i.e. all hens have different ln *L* values) from the terminal link demand curves, also the case with the demand curves generated for the demand assessment data.

As was found with the demand curves from the demand assessment, all *b* values generated from the terminal link data were negative, with the *b* values from puffed wheat being more negative than the *b* values from wheat. This again indicates a steeper initial slope of the demand curves generated using the terminal link data. Following the trend of the demand curves, all P_{max} values are higher for wheat compared to puffed wheat. This shows that the hens will respond longer at higher prices for wheat compared to puffed wheat. It should be noted however that P_{max} values for the demand assessment are much higher than those from the preference assessment. This is due to the experimental restrictions placed on the preference conditions (Conditions 3, 4 and 5) by the researcher (i.e. the highest FR was FR32).

An interpretation based on Tustin's (1994) suggestion might be that wheat is the stronger reinforcer, especially at higher schedule requirements. The demand curves generated for wheat (demand assessment) are longer and flatter than those of puffed wheat. It might be expected based on the demand curves shown in Figure 4 and Tustin's (1994) suggestions, that wheat is preferred over puffed wheat, and therefore the stronger reinforcer.

The demand curves generated in the terminal link of the preference assessment phase are very similar to those generated in the demand assessment phase (i.e. puffed wheat has higher initial (ln L) values compared to wheat across all hens). However unlike the ln L values from the demand assessment, some of the ln L values from the terminal link data are positive. All ln L values for puffed wheat in the terminal link are higher when compared to those for wheat. This suggests that the subjects are responding more rapidly for puffed wheat than wheat at low prices during the terminal link of the preference assessment.

It is interesting to note that the hens don't pause as much before the FR requirement in the terminal links as they do when an equal FR requirement is presented in the demand conditions. One possibility for this occurrence may be that the pause in the demand conditions is partly a function of just having completed the previous FR requirement, since otherwise both conditions are very much the same. In both cases (terminal link and demand) the hen is about to start a FR schedule of a value, with which she has already had a reasonable amount of experience. In the terminal link case, this FR schedule follows a concurrent scheduled key peck and is accompanied by a key-light colour change. In the demand conditions it simply follows the completion of an identical FR requirement and consumption of the schedules reinforcer. At least some of the extra pausing found in the demand conditions seems likely to be attributable to the previously completed FR; it seems to be a post-reinforcement pause rather than a pre-ratio pause.

The preference assessment was carried out to replicate and extend previous findings and to determine if preference would change along with ‘price’. There were a number of expectations from the preference assessment phase of this research. Firstly, based on previous research (Flevill, 2002) it was expected that a clear preference for wheat would be found at a ‘price’ of FR1 during the concurrent chain schedule of reinforcement. Flevill (2002) found a preference for wheat over puffed wheat in simple concurrent schedules. The present experiment replicated Flevill’s (2002) findings, that is, a preference for wheat was found at a ‘price’ of FR1. Even though a concurrent-chain schedule is not exactly the same as a simple concurrent schedules, it is probably similar enough for a preference at FR1, to have been expected.

Responding during the initial link of Condition 3 (FR1) resembles that found by Flevill (2002) on a basic concurrent schedule of reinforcement at a ‘price‘ of one peck. When the two commodities are made available concurrently more responding is directed towards the most preferred food. As the price in the terminal link of the concurrent-chain schedule increased, responding in the initial link of the concurrent-chain schedule changed. Figure 5 shows preference for wheat as measured by the ratio of responses in the initial link as becoming more extreme as the terminal link price increased. This suggests that wheat became more highly valued with increased schedule requirements compared to puffed wheat. Preference between the two commodities seems to vary predictably with price.

Flevill (2002) found that overall response rates from the demand assessment were higher for puffed wheat than for wheat at a ‘price’ of FR1, however she gives no explanation as to why this might have occurred. The averaged overall response rates from the demand phase of the current research (as shown in Figure 1) are slightly higher for puffed wheat than they are for wheat at a ‘price’ of FR1, once again replicating Flevill’s (2002) research findings. This tells us that the hens were responding faster or making more responses per second at FR1 for puffed wheat compared to wheat. The overall response rates from the terminal link of the preference phase (Figure 7) reflect those found during the demand assessment, that response rates are also faster for puffed wheat at the same ‘price’: FR1. This was somewhat unexpected as the initial link data, as presented in Figure 5, shows that wheat is preferred at a ‘price’ of FR1. What this may be indicating is that it is the schedule of reinforcement in the terminal link (in this case, FR1) that is more preferred rather than the commodity of wheat itself. The hens had higher response rates for puffed wheat at a ‘price’ of FR1 both in single (demand) assessment conditions and in the terminal links. If only this was known about the two commodities then it might be tempting to regard the one giving the higher response rate (puffed wheat) as the preferred commodity.

However, the concurrent schedules preference measures showed bias towards wheat, not puffed wheat.

Another way to assess the subjects' preference is to measure the latency to the first peck, with the lowest latency perhaps being regarded as the preferred commodity. Dawkins (1977) used latency to choose as a way of assessing hens preferences for outside runs or battery cages. The time taken for the hen to move from the starting box to the chosen environment (battery cage or outside run) was measured as the latency to choose. Dawkins (1977) concluded that all hens used in her research preferred the outside run over the battery cage. In the present experiment, the higher overall response rates at FR1 for puffed wheat result from the shorter latency to respond for (the less preferred) puffed wheat. Hence, using Dawkins' (1977) argument, puffed wheat would be judged as preferred from the latency data.

A further expectation was, that based on Flevill's (2002) demand results and Tustins' (1994) suggestion that a flatter longer demand curve can predict preference, wheat would be preferred over puffed wheat at higher prices (i.e. FR8 and FR32). Although a clear preference for wheat was found in the initial links for all subjects across all prices assessed, there was an unexpected result from Hen 12. During the initial link of Condition 4 (FR8) there was a distinct preference for puffed wheat by Hen 12. However, Hen 12's preference at the remaining two prices (FR1 and FR32) were for wheat. While it might be assumed that Hen 12 prefers puffed wheat at a price of FR8, it seems unlikely that this was the case. Based on the data produced from the five remaining hens, it is possible to assume that this set of data from Hen 12 is a random occurrence. If prediction of behaviour under economic conditions suggests that preference becomes more extreme as the price increases, as the data shows for the remaining five Hens, then Hen 12's preference for puffed wheat at a price of FR8 would be illogical.

Another expectation for the preference assessments was that preference might change as the 'price' in the terminal link increased. The current results supported this expectation as shown by the behaviour changes in both parts of the experiment (initial and terminal links) when the FR schedules in the terminal links increased. Responding for puffed wheat decreased proportionally more as the price in the terminal link increased. A decrease in responding for wheat was also seen as the FR requirement increased in the terminal link, however this decrease was proportionally less compared to the decrease seen for puffed wheat. This resulted in a change in preference, as seen in Figure 5; responding for wheat in the initial link became more extreme as the terminal link FR requirement increased.

It is tempting to consider these two changes (preference becoming more extreme and the change in behaviour as the terminal link FRs increased) as being directly linked, and that one might predict the other. That is specifically, changes in demand might predict changes in preference in equal FR sizes (i.e. as demand for puffed wheat decreases the preference for puffed wheat also decreases). At the higher FR sizes the demand data showed that responding for puffed wheat dropped faster than demand for wheat at the same high FRs. Responding for wheat during the demand phase was maintained to higher FR sizes as shown in Table 1, when compared to puffed wheat. The findings for the preference assessment are very similar; wheat was increasingly more preferred as the FR in the terminal link increased, while the opposite was found for puffed wheat. That is, puffed wheat became increasingly less valued with an increase in 'price' in the terminal link. However, this simple relation clearly does not hold, since it would have predicted that at FR1 preference should have been in favour of puffed wheat because it gave higher overall response rates in the demand assessment, as can be seen in Figures 1 and 2. This, however, was not the case with puffed wheat and the predicted results were not found; puffed wheat was not preferred at FR1 in the preference assessment. The averaged overall and running response rates for puffed wheat were clearly higher when compared to those of wheat. This clearly suggests that the relation between preference and demand is more complicated than anticipated.

Running response rates were calculated for both the demand and the preference assessments in the current study. The running response rates produced from the demand data show that at a ‘price’ of FR8 the hens were still responding generally faster for puffed wheat compared to wheat, which is similar to the overall response rates at FR1. The running response rates at a ‘price’ of FR8 in the terminal links of the preference assessment however did not favour puffed wheat. That is, responding was generally slightly faster for wheat compared to puffed wheat. These running response rate results differ from the overall response rates at a ‘price’ of FR1 in the terminal link.

