

QUANTITATIVE ANALYSES OF PIGEON SPATIAL MOVEMENTS
DURING BASIC REINFORCEMENT CONTINGENCIES

by

Francisco J. Silva

*A dissertation submitted to the Faculty of Graduate Studies as partial fulfillment of the
requirements for the degree of Doctor of Philosophy*

Department of Psychology
University of Manitoba
Winnipeg, Manitoba

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Francisco J. Silva

Abstract

This study quantified the movement patterns of pigeons during fixed-time (FT) and fixed-interval (FI) schedules of reinforcement and autoshaping. The three techniques used to quantify the movement patterns were: (a) a correlated random walk analysis, (b) an Information analysis, and (c) a Fourier analysis. The corresponding statistics were (a) sinuosity, which measures the amount of random turning in movement patterns, (b) dependency, which measures the degree to which knowledge of one variable conveys information about a second variable, and (c) frequency spectra of the movement patterns, which measures the degree to which the variability in a time series can be explained by a sinusoid of a certain frequency. The results showed that the correlated random walk, information, and Fourier analyses represented changes in the movement patterns generated by pigeons during FT and FI schedules of reinforcement that were consistent with previous analyses and interpretations. Furthermore, quantifying movement patterns showed that imposing a contingency on responding (i.e., shifting from an FT schedule to an FI schedule) resulted in an increase in the stereotypy of the movement pattern. In autoshaping, movement patterns during the conditioned stimulus initially become less stereotyped, but become increasingly more stereotyped as conditioning progressed. Movements during the intertrial interval become increasingly more stereotyped as conditioning progressed. It was concluded that any of the three techniques are suitable for quantifying the movement patterns of pigeons during basic reinforcement contingencies, although they are not necessarily interchangeable. Moreover, a quantitative analysis of movement patterns can be a powerful approach in the field of animal learning by providing information about the stereotypy of movements during basic reinforcement contingencies. Finally, further quantitative studies of animal movement may lead to higher level theories of behavior that refer to complex causal systems among the response-defining action, contingencies of reinforcement, and movement patterns.

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It is hard to imagine that writing the *Acknowledgements* represents the end of the dissertation and graduate school. It seemed that this day would never arrive. To Gloria Eldridge and Randy Atkinson... I now see why you both had such a hard time driving the spike into your dissertation's heart – these things have a life of their own. To Mike Halldorson, Laine Torgrud, and Dave Ness... you have nothing to look forward to as far as a dissertation is concerned. May you have the patience of a saint and the tenacity of a top-ranked tennis player. To my outstanding committee, Dr. Joseph Pear, Dr. Robert Tait, Dr. Stephen Holborn, Dr. Witold Kinsner, and Dr. William Timberlake, thanks for your immeasurable contributions, stimulating exchanges, and valuable influences. If I had to do it all over, I would enthusiastically work with each of you again (and add Dr. James Forest to the committee). Thanks also to William Vetterling (Polaroid Corporation) and Simon Benhamou (Laboratoire de Neurosciences Fonctionnelles) for promptly answering many e-mail questions regarding data analysis, and Bill Timberlake for allowing me the time to work on the dissertation when I really should have been doing something else.

I thought of writing "an extra special thank you" to Joe Pear, but that would seem to be insufficient given all the work he has done and all the support he has given me for the last six years. I mean, I even met my wife in his lab. How much more can he contribute? I suppose the only way I could adequately thank Joe is to win *Lotto 649* (or *Hoosier Millionaire*) and keep him in grant money for the rest of his life.

Finally, thanks Kathleen and Fozzy Bear for everything.

THE END
Saturday, 25 April 1992

Quantitative Analyses of Pigeon Spatial Movements During Basic Reinforcement Contingencies

Following the leads of Pavlov (1927) and Skinner (1938), the psychological study of animal learning has typically measured behavior as discrete responses. For example, Pavlov (1927) measured the number of drops that a dog salivated through an artificial fistulae, and Skinner (1938) measured the number of times that a rat pressed a lever.

Although it is a simple and obvious fact that animals serving as subjects in learning experiments do more than just press levers or peck keys, psychologists have neglected to record and/or analyze these other behaviors (Weiss, Ziriaux, & Newland, 1989). Specific response topographies or extraneous movements are viewed as uninteresting because the *response-defining action* (i.e., the response that results in reinforcement) is the closure of a microswitch resulting from a leverpress or a keypeck. Movements, for example, within the experimental chamber may be considered part of the *total reinforced behavior* (e.g., approaching and activating the lever or key) or sometimes part of *other behavior* (e.g., resting, grooming, preening). The total reinforced behavior and other behavior are dealt with, if at all, by inference from the rate of occurrence of the response-defining action. Since the behavior that is reinforced (i.e., the total reinforced behavior) can include a considerable amount more than the response-defining action, it seems that a complete account of behavior requires that investigators record and analyze behavior as a continuous spatiotemporal process (see Pear, 1985; Pear, Silva, & Kincaid, 1989; Robles, 1990; Schoenfeld, 1972; Weiss et al., 1989).

Overlooking behavior as a continuous spatiotemporal process may have had, and may be having, an impact on current conceptualizations of behavior (Marr, 1989; Weiss et al., 1989). For example, the field of animal learning has probably been misled by the ease that animals learn molar contingencies such as responding on basic schedules of reinforcement (Weiss et al., 1989). Increasingly elaborate models of schedule performance simply distance the theorist from the actual contingencies that maintain the behavior during these

schedules. The field of animal learning cannot afford to ignore how easily basic reinforcement contingencies yield complex spatiotemporal relationships, some of which determine many of the effects on the rate of the response-defining action. At present, published data investigating spatiotemporal aspects of behavior are too sparse even to support speculation about the mechanisms responsible for observed spatiotemporal patterns. The problem is that the study of behavior as a continuous process has been largely ignored, even now, when the technology for studying the continuity of behavior is so richly available (Weiss et al., 1989).

In a step toward analyzing the continuity of behavior, Pear, Rector, and Legris (1982) developed a video-tracking system that provides real-time tracking of the position of a single target animal as it moves about in three-dimensional (3-D) space. The behavioral tracking system has previously been used to study movement patterns of pigeons exposed to various reinforcement contingencies in an experimental chamber (e.g., Eldridge & Pear, 1987; Eldridge, Pear, Torgrud, & Evers, 1988; Pear & Legris, 1987; Silva, Silva, & Pear, 1992). Until recently, all papers published by Pear and his colleagues have relied on a qualitative examination of the movement patterns. The purpose of the present dissertation is to quantify movement patterns generated by pigeons during some basic reinforcement contingencies.

Quantitative Analysis of Movement Patterns

A legitimate question to ask is why quantify movement patterns? The answer is that quantification serves several useful purposes. One such purpose is that quantification can identify regularities that are not noticed by our perceptual process (termed *unconscious statistical assessment* by Marler and Hamilton, 1966, p. 715; Huntingford, 1984). For example, Davies (1978) identified only two postures while observing flamingos, but a computer-aided quantitative analysis identified four postures. Similarly, Machlis (1977) noticed an "attending" phase in her chicks' data only after a computer analysis had drawn it to her attention. Consider the difficulty of ascertaining the effects of reinforcement if

operant responses were not quantified. Whether quantified by a human or electromechanically, responses had to be counted before the relationship between them and certain events (called *reinforcers*) could be studied. Similarly, if the field of animal learning is to engage in a comprehensive study of behavior as a continuous process, then it is likely that movement patterns must be quantified before functional relationships between these movements, the response-defining action, and other environmental events can be ascertained.

There are also philosophical reasons for quantifying movement patterns. For example, quantitative prediction is generally more satisfying than qualitative, because quantitative prediction is widely considered the mark of a mature science (Baum, 1989). The field of animal learning is maturing, and the principal manifestation of that maturation is found not only in the sophistication of its methods, but in the sophistication of its theory, the ultimate of which is making quantitative predictions (Baum, 1989; Marr, 1989). Moreover, quantitative analysis of any phenomenon facilitates interdisciplinary research. For example, an appropriately quantified movement pattern may be examined as a geometric figure, a chaotic system, a fractal, or a periodic system. Finally, quantification allows for more precise prediction.

In contrast to the field of animal learning, the field of animal behavior considers the comparative spatiotemporal analysis of behavior as one of its defining characteristics (Lorenz, 1950). Many species perform often complex sequences of movements (Philips, Ryon, Danilchuk, & Fetress, 1991), the details of which offer rich material for quantitative evaluation at both the behavioral and neural levels (Barlow, 1977; Lashley, 1951). Quantitative analyses of animal movements have revealed differences in movements due to differences in habitat condition, physiological state, and social status (Inoue, 1978). In future, quantitative analyses of movements may allow for meaningful comparisons between different classes of behavior, different species, and different environmental situations (Seeley & Brozoski, 1989). Furthermore, quantitative analyses of movements may provide a better link between laboratory experiments and naturalistic experiments than have

traditional measures based on discrete responses such as response rate (which has little application outside the laboratory [Drummond, 1981; Gallistel, 1990]).

The field of animal behavior has developed and used several different techniques for quantifying movement patterns such as regression techniques (Inoue, 1978), two- and three-dimensional (2- and 3-D) home range models (Koepl, Slade, Harris, & Hoffmann, 1977), Brownian dynamics (Pyke, 1978), spatiotemporal diffusion models (Okubo, 1980), and population utilization distributions (Ford & Krumme, 1979). In addition, simpler methods such as average speed of execution and distance travelled can be used to quantify movement patterns. Given that there are a variety of methods for quantifying movements, one must select techniques that are suitable and tractable. Aspects such as data resolution, computer processing and storage capacities, statistical validity, and compatibility with various applications must also be considered. Frequently, the choice of a particular method involves compromises between several of these considerations (Fox & Hayes, 1985). The present study quantified movement patterns using a correlated random walk analysis (e.g., Bovet & Benhamou, 1988), an information analysis (e.g., Seeley & Brozski, 1989), and a Fourier analysis. These three techniques were chosen because (a) they were relatively simple, (b) they could accommodate the data collected by the behavioral tracking system, (c) variants of these methods have proven successful in quantifying and analyzing movement, and (d) the algorithms necessary for writing the analysis programs were available.

Correlated Random Walk Model

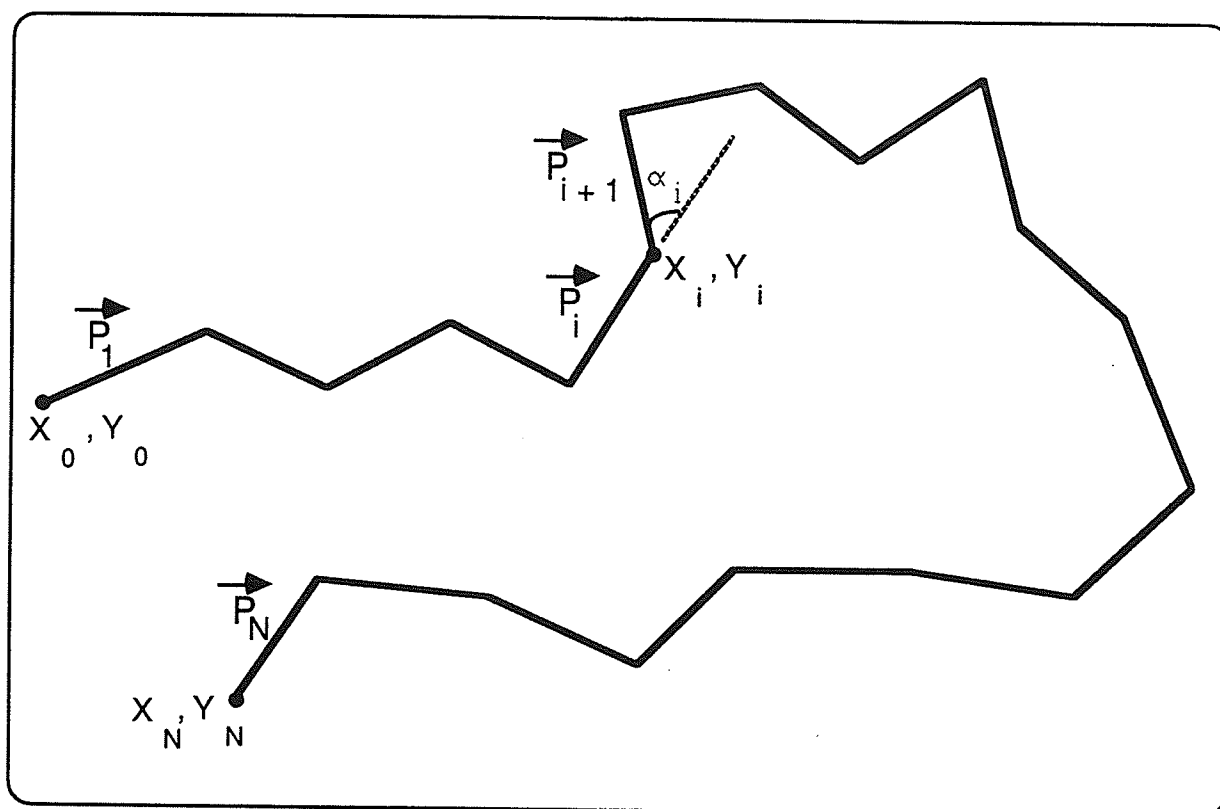
Animals' movements do not fit the simple deterministic kinematic equations used in classical physics (Bovet & Benhamou, 1988). In fact, their movement patterns have a random component that has been noted for many years (Wilkinson, 1952; e.g., Holgate, 1971; Jamon, 1987). It is this random component that makes quantifying movement patterns with continuous mathematical functions difficult; however, probabilistic discrete step models provide a useful means of representing animal movements. Several authors

have used a 2-D random walk model to represent animal movements (Holgate, 1971; Pyke, 1978). However, Bovet and Benhamou (1988) argue that the basic 2-D random walk model is too simple to represent animal movement patterns accurately because the cephalo-caudal polarization and the bilateral symmetry observed in most animals creates a tendency to move forward that is not accounted for in basic random walk models. A sufficient solution is to add an additional correlation between the directions of the successive steps to express an animal's tendency to move forward (Benhamou, 1989, 1990; Benhamou & Bovet, 1989; Benhamou, Sauve, & Bovet, 1990; Bovet & Benhamou, 1988; Jamon, 1987).

The simplest means of introducing this type of first order correlation consists of taking the distribution of changes of direction from one step to another, assuming the changes in direction to be independent of each other. This is a discrete version of a first order continuous Markovian process called the Ornstein-Uhlenbeck process. A first order Markovian process is a sequence in which the probability of observing a given event at a particular point is dependent on the immediately preceding event (Huntingford, 1984).

As shown in Figure 1, a movement pattern can be represented by a sequence of $N+1$ points $(X_0, Y_0), (X_1, Y_1), \dots, (X_N, Y_N)$ such that, for any i (integer, $1 \leq i \leq N$), $P_i = (X_i - X_{i-1}, Y_i - Y_{i-1})$, representing the i th step, is a vector (a line with a certain length and a direction) with the length P_i , and the value of the change of direction between the vectors P_i and P_{i+1} is measured algebraically by the turning angle α_i ($1 \leq i \leq N-1$). Like any angular distribution, the distribution of changes of direction is characterized by a mean vector (Batschelet, 1981). Its orientation, $\Phi = \arctan(\sum \sin \alpha_i / \sum \cos \alpha_i)$, defines the angular mean of the distribution, and its length $r = (\sum^2 \cos \alpha_i / \sum^2 \sin \alpha_i)^{1/2} / (N-1)$, ranging between 0 and 1, expresses the concentration of the distribution around Φ . To take into account the tendency of most animals to move forward, the distribution of changes of direction is taken to be symmetrical and to have an angular mean $\Phi = 0$. The mean vector length r is then equal to the mean

Figure 1. An example of an N -step movement pattern. The turning angles are measured between vectors $\mathbf{P}_i$ and $\mathbf{P}_{i+1}$. A similar schematic can be found in Jamon (1987).



cosine of changes of direction and constitutes a measure of the correlation between the directions of successive steps. When this correlation is null ($r = 0$), one again obtains the original random walk model; when the correlation is perfect ($r = 1$), one obtains a straight line movement.