As the ‘price’ increased running response rates at FR32 in the demand phase generally decreased. No clear difference can be seen between response rates for wheat and puffed wheat at this ‘price’. However running response rates during the terminal link phase of the preference assessment were generally slightly higher for wheat than they were for puffed wheat, continuing with the trend seen at a ‘price’ of FR8 in the terminal link. The running response rates in the terminal link were also higher when compared to those averages generated in the demand phase at the same ‘price’: FR32. This result may have been affected by the presence of the initial link preceding the terminal link of the concurrent-chain schedule of reinforcement. It becomes apparent, once again, that the terminal link FR schedule entered from the concurrent-chain does not function exactly the same as a FR schedule in a recurring demand schedule situation. During the demand phase only one commodity is available across series, however, during the preference assessment both commodities are available concurrently. One explanation that may be given for this occurrence is to consider the arrival of the terminal link and the change in key colour are secondary reinforcers to the primary reinforcer; the delivery of wheat or puffed wheat. Gollub (1958), and Ferster and Skinner (1957) used chained schedules to investigate response rates and both found that response rates in the chained schedule changed in a number of ways as the subjects learned to associate the secondary reinforcer with the primary reinforcer. Firstly, response rates in the initial link decreased compared to those in the terminal link, as reinforcers were not available in the initial link. As the terminal link stimulus became an effective conditioned reinforcer, response rates in the initial link increased. However, most theories of secondary reinforcers would predict that the stronger effect would be found with the more preferred reinforcer. This explanation works well for terminal link values of FR8 and FR32, since wheat was preferred to puffed wheat. It still offers, for this author, no satisfactory explanation for the anomalous relation found with FR1 in the terminal links (i.e. higher ln L (initial demand) values but lower preference for puffed wheat).

Post reinforcement pauses (PRP) were calculated for the demand assessment phase of this experiment, as were the terminal link pauses for the preference assessment phase. It should be noted that the averages shown in

Figure 3 are the calculated means, as are those shown in Figure 9. The researcher calculated the medians to investigate any differences there may have been between the means and the medians, however, no significant differences were found therefore the mean has been used. Harris (2006) also concluded similarly when she examined differences between the mean and median point estimates of log *c* for responses and time spent by subjects dust-bathing for every second five-session period.

The PRPs were all longer at FR1 for wheat than they were for puffed wheat. Post reinforcement pauses are said to increase and responding decrease as the FR schedule increases (Felton & Lyon, 1966; Ferster & Skinner, 1957). These authors also suggest that the pausing might be controlled by the upcoming response requirements and any aversive properties associated with that response requirement. The post-reinforcement pausing patterns for puffed wheat and all terminal link pauses of all subjects, in this case, do increase as the FR schedule increases. However, the functions of the PRPs for wheat during the demand phase are bitonic, an unexpected finding, which differs from previous literature (Felton & Lyon, 1966; Ferster & Skinner, 1957). While the hen's pausing after a wheat reinforcer increased at mid range FRs (FR8, FR16 etc), at high FR schedules the pausing decreased to something similar to that shown at FR1, and in some cases even below the PRP shown at FR1. Given that the means and medians of the PRP distribution were found to be similar, it is possible but unlikely, that this is a result of a few longer pauses during the FR1 determinations.

The PRPs at FR1 for wheat and puffed wheat during the demand phase had noticeable differences in the pause lengths across hens. However, the terminal link pauses show no difference between wheat and puffed wheat across subjects at the same 'price' of FR1. It is interesting to note however, that there is a noticeable difference between the PRPs and the terminal link pauses; the terminal link pauses are considerably smaller than the PRPs. This indicates that at a 'price' of FR1 in the terminal link the subjects were responding to the FR schedule of reinforcement sooner than they were at the same 'price' (FR1) in the demand phase. As the terminal link is a different schedule from the initial link, the pausing could be looked upon as pre-ratio pausing as the subjects have not yet received reinforcement. Derenne and Baron (2002) suggest pre-ratio pausing occurs as a result of a competition between the responses and the reinforcers scheduled by the researcher. At a 'price' of FR1 in the terminal link the subjects were required to make one response to gain 3 seconds access to the reinforcer; wheat or puffed wheat. The reinforcer is larger than the effort needed to make the response requirement. This suggestion from Derenne and Baron (2002) might be of significance as the 'price' in the terminal link increased but at a 'price' of FR1 this is not a satisfactory explanation. They also suggest that alternative reinforcers, such as scratching or grooming that may be available during the experimental session might have an affect on the pre-ratio pausing. The behaviour of the hens while in the operant chamber was not observed during the experimental session; therefore this explanation for pre-ratio pausing is also unsatisfactory for this author.

There are a number of papers discussing PRPs and pre-ratio pauses (Derenne & Baron, 2002; Mazur, 2000; Felton & Lyon, 1966; Ferster & Skinner, 1957), which found a positive correlation between increasing FR schedule requirements and pausing. However, none of the papers examined here give any explanation for the differences found in the PRPs for the demand assessment phase or the terminal link pauses in the preference assessment phase. One avenue of interest, which due to time constraints could not be examined, is the relation between the PRPs in the demand assessment phase and the pauses between exiting the terminal link and making the first response after entering the initial link of the concurrent-chain. This might enable a more enlightened understanding of what is happening in regards to PRP in the present experiment, and if there is a difference between the demand assessment PRPs and the concurrent-chain PRPs. The author of this research has found no satisfactory explanation as to why there is such a difference between the pauses found in the demand assessment and the terminal links of the preference assessment. Derenne and Baron (2002) suggest further research on pre-ratio pausing using qualitatively different commodities, which has been done in the present research. The differences seen in the present experiment between the two commodities within the terminal link pre-ratio pauses may be specific to the terminal link schedules of the concurrent-chain.

In conclusion, the relation found between preference and demand for different foods in previous research was also found in the current study between puffed wheat and wheat. Puffed wheat yielded higher initial demand (ln L) values, however it was found that wheat was the more preferred commodity across all prices studied. Grant's (2005) study (which was not completed at the commencement of the present study) suggests that the same relation also applies when the preference between the two reinforcers results from quantitative (three different amounts of wheat) rather than qualitative differences. Further research investigating preference and demand is required to add understanding to the findings of this and previous studies. Replication of the present study may be carried out to further investigate preference at differing prices. More qualitatively different commodities may also be used in the demand and preference assessments, such as salted and none salted wheat, or wheat and pellets. In future research a reversal of the commodities should be done to account for any inherent bias. A second-order concurrent schedule could possibly be used to assess preference at difference prices to determine whether the preference results found in this study are a product of the increases in prices, or because of the concurrent-chain schedule that was used to assess preference. This would also show if the preferences at different prices found in this study are replicable using different concurrent schedules.

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APPENDIX A

The raw data from each demand condition are presented for each hen. Series 2 and 3 are presented for the wheat condition (Condition 1) and Series 2 and 3 are presented for the puffed wheat condition (Condition 2). The hen number (Hen), the date (Year, Day, Mnth), the condition number (Cond), the series (Series), the FR requirement (FR), the latency to the first peck (First), the total number of responses (Rsp), the number of reinforcements gained (Rfts), the post-reinforcement pause durations (PRP), the runtime (RunT), the keytime (KeyT), the total session time (TotT), eat time (EatT) and the amount of food eaten (Eaten) are presented for each session. All measures are presented in seconds, except Eaten, which is presented in grams.

Hen	Year	Day	Mnth	Cond	Series	FR	First	Rsp	Rfts	PRP	RunT	KeyT	TotT	EatT	Eaten
11	5	18	5	1	2	1	3.7	214	214	2373.2	0	2400.1	3042.1	3821	-205
11	5	19	5	1	2	2	11.1	20	10	2003.2	385.5	2400.1	2430.1	0	-13.5
11	5	20	5	1	2	4	4.1	394	98	581.8	1809.2	2400.1	2694.1	1986	5.8
11	5	21	5	1	2	8	5	923	115	1053.2	1335.3	2400.1	2745.1	2399	-144
11	5	22	5	1	2	16	5.3	257	16	1526.4	867.4	2400.1	2448.1	365	-19.3
11	5	23	5	1	2	32	1.9	581	18	797.7	1599.6	2400.1	2454.1	400	-19.6
11	5	24	5	1	2	64	0.8	976	15	264.2	2134.1	2400.1	2445.1	331	-8.1
11	5	25	5	1	2	128	0.9	738	5	113	2285.9	2400.1	2415.1	111	0
11	5	26	5	1	2	256	0.8	711	2	15	2384.1	2400.1	2406.1	44	-2.6
11	5	27	5	1	2	512	1	338	0	0	2399.1	2400.1	2400.1	0	-0.2
12	5	18	5	1	2	1	9	111	111	2379.4	0	2400.1	2733.1	2065	-66.9
12	5	19	5	1	2	2	1.5	198	99	2322.6	70.1	2400.1	2697.1	2004	-115
12	5	20	5	1	2	4	1.3	412	103	2086.1	306.3	2400.1	2709.1	2274	-73.7
12	5	21	5	1	2	8	1.2	808	101	1966.5	427	2400.1	2703.1	2114	-110
12	5	22	5	1	2	16	0.7	1439	89	1093	1300.7	2400.1	2667.1	1650	-97.5
12	5	23	5	1	2	32	4.5	960	30	1078.3	1316.1	2400.1	2490.1	575	-34.6
12	5	24	5	1	2	64	0.8	1728	27	542	1856	2400.1	2481.1	377	-61.9
12	5	25	5	1	2	128	1.9	1305	10	457.9	1939.7	2400.1	2430.1	156	-14.8
12	5	26	5	1	2	256	1	739	2	28.7	2370.3	2400.1	2406.1	38	-2.3
12	5	27	5	1	2	512	1.8	124	0	0	2398.3	2400.1	2400.1	0	0
13	5	14	5	1	2	1	1.7	155	155	2382.7	0	2400.1	2865.1	1639	-80.7
13	5	15	5	1	2	2	1.3	145	72	1071.3	1324.3	2400.1	2616.1	1221	-82.9

13	5	16	5	1	2	4	12.9	188	47	2272.2	112.2	2400.1	2541.1	679	-45.8
13	5	18	5	1	2	8	1.6	608	76	1326.5	1068.5	2400.1	2628.1	1148	-95.9
13	5	19	5	1	2	16	2.6	417	26	868.1	1527.7	2400.1	2478.1	419	-6.4
13	5	20	5	1	2	32	2.8	608	19	1436.9	959.6	2400.1	2457.1	335	-37
13	5	21	5	1	2	64	5	556	8	687.8	1706.9	2400.1	2424.1	38	-4.6
13	5	22	5	1	2	128	2.7	750	5	420.9	1976.3	2400.1	2415.1	70	-6.1
13	5	23	5	1	2	256	84.4	122	0	0	2315.7	2400.1	2400.1	0	-0.3
14	5	18	5	1	2	1	5.1	165	165	2377.4	0	2400.1	2895.1	3368	-124
14	5	19	5	1	2	2	5.2	173	86	1187.7	1202.6	2400.1	2658.1	1604	-49.6
14	5	20	5	1	2	4	3	464	116	2132.1	259.4	2400.1	2748.1	2763	-42.8
14	5	21	5	1	2	8	1.5	688	86	1519.4	874.7	2400.1	2658.1	1765	-71.5
14	5	22	5	1	2	16	2.1	560	35	1691	704.9	2400.1	2505.1	773	-36.7
14	5	23	5	1	2	32	2.2	832	26	705.7	1690.1	2400.1	2478.1	613	-20.1
14	5	24	5	1	2	64	4.5	837	13	794.6	1600.3	2400.1	2439.1	297	-10.5
14	5	25	5	1	2	128	1.4	508	3	35.1	2363.5	2400.1	2409.1	64	-3.5
14	5	26	5	1	2	256	2.5	454	1	2.6	2395	2400.1	2403.1	18	-1.4
14	5	27	5	1	2	512	1.3	185	0	0	2398.8	2400.1	2400.1	0	0.1
15	5	18	5	1	2	1	3.8	94	94	2386.6	0	2400.1	2682.1	1286	-60.1
15	5	19	5	1	2	2	4.1	167	83	336.2	2054.2	2400.1	2649.1	1675	-61.2
15	5	20	5	1	2	4	0.9	284	71	2280.3	115.8	2400.1	2613.1	1537	-105
15	5	21	5	1	2	8	3.9	248	31	2266.6	127.4	2400.1	2493.1	814	-54.8
15	5	22	5	1	2	16	0.7	848	53	1850.1	546.4	2400.1	2559.1	1412	-97.6
15	5	23	5	1	2	32	2.9	704	22	1210.5	1185.6	2400.1	2466.1	584	-39.6
15	5	24	5	1	2	64	0.9	1152	18	423.6	1974.5	2400.1	2454.1	476	-21
15	5	25	5	1	2	128	1.9	555	4	326.8	2071.3	2400.1	2412.1	108	-7.2
15	5	27	5	1	2	256	1	655	2	17.9	2381.1	2400.1	2406.1	50	-4
15	5	28	5	1	2	512	8.8	198	0	0	2391.3	2400.1	2400.1	0	0.1
16	5	19	5	1	2	1	1.2	103	103	2387.9	0	2400.1	2709.1	2020	-75.6
16	5	20	5	1	2	2	79.8	127	63	1476.5	840.7	2400.1	2589.1	1300	-43.3
16	5	21	5	1	2	4	5.3	81	20	152	2241.6	2400.1	2460.1	406	-15.9
16	5	22	5	1	2	8	0.5	555	69	648.9	1747.6	2400.1	2607.1	1508	-82.8
16	5	23	5	1	2	16	1.9	336	21	1545.8	851.1	2400.1	2463.1	457	-19.1
16	5	24	5	1	2	32	5	1445	45	365.1	2027.7	2400.1	2535.1	1114	-51.1
16	5	26	5	1	2	64	1.2	282	4	32.8	2365.9	2400.1	2412.1	94	-4.5
16	5	27	5	1	2	128	0.9	1478	11	73.2	2325.6	2400.1	2433.1	264	-21.6
16	5	28	5	1	2	256	4.7	1256	4	36.8	2358.5	2400.1	2412.1	99	-8.8
16	5	30	5	1	2	512	4.4	879	1	12.9	2382.7	2400.1	2403.1	24	-2.1
16	5	31	5	1	2	1024	1.2	147	0	0	2398.9	2400.1	2400.1	0	-4.9
11	5	8	6	1	3	1	1.4	169	169	2380.5	0	2400.1	2907.1	2706	-148
11	5	9	6	1	3	2	2.4	278	139	2253.7	135.1	2400.1	2817.1	2386	-128
11	5	10	6	1	3	4	1.9	544	136	2098.4	291.1	2400.1	2808.1	2615	-141
11	5	11	6	1	3	8	1	1023	127	1577.6	815.2	2400.1	2781.1	3032	-168
11	5	12	6	1	3	16	1.4	1057	66	1429.9	965.9	2400.1	2598.1	1298	-66.3
11	5	13	6	1	3	32	2.1	806	25	902	1494.7	2400.1	2475.1	557	-30.7
11	5	14	6	1	3	64	1.2	964	15	491.8	1906.3	2400.1	2445.1	331	-24.2
11	5	15	6	1	3	128	1.2	1056	8	181	2217.3	2400.1	2424.1	171	-12.3
11	5	16	6	1	3	256	0.9	378	1	7.1	2392	2400.1	2403.1	16	-1.2