The simplest means of representing a movement pattern that takes into account the distribution of changes of direction is to take a walk on a square lattice (e.g., Pyke, 1978). In this model, an animal's choice at each step is restricted to one of four possibilities: (a) to move ahead (A), (b) turn right (R), (c) turn left (L), or move back (B), with probabilities $P_A < P_R = P_L < P_B$. With these conventions, the correlation between the directions of successive steps is $r = P_A - P_B$ (Bovet & Benhamou, 1988). A suitable distribution of the changes of direction consists of a linear normal distribution ranging from $-\pi$ to $+\pi$ (Batschelet, 1981). Doucet and Drost (1985) and Bovet and Benhamou (1988) proceed by drawing turning angles α_i between successive steps at random, independently from each other, from a normal distribution centered on 0 with a standard deviation of σ . The mean vector length r of the distribution of turning angles can then be expressed as a function of σ (Batschelet, 1981):

$$r = \exp(-\sigma^2/2). \quad (1)$$

Because step length is mostly arbitrary and has a purely formal function, there is no need to adopt a variable step length on biological grounds. Therefore, it is acceptable to consider only movement patterns of N steps with constant length P (Bovet & Benhamou, 1988).

Spatial Index of Animal Movement

One way to use the correlated random walk model to quantify an animal's movement pattern is with a single, purely spatial index termed *sinuosity*. Sinuosity expresses the

amount of random turning associated with a given pattern of movement (Benhamou & Bovet, 1989). The sinuosity of a path is determined both by the distribution of changes in direction (Φ) and by the step length (r). However, when dealing with actual patterns the data recording generally involves a discretization with an arbitrary step length that influences the distribution of changes of direction obtained; therefore, it is recommended that the function linking the step length (which is at least partly dependent on the data recording) and the observed changes in direction be quantified (Bovet & Benhamou, 1988).

Rediscretization

Consider a movement pattern that obeys the above model (i.e., the step length is P , and the distribution of changes of direction is normal, centered on 0 with a standard deviation σ). This movement path can be rediscretized with a step length R different from P . In spatial rediscretization, we look for the first point lying distance R from the starting point; we then look for the next point lying distance R from the first, and so on. By analyzing the step length of the distribution of changes of direction, it is possible to define an index of sinuosity that is independent of the rediscretized step length R . The major effect of rediscretization is a smoothing of the movement path.

Sinuosity is formally defined by Bovet and Benhamou (1988) as

$$S = \sigma / \sqrt{P} \text{ rad/u}^{1/2}, \quad (2)$$

where u is the unit of step length (e.g., mm, cm, inches, etc). After rediscretization, sinuosity can be written

$$S = 1.18 \sigma_R / \sqrt{R} \text{ rad/u}^{1/2} \quad (3)$$

where

$$\sigma_{\mathbf{R}} = 0.85 \sigma (\mathbf{R}/\mathbf{P})^{1/2} \quad (4)$$

(see Bovet & Benhamou [1988] for a description of how the constants 1.18 for equation [3] and 0.85 for equation [4] were obtained by computer simulation). $\mathbf{S}$ constitutes a reliable index since it can be used to characterize any family of movement patterns, regardless of the rediscrctization step length used. Note that equation (2) is a theoretical expression of sinuosity (i.e., σ and $\mathbf{P}$ belong to the model). Equation (3) can be used to quantify the sinuosity of an actual animal's movement pattern by taking the observed changes of direction, after rediscrctizing the path with a step length $\mathbf{R}$. The algorithm for this procedure is described by Bovet and Benhamou (1988).

Application to Data

As it applies to continuous movements, any discretization is arbitrary because it is not based on any actual behavioral feature. (Of course, some discretization of the movements is inevitably introduced by the recording process.) Discretization leads to unequal step lengths that do not correspond to any biological parameter specific to the experimental subject, but result from a combination between the animal's velocity and the sampling frequency of the recording apparatus.

Because the initial recording discretization is arbitrary, a rediscrctization with a constant step length ($\mathbf{R}$) makes it possible to give movement patterns a suitable form that is independent of the recording apparatus. It is then possible to determine the characteristics of the distribution of the changes of direction. It must be ensured that this distribution does not differ significantly from a normal one centered on 0 and the condition that the standard deviation of the distribution is greater than or equal to 0.1 and less than or equal to 1.2 radians (i.e., $0.1 \leq \sigma_{\mathbf{R}} \leq 1.2$ radians). If $\sigma_{\mathbf{R}}$ is greater than 1.2 radians, then $\sigma_{\mathbf{R}}$ does not increase proportionally to the square root of $\mathbf{R}$, and the distribution of changes of direction tends to become uniform. The sinuosity of the path can be estimated by equation (2).

In recording animal movements, it is important to use the highest sampling frequency of which the recording system is capable (Bovet & Benhamou, 1988). The lower the sampling frequency, the greater the need for a large rediscrctization step length, thereby leading the distribution of changes of direction toward uniformity and away from normality. Furthermore, the angular values will be larger and the standard deviation of sinuosity will be smaller and more accurate when the rediscrctization step length is small.

Practical Example

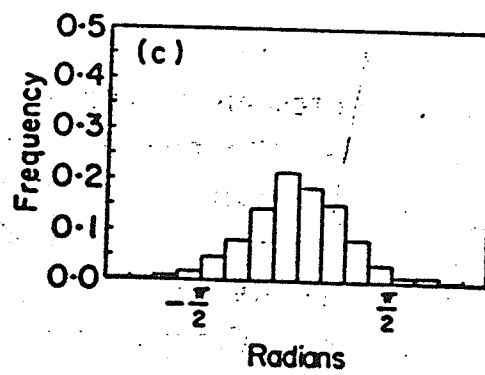
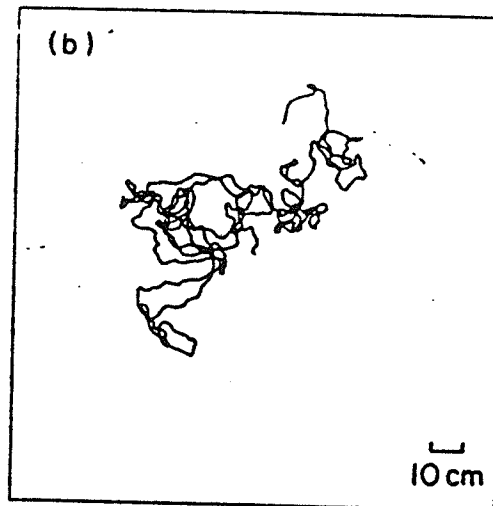
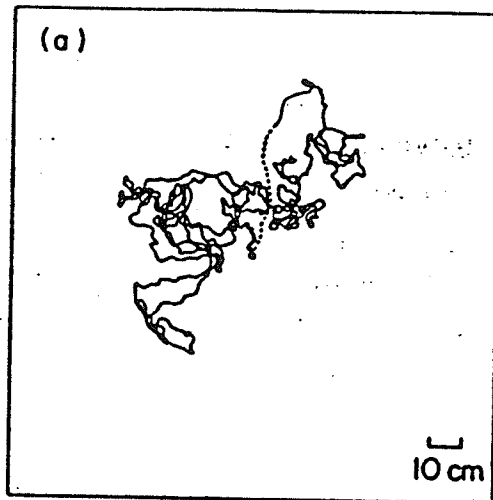
To illustrate the above considerations, an example from Bovet and Benhamou (1988) is given in Figure 2, which shows the foraging pattern of an ant. The pattern in panel *a* is the raw data ($t = 45$ min), and the data in panel *b* is the same pattern rediscrctized with a step length $R = 1.5$ cm. Panel *c* shows the distribution of changes of direction corresponding to the rediscrctized path in Panel *b* ($N_R = 664$, $m = -0.04$ rad, $\sigma = 0.82$ rad, where N_R is the number of angular values after rediscrctization and m is the mean of the distribution). Kuiper's test (see Batschelet, 1981) shows that this distribution does not differ significantly from a normal distribution centered on 0 with a standard deviation equal to that found here (i.e., $\sigma_{1.5\text{cm}} = 0.82$ rad [$k = 1.43$, $P > 0.20$, where k is Kuiper's statistic]); therefore, we are justified in calculating the sinuosity of this path after rediscrctization with the step length $R = 1.5$ cm. We then obtain

$$S = 1.18 \times 0.82 / \sqrt{1.5\text{cm}} = 0.79 \text{ rad/cm}^{1/2}. \quad (5)$$

Summary of the Correlated Random Walk Model

The movement pattern of an animal can be suitably described by a first order correlated random walk model. The pattern consists of a sequence of N steps with constant step length P , separated by changes in direction α drawn randomly in a normal distribution with a null mean and a standard deviation (σ) ranging between 0.1 and 1.2

Figure 2. An example of a movement pattern analyzed by Bovet and Benhamou (1988). Panel *a* is the foraging pattern of a *Serrastruma lujae* ant observed for 45 minutes. Panel *b* is the same pattern rediscretized with a step length $R = 1.5$ cm. Panel *c* is the distribution of changes of direction corresponding to the aforementioned rediscretization ($N_R = 664$, $m = -0.04$ rad, $\sigma = 0.82$ rad; from Bovet & Benhamou, 1988, p. 427).



radians. The orientation of the first step is randomly drawn in a uniform distribution. The sinuosity of the pattern is then defined by $S = \sigma/\sqrt{P}$ ranging between 0.1 and 1.2 rad/ $u^{1/2}$, where u is the units used to measure length (e.g., mm, cm, m, etc.).