11	5	17	6	1	3	512	1.2	231	0	0	2398.9	2400.1	2400.1	0	-0.1
12	5	8	6	1	3	1	1.1	169	169	2381.6	0	2400.1	2907.1	3154	-163
12	5	9	6	1	3	2	3.7	118	59	2354.1	38.8	2400.1	2577.1	1072	-41.2
12	5	10	6	1	3	4	2.1	516	129	1664.6	726.1	2400.1	2787.1	2826	-122
12	5	11	6	1	3	8	1.6	968	121	1993.3	398.7	2400.1	2763.1	2600	-130
12	5	12	6	1	3	16	1.1	1536	96	1643.5	750.7	2400.1	2688.1	1872	-90.3
12	5	13	6	1	3	32	2.8	1220	38	1523	872.4	2400.1	2514.1	793	-40.5
12	5	14	6	1	3	64	3.3	1920	30	569.3	1826	2400.1	2490.1	551	-37.5
12	5	15	6	1	3	128	1	1080	8	222.1	2176.5	2400.1	2424.1	131	-10.1
12	5	16	6	1	3	256	0.8	930	3	155.8	2243.2	2400.1	2409.1	55	-3.9
12	5	17	6	1	3	512	4.2	381	0	0	2395.9	2400.1	2400.1	0	0
13	5	8	6	1	3	1	0.9	167	167	2381.9	0	2400.1	2901.1	1770	-155
13	5	9	6	1	3	2	41.2	92	46	2311.4	44.8	2400.1	2538.1	472	-38.8
13	5	10	6	1	3	4	1.6	255	63	1558.6	836.4	2400.1	2589.1	886	-78.6
13	5	11	6	1	3	8	2.7	552	69	2020.5	372.7	2400.1	2607.1	1452	-97
13	5	12	6	1	3	16	3	848	53	1648.6	745.7	2400.1	2559.1	970	-61.6
13	5	13	6	1	3	32	3	642	20	604.2	1791.6	2400.1	2460.1	354	-23.8
13	5	14	6	1	3	64	1.8	1588	24	384.2	2012.7	2400.1	2472.1	412	-30
13	5	15	6	1	3	128	16.7	757	5	75.2	2308	2400.1	2415.1	96	-5.1
13	5	16	6	1	3	256	5.8	475	1	6.6	2387.6	2400.1	2403.1	0	0
13	5	17	6	1	3	512	3.6	123	0	0	2396.5	2400.1	2400.1	0	-0.1
14	5	8	6	1	3	1	0.8	173	173	2381.2	0	2400.1	2919.1	3772	-162
14	5	9	6	1	3	2	1.8	254	127	2212.2	179	2400.1	2781.1	2389	-77.6
14	5	10	6	1	3	4	0.7	519	129	433.8	1958.3	2400.1	2787.1	2854	-120
14	5	11	6	1	3	8	0.7	1139	142	790	1601.3	2400.1	2826.1	3131	-141
14	5	12	6	1	3	16	1	1015	63	889.3	1506.8	2400.1	2589.1	1260	-62.7
14	5	13	6	1	3	32	1.4	1450	45	591.4	1805.2	2400.1	2535.1	997	-52.1
14	5	14	6	1	3	64	2	1430	22	460.8	1936.1	2400.1	2466.1	485	-26.9
14	5	15	6	1	3	128	0.8	1294	10	253.9	2144.7	2400.1	2430.1	215	-12.1
14	5	16	6	1	3	256	0.9	427	1	55.5	2343.6	2400.1	2403.1	19	-1.5
14	5	17	6	1	3	512	1.3	246	0	0	2398.8	2400.1	2400.1	0	0
15	5	8	6	1	3	1	1	121	121	2386.6	0	2400.1	2763.1	2369	-160
15	5	10	6	1	3	2	2.3	97	48	1603.2	792.3	2400.1	2544.1	745	-47.5
15	5	11	6	1	3	4	1.1	118	29	101.5	2295.5	2400.1	2487.1	769	-51.8
15	5	12	6	1	3	8	1.3	480	60	2170.8	224.8	2400.1	2580.1	1407	-90.8
15	5	13	6	1	3	16	1	80	5	2352.4	46.5	2400.1	2415.1	114	-7.1
15	5	14	6	1	3	32	1.5	585	18	582.2	1815.8	2400.1	2454.1	430	-24.8
15	5	15	6	1	3	64	0.8	642	10	890.7	1507.9	2400.1	2430.1	233	-16.3
15	5	16	6	1	3	128	1.2	520	4	286.5	2112	2400.1	2412.1	91	-8.7
15	5	17	6	1	3	256	0.9	255	0	0	2399.2	2400.1	2400.1	0	-0.1
16	5	8	6	1	3	1	399	10	10	2000	0	2400.1	2430.1	35	-4
16	5	9	6	1	3	2	1.4	224	112	1872.4	520.5	2400.1	2736.1	2199	-76
16	5	10	6	1	3	4	7.5	328	82	2162.8	225.8	2400.1	2646.1	1848	-84
16	5	11	6	1	3	8	12.4	424	53	1970.4	413.9	2400.1	2559.1	1166	-75.4
16	5	12	6	1	3	16	5	594	37	440.3	1952.5	2400.1	2511.1	824	-64.1
16	5	13	6	1	3	32	3.2	1440	45	930.5	1463.7	2400.1	2535.1	1045	-80.2

16	5	14	6	1	3	64	1.5	1216	19	1029.2	1368.6	2400.1	2457.1	469	-33.2
16	5	15	6	1	3	128	2.4	1082	8	79.9	2317.2	2400.1	2424.1	201	-13.7
16	5	17	6	1	3	256	1.7	319	1	24	2374.3	2400.1	2403.1	26	-1.4
16	5	19	6	1	3	512	1	741	1	11.5	2387.6	2400.1	2403.1	22	-2.3
16	5	20	6	1	3	1024	1.7	243	0	0	2398.4	2400.1	2400.1	0	0
11	5	20	7	2	2	1	7.3	538	538	2337.8	0	2400.1	4014.1	7807	-68.6
11	5	21	7	2	2	2	2	998	499	1942.4	428.8	2400.1	3897.1	8828	-55.3
11	5	22	7	2	2	4	11.2	1140	285	1765.4	608.7	2400.1	3255.1	5463	-21.8
11	5	24	7	2	2	8	1.4	1848	231	1432.5	954.1	2400.1	3093.1	5042	-31
11	5	25	7	2	2	16	1.4	1392	87	1421.9	971.9	2400.1	2661.1	1975	-9.7
11	5	26	7	2	2	32	1.2	460	14	1690.7	707.5	2400.1	2442.1	341	-1.8
11	5	27	7	2	2	64	2.6	325	5	666.4	1730.7	2400.1	2415.1	113	-1.3
11	5	28	7	2	2	128	24.8	134	1	349.2	2026	2400.1	2403.1	22	-0.6
11	5	30	7	2	2	256	1.2	158	0	0	2398.9	2400.1	2400.1	0	-0.1
12	5	20	7	2	2	1	2.7	214	214	2374.6	0	2400.1	3042.1	3763	-34.9
12	5	21	7	2	2	2	1.2	679	339	1971.3	410.3	2400.1	3417.1	6049	-56.9
12	5	22	7	2	2	4	0.9	1516	379	1581	795.9	2400.1	3537.1	6267	-41.9
12	5	24	7	2	2	8	3.8	1483	185	1435.3	951.4	2400.1	2955.1	2818	-21
12	5	25	7	2	2	16	1.5	1593	99	1528.6	864.9	2400.1	2697.1	1982	-11.2
12	5	26	7	2	2	32	2.4	348	10	340.2	2056.9	2400.1	2430.1	258	-1.5
12	5	27	7	2	2	64	1.9	230	3	82.7	2315.2	2400.1	2409.1	68	-0.4
12	5	28	7	2	2	128	36.9	19	0	0	2363.2	2400.1	2400.1	0	0
13	5	20	7	2	2	1	102.1	363	363	2259.9	0	2400.1	3489.1	3981	-39.9
13	5	21	7	2	2	2	1	620	310	2070.4	311.2	2400.1	3330.1	5593	-45.7
13	5	23	7	2	2	4	0.6	1236	309	1622.7	758.2	2400.1	3327.1	5484	-38.8
13	5	24	7	2	2	8	1.7	1289	161	1297.7	1091.9	2400.1	2883.1	3248	-10
13	5	25	7	2	2	16	1.3	1616	101	1070.2	1323.2	2400.1	2703.1	1378	-9
13	5	26	7	2	2	32	1.2	418	13	892.6	1505.9	2400.1	2439.1	246	-1.8
13	5	27	7	2	2	64	37.3	320	5	1167.4	1195.1	2400.1	2415.1	52	-0.4
13	5	28	7	2	2	128	13.1	291	2	195	2191.8	2400.1	2406.1	35	-0.3
13	5	30	7	2	2	256	2.8	94	0	0	2397.3	2400.1	2400.1	0	0
14	5	20	7	2	2	1	3.9	445	445	2349.7	0	2400.1	3735.1	7372	-55.3
14	5	21	7	2	2	2	0.6	1126	563	1925.4	442	2400.1	4089.1	11672	-64.2
14	5	23	7	2	2	4	2.8	1648	412	1498.4	875	2400.1	3636.1	9512	-52.3
14	5	24	7	2	2	8	1.6	2071	258	1187.8	1195.7	2400.1	3174.1	5927	-30
14	5	25	7	2	2	16	0.6	841	52	195.8	2201.2	2400.1	2556.1	91	0.1
14	5	26	7	2	2	16	0.5	1984	124	897.4	1495.7	2400.1	2772.1	2989	-15.9
14	5	27	7	2	2	32	2.1	1185	37	886.6	1509.5	2400.1	2511.1	978	-4.6
14	5	28	7	2	2	64	73.6	191	2	19.1	2307.2	2400.1	2406.1	29	-0.5
14	5	30	7	2	2	128	2.1	651	5	325.9	2071.8	2400.1	2415.1	159	-0.9
14	5	1	8	2	2	256	1.7	372	1	20	2378.3	2400.1	2403.1	18	-0.4
14	5	2	8	2	2	512	1	266	0	0	2399.1	2400.1	2400.1	0	0
15	5	21	7	2	2	1	0.7	257	257	2372.6	0	2400.1	3171.1	4655	-46.5
15	5	22	7	2	2	2	0	1012	506	1996.4	374.7	2400.1	3918.1	9197	-57.1
15	5	23	7	2	2	4	1.9	1693	423	1574.8	801	2400.1	3669.1	8977	-57.3
15	5	24	7	2	2	8	0.8	2176	272	1412.5	971.5	2400.1	3216.1	6018	-34.5

15	5	26	7	2	2	16	0.5	187	11	55.1	2343.9	2400.1	2433.1	0	0.4
15	5	26	7	2	2	16	0.6	2448	153	1226.6	1165.2	2400.1	2859.1	4071	-19.9
15	5	27	7	2	2	32	0.6	1024	32	1361.8	1035.6	2400.1	2496.1	807	-6.2
15	5	28	7	2	2	64	241.7	248	3	128.3	2029.9	2400.1	2409.1	89	-0.6
15	5	30	7	2	2	128	1.7	462	3	104	2294.3	2400.1	2409.1	82	-0.6
15	5	31	7	2	2	256	1	129	0	0	2399.1	2400.1	2400.1	0	0
16	5	21	7	2	2	1	0.5	295	295	2368.5	0	2400.1	3285.1	5017	-56.6
16	5	22	7	2	2	2	2.6	742	371	1991.2	387.4	2400.1	3513.1	6679	-56.7
16	5	23	7	2	2	4	9.9	1179	294	1567.4	806.3	2400.1	3282.1	5915	-53.4
16	5	25	7	2	2	8	0.7	1395	174	1192.2	1198.7	2400.1	2922.1	3853	-29.5
16	5	26	7	2	2	16	2.1	564	35	34.6	2360.9	2400.1	2505.1	15	0
16	5	26	7	2	2	16	0.7	1440	90	1254.1	1140.7	2400.1	2670.1	2103	-15.7
16	5	27	7	2	2	32	0.2	1024	32	1360.7	1037.9	2400.1	2496.1	789	-6.7
16	5	28	7	2	2	64	0.3	640	10	1824	575.5	2400.1	2430.1	231	-1.9
16	5	30	7	2	2	128	1	274	2	30.4	2368.6	2400.1	2406.1	49	-0.5
16	5	1	8	2	2	256	0.9	346	1	16.3	2382.8	2400.1	2403.1	23	-0.2
16	5	2	8	2	2	512	5.3	294	0	0	2394.8	2400.1	2400.1	0	0
11	5	10	8	2	3	1	2	371	371	2359.1	0	2400.1	3513.1	4381	-59.1
11	5	11	8	2	3	2	3.5	684	342	2042.2	337.1	2400.1	3426.1	5460	-58.9
11	5	12	8	2	3	4	3	1164	291	1493.5	887.7	2400.1	3273.1	5153	-55.3
11	5	14	8	2	3	8	0.7	1627	203	1363	1024.7	2400.1	3009.1	3910	-33.7
11	5	15	8	2	3	16	1.3	1210	75	1368.2	1026.6	2400.1	2625.1	1591	-10.3
11	5	16	8	2	3	32	1	298	9	851.6	1546.9	2400.1	2427.1	210	-2.2
11	5	17	8	2	3	64	1.5	539	8	219.9	2178.3	2400.1	2424.1	164	-1.8
11	5	19	8	2	3	128	1.9	425	3	93.4	2304.7	2400.1	2409.1	61	-0.8
11	5	20	8	2	3	256	1.5	174	0	0	2398.6	2400.1	2400.1	0	-0.2
12	5	9	8	2	3	1	1.7	282	282	2368.7	0	2400.1	3246.1	3206	-37
12	5	10	8	2	3	2	1.1	661	330	1064.5	1313.4	2400.1	3390.1	2585	-53.4
12	5	11	8	2	3	4	1.7	1251	312	1119	1262.6	2400.1	3336.1	3035	-56.4
12	5	12	8	2	3	8	1.8	2320	290	1383.6	997.7	2400.1	3270.1	2926	-46.3
12	5	14	8	2	3	16	1.5	2464	154	1266.9	1122.1	2400.1	2862.1	1626	-28.6
12	5	15	8	2	3	32	1.1	889	27	875.2	1522.4	2400.1	2481.1	569	-3.6
12	5	16	8	2	3	64	3.1	424	6	122.1	2274.6	2400.1	2418.1	75	-1
12	5	17	8	2	3	128	1.3	435	3	41.4	2357.4	2400.1	2409.1	50	-0.5
12	5	19	8	2	3	256	1.2	201	0	0	2398.9	2400.1	2400.1	0	0
13	5	10	8	2	3	1	0.8	484	484	2347.9	0	2400.1	3852.1	3746	-57.4
13	5	11	8	2	3	2	0.7	650	325	1908.7	472	2400.1	3375.1	2725	-48.2
13	5	12	8	2	3	4	0.7	1546	386	1510.1	868.9	2400.1	3558.1	4297	-55.8
13	5	14	8	2	3	8	1.1	1760	220	1324.9	1062.8	2400.1	3060.1	3078	-41.5
13	5	15	8	2	3	16	0.8	1376	86	1271.6	1122.9	2400.1	2658.1	1364	-11.3
13	5	16	8	2	3	32	0.8	672	21	1671.8	726.1	2400.1	2463.1	263	-3.3
13	5	17	8	2	3	64	0.8	862	13	618	1780.6	2400.1	2439.1	228	-3
13	5	19	8	2	3	128	0.9	504	3	110.4	2288.7	2400.1	2409.1	53	-0.8
13	5	20	8	2	3	256	1	186	0	0	2399.1	2400.1	2400.1	0	0
14	5	9	8	2	3	1	0.8	368	368	2361.6	0	2400.1	3504.1	4026	-40.7
14	5	10	8	2	3	2	0.7	691	345	1884	495.9	2400.1	3435.1	5798	-55.7

14	5	11	8	2	3	4	1.4	1279	319	1392.5	989.2	2400.1	3357.1	5851	-52.2
14	5	14	8	2	3	8	1.1	1847	230	1146.2	1239.5	2400.1	3090.1	4354	-35.8
14	5	15	8	2	3	16	1.4	2112	132	1038.3	1353	2400.1	2796.1	2699	-19.6
14	5	16	8	2	3	32	1.3	550	17	559.2	1839	2400.1	2451.1	364	-3.2
14	5	17	8	2	3	64	1.7	961	15	730.7	1666.7	2400.1	2445.1	309	-2.8
14	5	19	8	2	3	128	1.2	603	4	96.2	2302.6	2400.1	2412.1	75	-0.6
14	5	20	8	2	3	256	1.5	214	0	0	2398.6	2400.1	2400.1	0	-0.1
15	5	9	8	2	3	1	1	364	364	2360.5	0	2400.1	3492.1	6057	-57
15	5	10	8	2	3	2	1.7	834	417	2100.8	273.5	2400.1	3651.1	7192	-67.7
15	5	12	8	2	3	4	0.7	1256	314	1909.4	472.1	2400.1	3342.1	6581	-59
15	5	14	8	2	3	8	0.5	2193	274	1404.1	979.6	2400.1	3222.1	6483	-55
15	5	15	8	2	3	16	1.6	2702	168	1175.7	1213.3	2400.1	2904.1	4285	-31.3
15	5	16	8	2	3	32	0.7	2172	67	1094.8	1300.8	2400.1	2601.1	1789	-36.2
15	5	17	8	2	3	64	2.4	1472	23	1122	1274.6	2400.1	2469.1	611	-6
15	5	19	8	2	3	128	1.7	694	5	748.5	1649.4	2400.1	2415.1	131	-1.5
15	5	20	8	2	3	256	69.5	373	1	435.9	1894.7	2400.1	2403.1	21	-0.5
15	5	21	8	2	3	512	1.6	130	0	0	2398.5	2400.1	2400.1	0	2.2
16	5	9	8	2	3	1	5.4	257	257	2367.5	0	2400.1	3171.1	3900	-49.3
16	5	11	8	2	3	2	1.1	455	227	1977.9	408.9	2400.1	3081.1	3436	-45.5
16	5	12	8	2	3	4	1.2	822	205	1662.9	724.6	2400.1	3015.1	3165	-48.6
16	5	14	8	2	3	8	0.7	1328	166	1283.4	1106.7	2400.1	2898.1	3043	-42.1
16	5	15	8	2	3	16	1	1520	95	971	1422.5	2400.1	2685.1	2086	-25
16	5	16	8	2	3	32	0.3	897	28	484	1914.4	2400.1	2484.1	616	-7
16	5	17	8	2	3	64	0.3	900	14	388.3	2010.6	2400.1	2442.1	344	-1.4
16	5	19	8	2	3	128	2.4	383	2	14.5	2383	2400.1	2406.1	50	-0.4
16	5	20	8	2	3	256	0.5	513	2	67.9	2331.6	2400.1	2406.1	41	-0.5
16	5	21	8	2	3	512	1.7	129	0	0	2398.4	2400.1	2400.1	0	-0.5