The main advantage of the correlated random walk model is that it can be used to describe any movement pattern by a single numerical index. This is a valuable feature because, with this index, it is possible to compare various patterns in quantitative terms (i.e., from the point of view of their sinuosity). It could, for example, be used to compare the sinuosity of movement patterns of different species moving in the same environment or the same species moving in different environments. These sinuosity values could then be examined in terms of their relation to various independent variable manipulations. For example, animal behaviorists have noted the importance of search patterns within the framework of Optimal Foraging Theory. An animal foraging in a patchy environment should exhibit increased sinuosity in a patch, but decreased sinuosity (ideally a beeline) when moving between patches (Bovet & Benhamou, 1988).

Information Theory

Information analyses have been applied to psychological phenomena (e.g., Attneave, 1959), posture analysis of animals (e.g., Recuerda, Arias de Reyna, Redondo, & Trujillo, 1987), movement patterns of animals (e.g., Seeley & Brozoski, 1989), and various other behavioral, biological, and ecological phenomena (e.g., Altmann, 1965; Hailman, 1982; Weber, Depew, & Smith, 1988). A brief description of Information Theory, summarized from Press, Flannery, Teukolsky, and Vetterling (1989), is presented here; however, Steinberg (1977) provides a more detailed discussion on the application of Information Theory to a quantitative analysis of animal behavior, and Attneave (1959) provides a monograph on the application of Information Theory to psychology.

Basic Information Theory

Consider the game of "twenty questions", in which you try to eliminate all except one correct possibility for an unknown object by repeatedly asking yes/no questions. Consider further a generalization of the game where you are allowed to ask multiple choice questions and binary (yes/no) ones. The categories in your multiple choice questions must be mutually exclusive and exhaustive.

The value of an answer increases with the number of possibilities that it eliminates. More specifically, any information that eliminates all except a fraction p of the remaining possibilities can be assigned a value of $-\ln p$ (a positive number, since $p < 1$). The purpose of the logarithm is to make the value additive, since, for example, one question that eliminates all but $1/6$ of the possibilities is considered as good as two questions that, in sequence, reduce the number by factors $1/2$ and $1/3$.

The value of an answer has been indicated above, but what is the value of a question? If there are I possible answers to the question ($i = 1, \dots, I$) and the fraction of possibilities consistent with the i th answer is p_i (with the sum of the p_i 's equal to one), then the value of the question is the expectation value of the value of the answer, denoted H ,

$$H = \sum_{i=1}^I p_i \ln(p_i). \quad (6)$$

The value H lies between 0 and $\ln I$. It is zero only when one of the p_i 's is one and all the others zero. In this case, the question is valueless since its answer is preordained. H takes on a maximum value when all the p_i 's are equal, in which case the question is sure to eliminate all but a fraction $1/I$ of the remaining possibilities. Borrowing terminology from statistical physics, the value H is conventionally termed the *entropy* of the distribution given by the p_i 's.

Excluded thus far from this introduction to Information Theory is the association of two variables. However, suppose we are deciding what question to ask next in the game

and have to choose between two candidates, or possibly ask both in one order or another. Suppose that one question, x , has I possible answers, denoted by i , and that the other question, y , has J possible answers, denoted by j . Then the possible outcomes of asking both questions form a contingency table whose entries N_{ij} , when normalized by dividing the total number or remaining possibilities N , give all the information about the p 's

$$p_{ij} = N_{ij}/N \quad (7)$$

The entropies of the questions x and y are respectively

$$H(x) = -\sum_i p_{i\cdot} \ln p_{i\cdot} \quad H(y) = -\sum_j p_{\cdot j} \ln p_{\cdot j} \quad (8)$$

The entropy of the two questions together is

$$H(x,y) = -\sum_{i,j} p_{ij} \ln p_{ij} \quad (9)$$

We can now ask, what is the entropy of the question y **given** x (i.e., if x is asked first)? It is the expectation value over the answers to x of the entropy of the restricted y distribution that lies in a single column of the contingency table (corresponding to the x answer)

$$H(y|x) = -\sum_i p_{i\cdot} \sum_j p_{ij}/p_{i\cdot} \ln p_{ij}/p_{i\cdot} = -\sum_{i,j} p_{ij} \ln p_{ij}/p_{i\cdot} \quad (10)$$

Correspondingly, the entropy of x given y is

$$H(x|y) = -\sum_j p_{\cdot j} \sum_i p_{ij}/p_{\cdot j} \ln p_{ij}/p_{\cdot j} = -\sum_{i,j} p_{ij} \ln p_{ij}/p_{\cdot j} \quad (11)$$

It can be readily proven that the entropy of y given x is never greater than the entropy of y alone (i.e., asking x first can only reduce the usefulness of asking y , in which case the two variables are associated; see Press et al., 1989).

It is now possible to measure the dependency of y on x (i.e., a measure of association). This measure is sometimes called the *uncertainty coefficient* of y , denoted $U(y|x)$

$$U(y|x) \equiv [H(y) - H(y|x)]/H(y) \quad (12)$$

This measure lies between zero and one, with the value 0 indicating that x and y have no association and the value 1 indicating that knowledge of x completely predicts y . For values between zero and one, $U(y|x)$ gives the fraction of y 's entropy $H(y)$ that is lost if x is already known (i.e., it is redundant with the information in x). In the above example of "twenty questions", $U(y|x)$ is the fractional loss in the utility of question y if question x is asked first.

If we wish to view x as a dependent variable, and y as an independent variable, then interchanging x and y will allow the dependency of x on y to be defined

$$U(x|y) \equiv [H(x) - H(x|y)]/H(x) \quad (13)$$

If x and y are treated symmetrically, then the combination turns out to be

$$U(x,y) \equiv 2\{[H(y) + H(x) - H(x,y)]/H(x) + H(y)\} \quad (14)$$

If the two variables are completely independent, then

$$H(x,y) = H(x) + H(y) \quad (15)$$

If the two variables are completely dependent, then

$$H(x) = H(y) = H(x,y) \quad (16)$$

Furthermore, the identities

$$H(x,y) = H(x) + H(y|x) = H(y) + H(x|y) \quad (17)$$

can be used to show that

$$U(x,y) = [H(x) U(x|y) + H(y) U(y|x)] / H(x) + H(y) \quad (18)$$

In other words, the symmetrical measure is just a weighted average of the two asymmetrical measures weighted by the entropy of each variable separately.

Relating Information Theory to Movement Patterns

One way to apply an information analysis to movement patterns is to ask questions of the type: (a) Given that $t = 8$ s (where t is time) in a 15-s interreinforcement interval (IRI), can we predict the animal's location? (b) Given that the animal's location is 50 cm from the feeder, can we predict the value of t ? In other words, what are the bidirectional dependencies between distance and time (see equations [12] and [13] above)?

If a movement pattern is irregular, then it will be difficult to predict the animal's location by knowing the value of t and vice versa. However, if a movement pattern is regular and repeats itself within a time interval, then it is possible to predict the animal's location by knowing the value of t . In perfect spatiotemporal regularity, a specific instance in time (e.g., $t = 2$ s) will be associated with a specific location (e.g., **distance from reference point** = 18 cm). For example, by knowing that we are 2 s into the time

interval, we know that the organism is located 18 cm from the reference point. The converse is not necessarily true. Since the pattern repeats itself within a time interval, a location that is a part of the pattern will be occupied several times within the interval. For example, by knowing that an organism is located 18 cm from the reference point, we know that we could be 2 s, 10 s, or 18 s into the time interval.

Quantification of Stereotypy

Given the above discussion, it is possible to use Information Theory to quantify movement patterns in terms of their degree of regularity or stereotypy (e.g., Seeley & Brozoski, 1989; see also Recuerda et al., 1987). Although many studies are concerned with changes in stereotypy, few actually quantify these purported changes (Seeley & Brozoski, 1989; cf., Brandon & Paul, 1987; Eldridge et al., 1988; Matthews & Lerer, 1987; Philips et al., 1991; Staddon & Simmelhag, 1971; Timberlake & Lucas, 1985; although see Innis, Simmelhag-Grant, & Staddon, 1983).

All that is required to use an information analysis is that the dependencies between an animal's location within an environment and time in a repeating temporal interval be quantified. Stereotyped movement patterns will yield dependencies closer to one than less stereotyped patterns, which will yield dependencies closer to zero. Using an information analysis, Seeley and Brozoski (1989) reported that the degree of stereotypy, as induced by injecting rats with different doses of a stereotypy-inducing drug, was related to the dose of the drug. Their procedure was sensitive to the different degrees in stereotypy. Similarly, Recuerda et al. (1987) effectively used an information analysis to quantify the degree of stereotypy in the alarm postures in red deer.

Fourier Analysis

A phenomenon that occurs regularly in time can be considered periodic. Periodic processes are processes that repeat themselves at regular intervals. A large class of computational methods falls under the general rubric of *Fourier transform methods* or

spectral methods that are techniques for analyzing how often a process repeats itself in a time series (McFarland, 1971; Gallistel, 1980, 1990). Fourier analysis of time series has become an important means of obtaining insights into the data of many fields in the natural (e.g., physics), social (e.g., economics), and applied sciences (e.g., engineering). For example, Fourier analysis has been used to represent and study cycles in sunspot activity (e.g., Anderson, 1971) and walking in humans (e.g., Cotes & Mead, 1960).

Detailed discussions of the theory and the wide range of applications of frequency analysis techniques are provided in several texts covering time series in general and Fourier analysis procedures in particular (e.g., Bloomfield, 1976; Brockwell & Davies, 1987; Chatfield, 1980). The present description is intended to represent a practical synopsis of Fourier analysis and, therefore, for the sake of simplicity, most of the accompanying rationale and mathematical derivation has been omitted.

Fourier analysis allows examination of the periodic processes that vary with time. Specifically, Fourier analysis techniques are used to look for cyclical patterns in data, or *periodicities*. This technique is applicable to the analysis of time series data that are bounded, continuous, stationary (i.e., possess mean and variance that are independent of time), and ergodic (i.e., possess mean and autocorrelation values that are equivalent when calculated from different sample functions). Many physical processes and processes that represent the continuous output of an organism performing a steady-state task meet these requirements (Sturgis, 1983).

As stated above, periodic processes repeat themselves at regular intervals. The duration of the interval is called the *period*. Periodic processes are commonly produced through an interaction of two or more variables. The values of these variables at a given moment describe or specify the state of the process at that moment (termed its *phase*). Consider an object secured to the circumference of a phonograph turntable turning at a constant rate: The relevant variables in the physical description of this process are the momentary position of the object (above or below a resting or zero position) and its velocity (how fast its moving upward or downward). To specify the momentary state of

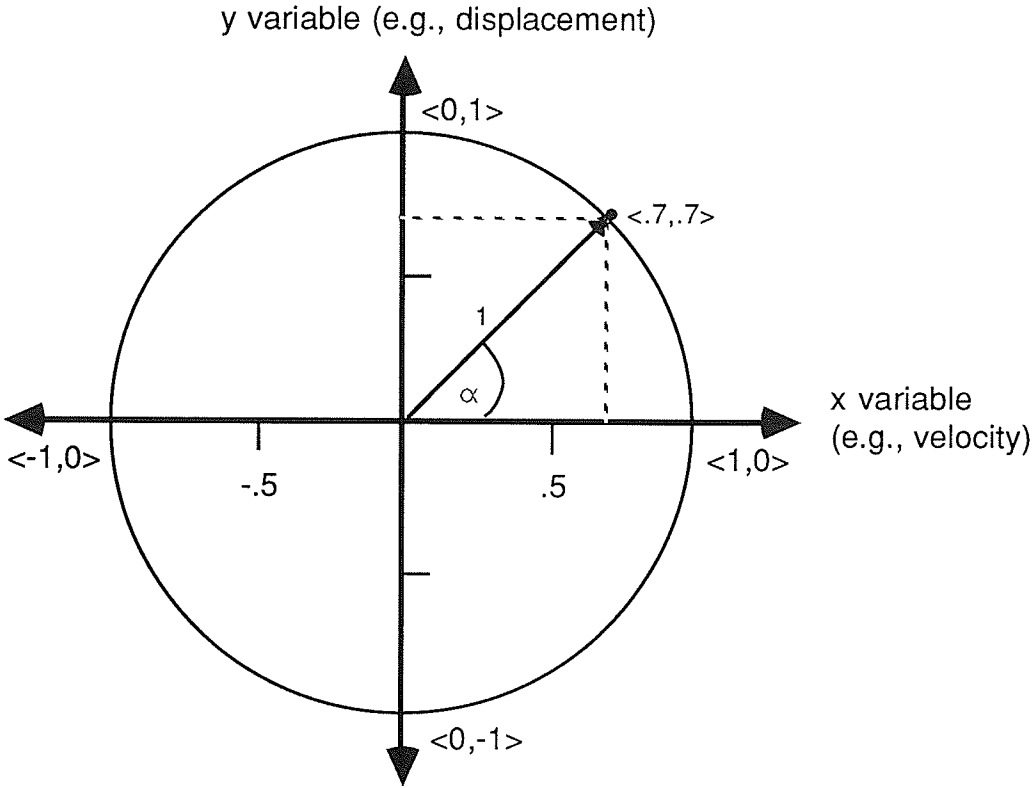
the object, it is necessary to specify both quantities. The description of the processes may be represented as illustrated in panel A in Figure 3 (adapted from Gallistel, 1990, p. 233). The y-axis of the representation gives the object's distance above (+) or below (-) its resting position (zero on the y-axis). The x-axis gives the upward or downward velocity of the object. When the point specifying the momentary state of the process is at the top of the circle at coordinates $\langle 0, 1 \rangle$, the object has reached its uppermost displacement (arbitrarily designated a displacement of one unit), and its upward velocity has completely dissipated; thus, at this moment its upward velocity is zero. When the object moves downward through its resting position, it attains its maximum downward velocity (arbitrarily scaled in the figure to -1); thus the object is at $\langle -1, 0 \rangle$ at this moment.

The portrayal of the periodic process in panel A of Figure 3 is called the *phase-plane representation* because each point in the plane is a potential description of a momentary state (i.e., phase) of the process. The two axes are called the *state variables* because it is their values that describe the state of the process. Because the plot of the value of one of these variables as a function of the value of the other generally yields a circle-like trajectory in the phase plane, it is also possible to represent the state of the process by polar coordinates. For example, if the state variables are scaled such that the radius of the circle produced by the moving object is equal to 1, then the state of the process is given by the angular coordinate of the polar representation (α in panel A). This value is called the *phase angle* of the process. Since the radius of the polar system is equal to 1, the x and the y coordinates of the phase-plane representation of the state of the process are equal to the cosine and the sine, respectively, of the phase angle.