APPENDIX B

The raw data from the last five sessions from Conditions 3, 4 and 5 (preference assessment) are presented for each hen. The hen number (H), the year (Yr), the day (D), the month (M), the left (L) and right (R) variable intervals (VI), the left (L) and right (R) fixed ratio's (FR), the responses to the left (L) and right (R) made during the Variable interval (VIRsp), the variable interval time left (VITL), the variable interval time right (VITR), the change overs from left to right (CoL>R), the change overs from right to left (CoR>L), the left reinforcements (RftsL), the right reinforcements (RftsR), the terminal link pauses on the left (TLPL), the terminal link pauses on the right (TLPR), the left terminal link responses (FRRspL), the right terminal link responses (FRRspR), the left run time (RunTL), the right run time (RunTR), the left eat time (EatTL), the right eat time (EatTR), the time to first response (FRsp), the side of the first response (SFRsp), the time of the last response (TLstRp), the side of the last response (SLRp), the total time for each session (TotT), the post-reinforcement pauses (PRP), post left then peck left (LL), post left, then peck right (LR), post right then peck right (RR), post right then peck left (RL), the number of post-reinforcment pauses (NumPRP) left left (LL), left right (LR), right right (RR), right left (RL), the concurrent chain time (ConcT), the left terminal link key time (FRLKT) and the right terminal link key time (FRRKT) are all recorded. The measures are presented in seconds.

				VI		FR		VIRsp																					PRP				Num PRP						
H	Yr	D	M	L	R	L	R	L	R	VITL	VITR	CoL>R	CoR>L	RftsL	RftsR	TLPL	TLPR	FRRspL	FRRspR	RunTL	RunTR	EatTL	EatTR	FRsp	SFRsp	TLstRp	SLRp	TotT	LL	LR	RR	RL	LL	LR	RR	RL	ConcT	FRLKT	FRRKT
11	5	30	10	90	90	1	1	527	424	1213	953.5	360	344	22	21	28.6	25.3	22	21	2.2	2.1	548	486	7.6	1	2398	2	2400	951	894	72	820	10	12	1	20	2174.4	29.7	26.2
11	5	31	10	90	90	1	1	594	447	1305	851.8	396	381	22	22	36.2	26.6	22	22	2.2	2.2	502	485	1.2	1	2377	1	2400	524	766	130	883	9	12	2	20	2157.6	37.2	27.7
11	5	1	11	90	90	1	1	602	564	1109	1043	459	442	24	21	33.3	25.2	24	21	2.4	2.1	547	485	0.9	1	2399	2	2400	858	695	114	768	13	11	2	19	2152.9	34.3	26.1

11	5	2	11	90	90	1	1	748	584	1215	920.8	526	516	25	22	32	27.4	25	22	2.5	2.2	551	471	1.1	1	2400	1	2400	505	767	93	769	11	14	3	19	2136.8	33.2	28.4
11	5	4	11	90	90	1	1	493	516	992	1139	411	419	24	23	32.8	29.5	24	23	2.4	2.3	607	532	14.9	1	2399	2	2400	82	1146	261	689	2	22	5	18	2145	34.4	30.8
12	5	31	10	90	90	1	1	1141	888	1225	910.8	673	678	24	24	26.6	16.2	24	24	2.4	2.4	296	433	0.9	1	2399	2	2400	374	984	250	480	4	20	7	17	2136.5	27.4	17.2
12	5	1	11	90	90	1	1	1046	774	1228	909.1	618	616	22	23	31.1	17.9	22	23	2.2	2.3	411	521	5.7	1	2396	2	2400	331	761	213	527	6	16	5	17	2142.7	32.4	19.4
12	5	2	11	90	90	1	1	991	707	1238	905.2	607	610	23	24	24	19.6	23	24	2.3	2.4	246	430	1.4	1	2399	1	2400	75	1141	134	814	1	22	3	21	2145	25.3	20.7
12	5	3	11	90	90	1	1	1117	848	1227	907.3	720	722	23	24	23.1	17.9	23	24	2.3	2.4	378	429	1.9	1	2398	2	2400	97	913	144	649	2	21	4	20	2135.9	24.5	19.2
12	5	4	11	90	90	1	1	1187	883	1227	892.9	744	733	25	24	24.4	15.7	25	24	2.5	2.4	490	496	5.9	1	2400	1	2400	400	643	57	562	9	16	2	22	2126.2	25.5	17.2
13	5	31	10	90	90	1	1	921	535	1532	597.1	455	409	24	24	36.1	13	24	24	2.3	2.2	365	508	9.7	1	2400	1	2400	1355	102	0	648	23	1	0	24	2138.3	36.7	37.2
13	5	1	11	90	90	1	1	856	615	1446	723.8	484	442	22	23	17.2	12.4	22	23	2.2	2.2	296	486	2	1	2400	2	2400	1134	139	0	656	20	2	0	23	2171.7	18.9	21.6
13	5	2	11	90	90	1	1	534	514	1263	914.3	372	337	24	22	24	14.1	24	22	2.4	2.2	316	448	3	1	2400	1	2400	1555	247	44	706	21	3	1	21	2180.5	25.5	15.2
13	5	3	11	90	90	1	1	778	557	1416	747.1	470	426	22	23	28.8	12.2	22	23	2.2	2.3	427	486	6.3	1	2399	1	2400	1306	66	0	694	21	1	0	23	2169.5	30.1	13.5
13	5	4	11	90	90	1	1	715	529	1398	767.5	473	423	21	25	21.5	15.3	21	25	2.1	2.5	346	552	5.5	1	2399	1	2400	1378	0	0	908	21	0	0	25	2170.8	22.8	16.8
14	5	31	10	90	90	1	1	650	268	1106	1069	212	208	21	19	45.4	16	21	19	2.1	1.9	527	499	15.8	1	2398	2	2400	284	828	81	774	6	15	2	17	2191.1	46.8	16.8
14	5	1	11	90	90	1	1	711	222	1363	799.7	215	185	22	24	45.4	16.7	22	24	2.2	2.4	480	591	11.1	1	2399	1	2400	732	492	0	1023	13	9	0	24	2173.3	46.5	18.2
14	5	2	11	90	90	1	1	737	259	1325	845.4	237	222	24	20	41.4	12.7	24	20	2.4	2	482	478	13.4	1	2400	2	2400	521	646	0	743	11	13	0	20	2183.5	42.7	13.8
14	5	3	11	90	90	1	1	735	267	1231	932.9	248	227	22	23	36.4	16.6	22	23	2.2	2.3	467	528	15.8	1	2389	1	2400	404	547	0	989	9	13	0	23	2179.8	37.7	18.2
14	5	4	11	90	90	1	1	524	189	1330	850.9	162	142	21	20	40.8	28.4	21	20	2.1	2	502	503	6.1	1	2397	1	2400	745	694	0	1291	11	10	0	20	2186.9	41.6	29.1
15	5	30	10	90	90	1	1	987	624	1534	635	430	414	22	24	21.7	15.2	22	24	2.2	2.4	356	496	5.5	1	2400	1	2400	500	930	29	785	7	15	1	23	2174.2	23.1	16.5
15	5	31	10	90	90	1	1	1211	732	1487	676.4	500	495	25	23	19.1	12.2	25	23	2.5	2.3	362	519	1.4	1	2400	2	2400	352	1052	53	636	6	19	2	21	2165	20.6	13.5
15	5	1	11	90	90	1	1	1221	725	1497	669.3	541	515	22	24	14.9	16.7	22	24	2.2	2.4	315	508	1.4	1	2400	1	2400	610	544	0	720	11	11	0	24	2168	16.1	17.8
15	5	2	11	90	90	1	1	1196	713	1516	647.9	566	528	22	24	16.4	15.2	22	24	2.2	2.4	291	544	1.2	1	2400	1	2400	782	302	0	704	17	5	0	24	2165.4	17.9	16.1
15	5	4	11	90	90	1	1	1105	604	1517	654.7	488	472	23	23	18.1	15.4	23	23	2.3	2.3	466	458	3.5	1	2399	1	2400	435	822	57	836	8	14	1	22	2174.9	19.4	16.8
16	5	31	10	90	90	1	1	491	317	1702	482.2	287	275	22	22	25.2	20.3	22	22	2.2	2.2	533	452	2.2	1	2399	1	2400	554	993	95	757	7	15	1	21	2186.6	26.2	21.4
16	5	1	11	90	90	1	1	270	214	1566	639.1	183	179	20	20	23.8	23.3	20	20	2	2	459	412	4	1	2387	1	2400	693	1550	692	737	5	15	3	17	2208.9	24.6	24.4
16	5	2	11	90	90	1	1	144	123	1151	1083	92	91	15	15	40.8	18.5	15	15	1.5	1.5	273	283	3.3	1	2359	1	2400	603	1393	3598	863	3	11	3	12	2236.8	41.9	19.6
16	5	3	11	90	90	1	1	399	444	1343	826.8	304	308	21	22	31	20.7	21	22	2.1	2.2	505	440	11.8	1	2396	1	2400	121	1332	350	770	2	19	5	17	2181.2	32.1	22.1
16	5	4	11	90	90	1	1	347	370	1333	849.1	271	273	20	21	28.2	25.8	20	21	2	2.1	414	444	7.7	1	2400	1	2400	1845	1688	819	1079	2	18	4	17	2189.6	29.4	27.1
11	5	17	12	90	90	8	8	397	206	1430	610.4	202	174	19	20	15.8	33.1	152	160	84	86.7	471	428	3.7	1	2397	1	2400	1000	524	0	1013	13	6	0	20	2043.6	98.9	118
11	5	18	12	90	90	8	8	385	223	1330	682.7	231	193	20	20	17	34.4	163	160	104	84.8	463	429	3.3	1	2397	1	2400	1542	93	0	1196	19	1	0	20	2015.8	120.4	118
11	5	19	12	90	90	8	8	418	258	1373	671.5	256	220	20	21	16.3	28	160	168	76	82.8	479	466	4	1	2398	1	2400	1006	229	0	982	17	3	0	21	2048.4	91.3	110
11	5	20	12	90	90	8	8	374	252	1263	750.2	244	212	19	20	15.2	44.2	152	160	75	107	439	452	2.5	1	2399	1	2400	1105	331	0	1117	15	4	0	20	2015.7	89.5	150
11	5	21	12	90	90	8	8	560	401	1227	773.4	372	335	19	21	18.6	30.6	152	168	80	108	446	451	3.9	1	2398	2	2400	1065	58	66	743	18	1	2	19	2004.4	97.5	137