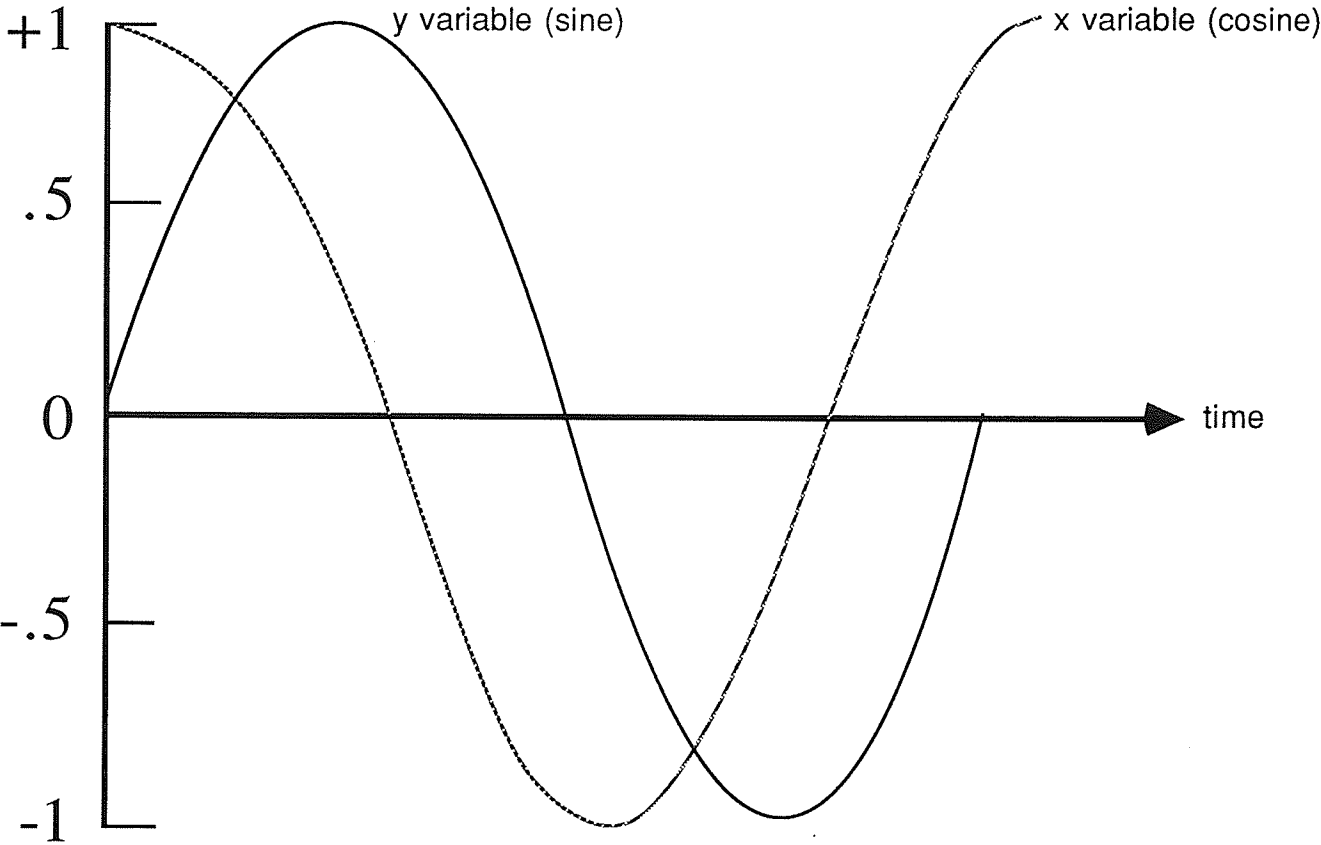
The phase-plane representation of a periodic process does not show how the values of these variables vary with time; it just shows how these values relate to one another at any point in the cycle. When the state variables are plotted as functions of time, the sine-cosine graph in panel B of Figure 3 is obtained. One variable rises to a peak as the other falls to near zero; then as the other continues past zero toward negative values, the first variable begins to decline. As the first variable approaches zero, the second variable attains its

Figure 3. A graphic representation of the variables in a periodic process. In panel *A*, the phase-plane representation has the value of one state variable along one axis and the value of another along the other. A point in this representation defines a momentary state of the system in that the coordinates of the point give the values of the two state variables at that moment. Period processes describe circular trajectories in the phase plane; therefore, the state of the process may be described by an angle (the phase angle). The coordinates of the point are equal to the cosine and the sine of the phase angle because the axes have been scaled to make the radius of the circle equal to 1. In panel *B*, the sine-cosine representation of angle as a function of time plots the values of the state variables as functions of time. When the maximum and minimum values of these variables are set equal to one, then these functions are the sine (*y*-variable) and cosine (*x*-variable) functions. By recording the momentary values of these variables, a system specifies a momentary state of the periodic process. This yields a specification of time unique up to a translation by an integer number of periods along the temporal axis (from Gallistel, 1990, p. 233).

A



B



minimum and begins to increase; it continues this increase while the other drops to its minimum and then begins to increase again. Periodic processes exhibit this general pattern over time.

Using a fast Fourier transform (FFT), it is possible to describe the amount of variation in a time series. Like other techniques for representing variation over time (e.g., complex demodulation), the FFT takes sinusoidal patterns of variation as the elementary pattern of variation. All patterns of variation over time are represented as the sum of a number of elementary sinusoidal patterns (called *Fourier components*). What distinguishes one elementary pattern from another are three parameters that uniquely specify a sine or a cosine curve: (a) frequency, (b) amplitude, and (c) phase. The FFT assumes that the sinusoidal components of a time series extend backward in time to minus infinity and forward to plus infinity. Any given Fourier component is characterized by two coefficients: one gives the amplitude of the variation, and the other gives the change in phase – the amount by which the up and down swings of one variable are shifted in time relative to the up and down swings of another variable. These two values (the *gain coefficient* and the *phase-lag coefficient*) are called the *complex* of the transfer function at a given frequency. The transfer function for two variables is the representation of the predictive relation between them. The gain predictor is the magnitude (or absolute value, or modulus) of the complex number, and the predictor of the phase shift is its angle. Thus, the transfer function is a complex valued function of frequency in which the gain and phase prediction coefficients are the magnitude and angle in the polar form of the complex values of this function (Gallistel, 1990). It is thus possible to represent the importance of a sinusoidal frequency by how often that sinusoid occurs in a time series. The resulting representation is termed a *periodogram* (the terms *deterministic spectrum*, *frequency spectrum*, *amplitude spectrum*, and *power spectrum* are often used synonymously with periodogram [e.g., Baker & Gollub, 1990; Fox, 1989; Press et al., 1989]). A periodogram represents the importance of each sinusoidal frequency within a time series,

where importance is measured in terms of its contribution to the explained variance of the original process.

Description of Experimental Phenomena

The experimental phenomena examined in the present study concerned the movement patterns of pigeons during basic reinforcement contingencies. Specifically, data collected by Eldridge et al. (1988) and by Eldridge (1991) were analyzed in this dissertation.

Eldridge et al. (1988) investigated the control of movement patterns by response-dependent and response-independent reinforcement. These data were used because plots of the birds' movements in the *xy* plane and as distance from the feeder over time were readily interpretable; therefore, these data served as a sample against which to compare the outcome of the quantitative analyses of the movement patterns. Eldridge (1991) investigated the sensitivity and appropriateness of movement assays of conditioned inhibition in an autoshaping procedure. These data were used because they permitted a test of the quantitative analyses when there was more than one stimulus condition. (Response-dependent and response-independent schedules of reinforcement and autoshaping are described below.)

Fixed-Interval and Fixed-Time

A fixed-interval (FI) schedule of reinforcement is a *response-dependent* schedule in which reinforcement is delivered following the first target response after a regular interval of time. Response-dependent schedules require an organism to emit an experimenter-specified response (termed the *target response*) in order for reinforcement to occur. Thus, during an FI 15-s schedule of reinforcement for contacting a *virtual sphere* (a computer-defined spherical region located within an experimental chamber), food would be delivered following the first computer-detected contact with the virtual sphere after 15 s.

A fixed-time (FT) schedule of reinforcement is a *response-independent* schedule in which reinforcement is delivered at regular intervals of time. Response-independent

schedules do not require the organism to emit any particular response in order for reinforcement to occur — the presentation of reinforcement is completely independent of the organism's behavior. Thus, during an FT 15-s schedule, food would be delivered every 15 s independent of the organism's behavior.

Characteristic effects. The characteristic effects of an FI schedule is a pause in responding after reinforcement followed by accelerated responding during the IRI until the next reinforcement. Longer FI schedules (e.g., FI 5-min) produce longer pauses after reinforcement and lower rates of responding than shorter FI schedules (e.g., FI 15-s). Finally, longer FI schedules are correlated with movements that occur further from the response key than shorter FI schedules, which result in movements that occur close to the response key (Pear & Rector, 1979; Rector, 1983).

The characteristic effect of an FT schedule consists of the reinforcement of behavior that the organism has some phylogenetic or ontogenetic predisposition to perform (Eldridge et al., 1988; Staddon & Simmelhag, 1971; Timberlake & Lucas, 1985). If an organism's behavior is reinforced on an FT schedule of reinforcement after having been previously reinforced on an FI schedule, the typical effect is a reduction in the rate of the target response (Lachter, 1968; Zeiler, 1971); however, the organism continues to engage in the movement patterns that were conditioned during the FI condition (Eldridge et al., 1988; Timberlake & Lucas, 1985).