12	5	17	12	90	90	8	8	805	963	866	1167	666	674	23	22	21.4	17.2	191	176	59	59.3	520	420	2	1	2397	1	2400	249	944	391	632	4	19	7	15	2035.2	79	75.8
12	5	18	12	90	90	8	8	402	886	504	1559	348	358	23	20	23	17.9	184	160	67	59.1	485	324	1.7	1	2400	1	2400	60	1127	181	890	1	22	3	17	2063.7	89.5	75.7
12	5	19	12	90	90	8	8	742	1001	707	1300	636	645	20	24	15.2	19.4	160	192	48	60.3	448	521	48.1	1	2400	1	2400	0	813	362	658	0	20	8	16	2054.8	62.2	78.4
12	5	20	12	90	90	8	8	543	1062	511	1544	493	513	20	22	16.6	16.2	160	176	52	61.3	457	526	15.7	1	2400	2	2400	0	699	591	525	0	20	12	10	2070.4	68.1	76.9
12	5	21	12	90	90	8	8	850	837	974	1079	641	644	20	22	18.6	17.5	160	176	50	55.3	430	398	8	1	2400	1	2400	96	891	289	740	2	18	5	17	2061.2	67.8	71.6
13	5	17	12	90	90	8	8	756	298	1525	521	287	253	22	21	18	18.3	176	168	80	74.6	443	354	3.1	1	2399	1	2400	1205	407	0	785	18	4	0	21	2049.2	97.1	91.9
13	5	18	12	90	90	8	8	532	183	1551	499.9	185	161	21	20	16.9	19.3	168	160	82	79	371	219	7.8	1	2400	1	2400	1195	840	0	1122	13	8	0	20	2059.1	97.5	98.7
13	5	19	12	90	90	8	8	846	275	1610	453.3	278	242	21	20	15.2	23	168	160	73	70.5	413	363	4.1	1	2399	1	2400	1324	64	33	601	20	1	1	19	2067.2	86.9	92.2
13	5	20	12	90	90	8	8	911	293	1596	456.9	295	257	21	21	14.5	30.1	168	168	67	70.8	418	386	9.7	1	2398	1	2400	1241	66	46	666	20	1	1	20	2062.1	80.4	99.8
13	5	21	12	90	90	8	8	704	192	1546	497.8	191	157	21	20	18.8	19.3	168	160	93	76.9	417	309	6.6	1	2397	1	2400	1563	260	0	1071	18	3	0	20	2050.1	110.9	94.9
14	5	17	12	90	90	8	8	824	270	1211	836.1	239	217	21	21	24.9	27.8	168	168	79	68.5	474	458	2.3	1	2397	2	2400	524	475	0	846	11	10	0	21	2049.4	103	95.3
14	5	18	12	90	90	8	8	795	223	1327	719.6	197	174	21	22	28.6	25	168	176	75	71.2	495	479	3.9	1	2390	1	2400	758	578	0	909	10	10	0	22	2050.1	103	95.2
14	5	19	12	90	90	8	8	807	270	1225	822.5	239	226	21	20	27.6	22	168	160	78	73.5	490	440	1.5	1	2400	1	2400	542	689	54	775	9	12	1	19	2049.4	105.3	94.4
14	5	20	12	90	90	8	8	751	219	1278	752.7	194	175	22	20	26.2	23.4	176	160	96	71.5	508	454	4.6	1	2389	1	2400	544	502	0	961	11	10	0	20	2035.7	121.5	94
14	5	21	12	90	90	8	8	652	185	1367	683.7	162	141	22	19	36.5	23.1	176	152	84	62.1	423	374	4.1	1	2397	1	2400	1050	587	0	843	14	8	0	19	2054.4	118.7	83.9
15	5	17	12	90	90	8	8	1241	415	1603	436.1	342	331	22	20	18.4	18.1	176	160	80	78.3	493	462	1.9	1	2399	1	2400	740	456	153	486	13	9	5	15	2041.1	97.8	95.4
15	5	18	12	90	90	8	8	1127	396	1606	434	324	311	19	20	16.3	19.5	152	160	76	94.1	401	461	1.3	1	2398	1	2400	567	556	163	631	10	9	4	16	2041.2	91.1	113
15	5	19	12	90	90	8	8	1316	350	1699	354.4	306	289	20	20	15	26.3	160	160	73	76.1	434	448	2.4	1	2400	1	2400	840	432	105	522	13	7	4	16	2056.1	86.9	101
15	5	20	12	90	90	8	8	1392	401	1679	368.7	338	310	21	20	15.7	19.2	168	160	75	81.2	473	450	2.2	1	2400	1	2400	823	267	38	545	16	5	1	19	2050	89.4	99.3
15	5	21	12	90	90	8	8	1387	366	1653	376.1	298	276	20	23	12	26.8	160	184	71	92.3	433	523	8.2	1	2399	1	2400	666	445	151	599	13	7	5	18	2037.7	82.4	118
16	5	17	12	90	90	8	8	746	543	1365	599.4	513	499	19	22	12.8	109	152	176	59	76.2	510	527	1.4	1	2397	1	2400	196	723	0	703	4	15	0	22	1965.4	70.6	184
16	5	18	12	90	90	8	8	848	402	1491	442.3	364	364	20	18	12.4	111	160	144	76	107	515	435	5.9	1	2399	2	2400	126	971	0	567	2	18	0	18	1939.5	87.4	217
16	5	19	12	90	90	8	8	786	503	1400	547.3	462	458	22	22	14.2	87.2	176	176	69	95	581	520	2.5	1	2399	1	2400	176	944	41	643	3	19	1	21	1950.2	81.9	181
16	5	20	12	90	90	8	8	774	368	1492	405.4	349	342	20	20	13.6	145	160	160	63	122	555	510	2.3	1	2400	2	2400	221	875	37	662	4	16	1	19	1899.4	75.1	266
16	5	21	12	90	90	8	8	592	483	1274	695.5	416	416	20	21	12.9	101	160	168	60	84.2	520	493	2.1	1	2399	1	2400	200	1106	436	721	3	17	4	17	1972	71.7	184
11	6	26	3	90	90	32	32	41	2	1398	21	4	0	2	2	1.5	767	64	64	83	94.7	39	37	23.4	1	2372	1	2400	367	0	0	208	2	0	0	2	1442.1	84.1	861
11	6	27	3	90	90	32	32	86	5	1592	57.6	10	0	7	5	127	100	224	160	313	158	144	107	15	1	2395	1	2400	4684	0	0	572	7	0	0	5	1664.4	440.3	258
11	6	28	3	90	90	32	32	128	11	1779	89.4	14	2	6	7	24.6	59.8	192	224	208	196	132	163	3.4	1	2110	1	2400	1275	0	95	657	6	0	1	6	1872.2	232	255
11	6	29	3	90	90	32	32	48	1	2240	9.3	2	0	2	1	3.5	17.6	64	32	83	20.4	48	25	17.6	1	1799	1	2400	295	0	0	92	2	0	0	1	2266.9	85.9	38
11	6	30	3	90	90	32	32	16	1	2294	19.7	2	0	0	1	0	16	0	32	0	54.1	0	21	12.7	1	2298	2	2400	0	0	0	197	0	0	0	1	2326.8	0	70.1
12	6	27	3	90	90	32	32	333	68	1078	179.3	78	54	10	12	218	333	320	384	193	315	195	252	9.9	1	2397	1	2400	826	0	0	728	10	0	0	12	1267.4	410.8	647