Autoshaping

During autoshaping, a response key is transilluminated with colored light, called the *conditioned stimulus* (CS), for a brief period (e.g., 8 s) before the presentation of food that is delivered independently of the bird's behavior. The food is typically presented for about 3 s, and is frequently termed the *unconditioned stimulus* (US). The period between the termination of the food presentation and the onset of the CS is termed the *intertrial interval* (ITI).

Characteristic effects. The characteristic effect during autoshaping is stereotyped pacing during the ITI, followed by an approach toward the CS when it is presented. Usually, pigeons also peck the CS (Eldridge & Pear, 1987; Locurto, Terrace, & Gibbon, 1981). Approaching and pecking the CS is termed the *conditioned response* (CR).

Method

Experimental Apparatus

Experimental room and chamber. The experimental room containing the operant chamber used by Eldridge et al. (1988) and Eldridge (1991) measured 3.1 x 3.1 m and was illuminated by four banks of fluorescent lights in open light fixtures on the ceiling. Each bank contained three 40-watt 4-foot fluorescent Cool White bulbs. The lights were wired through a relay that was controlled by the programming equipment, ensuring that the room lights were on during experimental sessions and off when the session concluded. A register in the ceiling ventilated the room. A speaker in the room provided 82 dB white noise as a masking stimulus.

A metal frame painted white supported the top and sides of the operant chamber, the inside dimensions of which were 57 x 57 x 38 cm. An aluminum panel and two pieces of white opaque Plexiglas, each of which was attached to one side of the panel, formed the front wall of the chamber. The left adjacent wall was made entirely of white opaque Plexiglas, while the other two walls were made of clear glass. The top of the chamber was made of clear Plexiglas attached by hinges to facilitate opening the chamber, and an aluminum mesh floor fitted into a stainless steel drop pan. Air spaces in the top and bottom of the chamber provided ventilation to the chamber. The room lights illuminated the chamber through the top and two clear glass sides.

Mounted on the aluminum panel of the front wall were: (a) a translucent plastic response key, 2.75 cm in diameter with its center located 26 cm from the mesh floor and 21 cm from the left adjacent wall, and (b) the feeder aperture located 13.5 cm from the floor

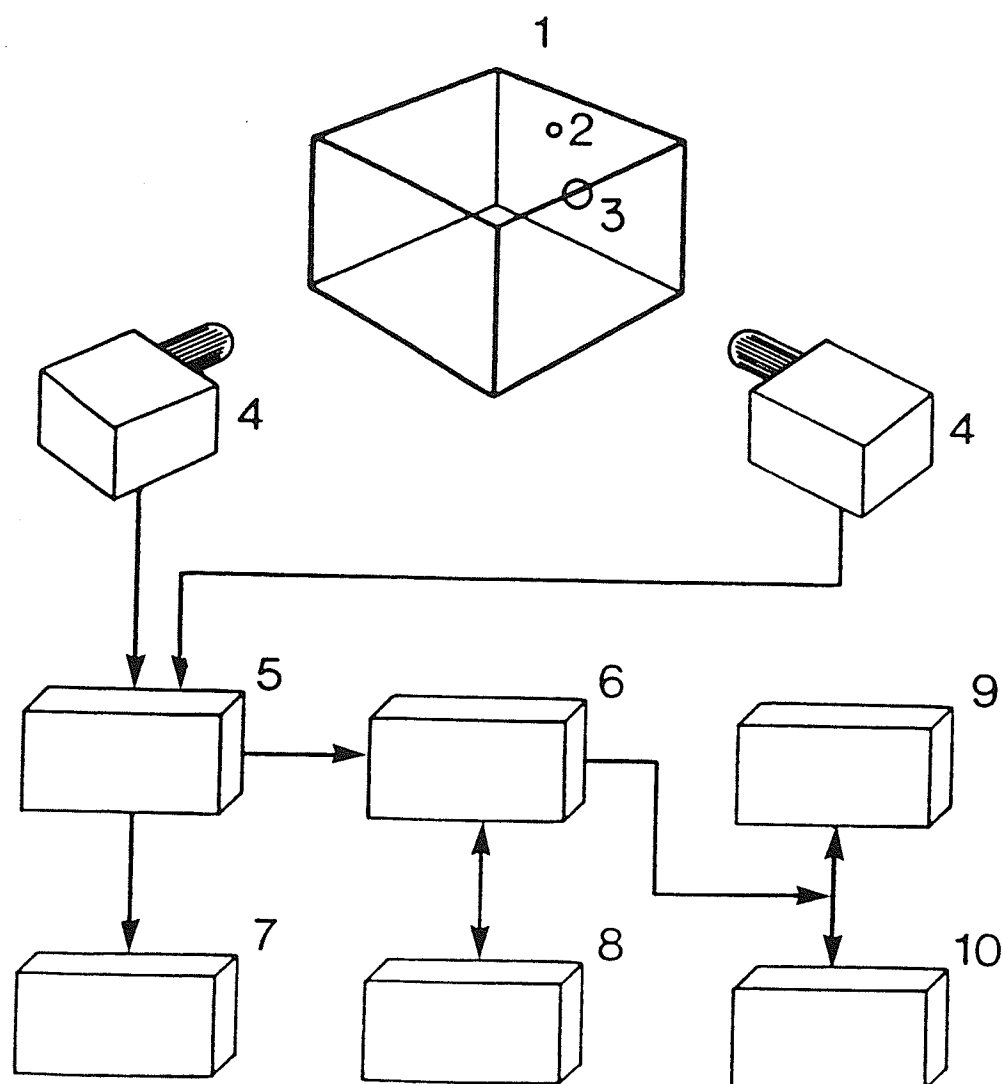
and equidistant from the side walls. The key required a force of 0.18 N to record a peck. It could be transilluminated with white light with any combination of three discrete circles of 6-mm diameter colored light (red, green, and yellow) projected from three 200 mcd light-emitting diodes (LEDs). The red light was placed at the left, the green light at the right, and the yellow light at the top of the key in a triangular configuration. The feeder aperture was illuminated continuously by two SL-313 bulbs in series with a 3352-ohm resistor. During reinforcement, which consisted of brief access to the food hopper filled with the same food used in the home cages, the brightness of the feeder light was intensified by the isolation of the resistor from the circuit.

Behavioral tracking system. Tracking was done by a unit termed a *video-acquisition module* that analyzed the signals from two black-and-white video cameras observing the target. Discrimination between the target and the background was made based on relative brightness. The cameras were electronically linked so that they scanned the observed scene synchronously at 30 Hz. The video signal from each camera was analyzed line by line from the top of the image until, having satisfied minimum width and darkness criteria, the target was identified. Logic circuits within the video-acquisition module determined the horizontal and vertical positions of the target relative to each camera. A microcomputer within the video-acquisition module accepted these raw position data and used them to compute the 3-D Cartesian coordinates of the target relative to a predetermined origin. Since the video-acquisition module had limited storage capacity, a second computer was required to acquire, average, and store the data. The second computer was a Cromemco Z-2D. A block diagram of the behavioral tracking system is illustrated in Figure 4 (from Pear & Eldridge, 1984, p. 461).

General Experimental Procedures

Experimental sessions were conducted at the same time daily, five to seven days per week. Each session terminated after 60 reinforcements. Each bird was weighed and had its head darkened with black shoe polish before the start of each session so that the

Figure 4. The behavioral tracking system. Two video cameras are connected to a video-acquisition module that computes the Cartesian coordinates (x, y, z) of a hypothetical dark point on a pigeon's head as it moves about an operant conditioning chamber. The bird's head is usually painted black to permit adequate tracking by the video-acquisition module. The coordinate values are obtained 30 times per second. The resulting data are averaged in groups of three and stored on floppy disks for later analysis (from Pear & Eldridge, 1984, p. 461).



- | | |
|-----------------------------|------------------|
| 1. Chamber | 6. Microcomputer |
| 2. Response Key | 7. TV Monitor |
| 3. Food Aperture | 8. Disc Storage |
| 4. TV Cameras | 9. CRT |
| 5. Video-Acquisition Module | 10. Printer |

apparatus could track the bird. Following each session, the food the bird received in the session was supplemented by an amount sufficient to maintain its weight at approximately 80% of its free-feeding level.