12	6	28	3	90	90	32	32	365	100	1129	246.6	104	82	12	11	249	159	384	352	247	283	233	235	7.6	1	2398	1	2400	1123	0	0	705	12	0	0	11	1382.8	495.3	441
12	6	29	3	90	90	32	32	215	26	1338	150.4	36	16	9	10	187	158	288	320	202	280	157	217	25.3	1	2230	2	2400	1193	0	0	1012	9	0	0	10	1513.2	388.5	437
12	6	30	3	90	90	32	32	286	33	1204	118.1	43	23	11	10	247	203	352	320	260	292	204	230	10.2	1	2400	1	2400	1051	0	0	654	11	0	0	10	1332.1	506	494
12	6	31	3	90	90	32	32	303	45	1163	179.8	56	32	12	12	183	243	384	384	229	313	243	251	12.4	1	2397	1	2400	1132	0	0	925	12	0	0	12	1355.2	411.5	555
13	6	27	3	90	90	32	32	202	6	2241	30.5	8	4	2	2	11.3	7.8	64	64	42	47.4	32	21	7.6	1	2154	1	2400	232	0	0	216	2	0	0	2	2279.1	53	55.2
13	6	28	3	90	90	32	32	499	28	1735	110	24	8	9	11	11.6	92.3	288	352	137	245	172	124	6.9	1	2345	1	2400	938	0	167	585	8	0	3	8	1851.4	148.4	337
13	6	29	3	90	90	32	32	330	6	1890	57.1	12	0	8	6	17.2	25	256	192	154	188	145	47	21	1	2395	1	2400	1301	0	0	569	8	0	0	6	1968.1	171.2	217
13	6	30	3	90	90	32	32	593	34	1803	127.9	32	19	7	9	12.6	73	224	294	112	210	139	156	10.6	1	2378	2	2400	803	0	211	423	7	0	3	6	1941.4	124.2	283
13	6	31	3	90	90	32	32	398	13	1843	90.5	18	4	5	9	10.1	82.3	160	288	89	212	99	114	30.2	1	2399	1	2400	424	0	99	633	5	0	2	7	1963.9	98.3	294
14	6	27	3	90	90	32	32	396	16	1384	134.4	21	6	7	8	28	104	224	256	223	471	155	135	8.7	1	2261	2	2400	700	0	0	949	7	0	0	7	1527.5	250.3	575
14	6	28	3	90	90	32	32	611	24	1382	158.2	31	11	11	10	26.8	71.4	352	320	345	345	232	235	6.9	1	2356	1	2400	773	0	0	1063	10	0	0	10	1547.4	371.6	416
14	6	29	3	90	90	32	32	554	9	1451	91.5	16	1	8	7	33.6	117	256	251	267	389	167	150	5.5	1	2316	2	2400	689	0	0	860	8	0	0	7	1548.1	299.8	505
14	6	30	3	90	90	32	32	493	16	1494	137	25	7	6	9	19.6	107	192	288	200	387	128	210	8.7	1	2391	1	2400	614	0	0	1058	6	0	0	9	1639.7	218.9	494
14	6	31	3	90	90	32	32	472	16	1402	127.5	21	7	9	8	29.7	121	288	256	286	375	190	177	5.7	1	2399	1	2400	730	0	39	800	9	0	1	7	1535.5	315.1	496
15	6	27	3	90	90	32	32	1206	134	1431	208.7	134	107	15	16	10.8	63	480	512	247	331	315	385	2	1	2372	2	2400	917	0	74	583	15	0	2	13	1641.5	256.6	393
15	6	28	3	90	90	32	32	1229	160	1402	210.4	166	136	16	15	10.5	67.2	512	480	271	318	334	356	10.4	1	2400	1	2400	855	0	0	657	16	0	0	15	1623.1	280.3	385
15	6	29	3	90	90	32	32	1125	36	1539	86.8	45	23	13	12	11.1	77.6	416	384	275	303	260	291	28	1	2398	1	2400	845	0	41	553	13	0	1	11	1653.8	285.7	380
15	6	30	3	90	90	32	32	1435	25	1668	64.4	31	14	10	10	7.5	99.3	320	323	194	276	228	241	28.5	1	2389	2	2400	591	0	93	380	10	0	2	8	1760.8	201	374
15	6	31	3	90	90	32	32	1031	24	1397	69.4	31	13	12	11	12.9	151	384	352	396	298	300	284	3.7	1	2355	1	2400	786	0	86	427	11	0	2	9	1470.4	409	448
16	6	27	3	90	90	32	32	486	42	1257	69.2	36	27	8	4	81.8	460	256	128	342	147	210	89	3.4	1	2006	2	2400	890	0	0	180	8	0	0	4	1329.4	423.3	607
16	6	28	3	90	90	32	32	508	56	1188	104	49	37	7	6	119	299	224	192	383	260	182	135	3.1	1	2384	2	2400	523	0	0	293	7	0	0	6	1295.5	501.6	559
16	6	29	3	90	90	32	32	535	37	1038	93.6	41	25	9	8	81.7	216	288	256	515	390	218	168	11.7	1	2332	2	2400	808	0	0	429	9	0	0	8	1143.4	595.7	606
16	6	30	3	90	90	32	32	447	16	854	43.8	22	8	4	7	52.1	921	128	224	201	285	94	156	8.5	1	1753	2	2400	444	0	0	337	4	0	0	7	906.7	252.6	1206
16	6	31	3	90	90	32	32	153	32	456	95.4	32	23	5	4	60.8	1228	160	128	301	225	127	93	2.9	1	1320	2	2400	705	0	0	282	5	0	0	4	554.5	361.8	1453