Preliminary training. The birds were trained to approach and eat from the feeder prior to the start of the experiments. During this training the birds were placed in the experimental chamber with the food hopper raised and the feeder aperture illuminated. Once the subject approached the raised hopper and consumed the food for about 20 s, the hopper was repeatedly lowered and raised at random intervals independent of the bird's behavior. This continued until the bird approached and consumed the food within 3 s for 10 consecutive trials. The feeder light was brightened only when the food hopper was raised. The response key was covered with a white paper shield while the bird was being trained to eat from the feeder.

Dependent measures. The following measure was used in both experiments: (a) plots of the birds' movements in the chamber in the form of the distance of the bird's head from a reference location (response key or feeder) over time and (b) the path produced by the bird in the *xy* plane (top view). The number of keypecks during the CS and during the ITI were recorded by Eldridge (1991).

Specific Experimental Method Used in the FT/FI Study

Two male Texas Pioneer pigeons (a White Carneau/Silver King crossbreed; Birds 1 and 2) and one, male White King pigeon (Bird 3) served as subjects. (Hereafter, these birds will be referred to as Birds F1, F2, and F3, respectively.) Following training to approach and eat from the feeder when it was presented, the birds were given a baseline session of 3600 s during which no reinforcement was presented. They were then exposed to the following phases: (a) FT 15-s, (b) shaping to contact the virtual target sphere according to the method described by Pear & Legris (1987), (c) gradually increasing FI values until FI 15-s was reached, (d) reinforcement for contacting the virtual sphere with

the head on FI 15-s, and (e) return to FT 15-s. The number of sessions for each bird in each phase is shown in Table 1. (Due to space restrictions, schedule shaping is abbreviated *s shaping*.)

Table 1
Number of Sessions in Each Phase

Phase	Bird F1	Bird F2	Bird F3
FT 15-s	10	13	10
SHAPING	3	3	4
S SHAPING	4	26	7
FI 15-s	19	40	13
FT 15-s	20	33	27

The response key was covered by a white paper shield in all sessions. The computer defined a 3-cm virtual target sphere whose center was located 13.5 cm from the left wall, 21 cm from the back wall, and 32 cm from the aluminum mesh floor of the chamber. Because this was slightly above the usual standing heights of the birds, each bird had to raise its head to contact the target sphere. Each contact of the bird's head with the target sphere resulted in the occurrence of a feedback click. Reinforcement was presented for 5 s.

Specific Experimental Method Used in the Autoshaping Study

Three male White King pigeons served as subjects (Birds 1, 2, and 4). (Hereafter, these birds will be referred to as Birds A1, A2, and A4.) I chose to analyze the data from Birds A1, A2, and A4 for this dissertation because their behavior during the CS appeared to reach asymptote before the other birds in Eldridge's (1991) study.

Following training to approach and eat from the feeder when it was presented, the birds were exposed to three sessions of a baseline condition designed to assess any

tendency to approach, withdraw, or peck an illuminated response key. The baseline sessions consisted of continuous exposure to the white keylight and no delivery of food. Each baseline session terminated at 3600 s.

During autoshaping a 6-mm diameter circle of colored light was projected in a unique position onto the white keylight for a fixed period of 8 s. The yellow circle at the top served as the CS for Birds A1 and A2, and the green circle at the right side served as the CS for Bird A4. At the end of the 8 s the keylight was darkened and food presented for 4 s. Trials were separated by ITIs varying in length with a mean of 60 s and a range from 30 s to 90 s, during which the keylight was illuminated white. Pecks to the key were recorded but had no programmed consequences. The lengths of the ITIs were determined by a pseudorandom probability generator. The sequence of intervals was changed randomly across sessions.

Apparatus and General Method Used in the Quantitative Analyses of the Present Study

Since the Cromemco had limited data storage capability and the kinds of data analysis programs required for this dissertation were not available for it, the reanalysis of the data collected by the Cromemco was done using a Macintosh Plus with an Apple SC 20 megabyte hard drive. The Cromemco was connected to the modem port of the Macintosh by a standard RS-232 connector and a Macintosh Plus Peripheral Adaptor. A data read-and-transfer program written in FORTRAN was executed using the Cromemco, while a commercially available communications program (*Red Ryder 9.2*) was loaded and executed using the Macintosh. The data were transferred from the Cromemco to the Macintosh using full duplex at 4800 baud, 7 data-bits, even parity, and 1 stop-bit. The data were saved as a file of ASCII characters and stored on the hard drive and backed up on 3½ inch 800 K diskettes.

All programs used to analyze the data for this dissertation were written in *THINK Pascal 2.0* from algorithms or numerical recipes available from various sources (see

Appendices A, B, and C). Data resulting from the correlated random walk and entropy analyses were graphed using *Cricket Graph 1.3.1*, and data resulting from the Fourier analysis were graphed using *SYSTAT 5.1* on a Macintosh II computer. All graphs were printed using a Hewlett-Packard Laserjet III printer.

General Purpose of the Present Study

This dissertation assessed whether the correlated random walk, information, and Fourier analyses introduced above represented changes in the movement patterns generated by pigeons during FT and FI schedules of reinforcement that were consistent with the analyses and interpretations of Eldridge et al. (1988). This dissertation also examined whether quantifying movement patterns with these techniques resulted in additional information or heuristic advantages about these patterns during FT and FI schedules and autoshaping that were not provided by analysis of the movement plots. In addition, the present study attempted to determine whether the three techniques were consistent in their representations of movement patterns.

FT/FI study. The last three sessions for each bird in the FT/FI study were examined across three phases (FT 15-s, FI 15-s, and reversal to FT 15-s). Furthermore, the first three sessions of the reversal to FT 15-s were examined to identify changes in movement patterns during the transition from FI 15-s to FT 15-s. The analyses attempted to address the following question: How do the quantitative analyses of the movement patterns during response-independent schedules compare with the same analyses of the movement patterns during response-dependent schedules?

Autoshaping study. The movement data from the first session of conditioning in the autoshaping study, through acquisition to asymptote were examined. Asymptote was defined as the session when the bird pecked at least 90% of the CSs presented. According to this criterion, asymptote was reached at three sessions for Birds A1 and A2, and at two sessions for Bird A4. The analyses were conducted on behavior during the CS and during the ITI separately, and attempted to address the following questions:

1. How does the acquisition of autoshaped movements proceed? There is abundant information on acquisition using traditional keypeck-related measures; but, there is very limited information on how the quantitative indices of the movement patterns change in a session and from session-to-session. For example, Wasserman, Franklin, and Hearst (1974) divided an experimental chamber into two halves and grossly measured a pigeon's location relative to a CS by determining the amount of time the pigeon spent in the half closest to the CS. They noted that pigeons increasingly approach CSs that predict food, but avoid CSs that predict the absence of food.
2. Which behavior, movement patterns during the CS or pecking the CS, reaches asymptote first?
3. How will the quantitative indices of the movement patterns during the CS compare with the quantitative indices of the movement patterns during the ITI?

Types of Analyses

Correlated random walk analysis. A program written in Pascal modified from the one used by Bovet and Benhamou (1988) was used to analyze the data according to the correlated random walk model. Since Benhamou and his colleagues have published several papers that used their correlated random walk analysis program (e.g., Benhamou, 1989; Benhamou, 1990; Benhamou & Bovet, 1989; Benhamou et al., 1990; Bovet & Benhamou, 1988; Bovet & Benhamou, 1991) and a dataset with known parameters was not available, I did not test the program to verify the accuracy of its output. This should be of limited concern because the results of the correlated random walk analysis were consistent with other analyses in which there were datasets of known parameters (see below). The correlated random walk analysis program is listed in Appendix A.

Kuiper's test (see Batchelet, 1981) was conducted to determine whether the turning angles in the rediscritized data were normally distributed. If the data were not normally distributed with a mean centered on 0 and a standard deviation less than or equal to 1.2 radians, then the data were rediscritized with another step length. Unfortunately, virtually

all movement patterns failed to meet the assumption of normally distributed turning angles with a mean of zero and standard deviation less than or equal to 1.2 radians. Despite the failure to satisfy these prerequisites, sinuosity was calculated for all data from the FT/FI study with a rediscritized step length of 4 cm. This step length was chosen because it resulted in less severe violations of the prerequisites. Other step lengths that were tried varied from 1 cm to 8 cm. For similar reasons, sinuosity was calculated for data during the CS and during the ITI from the autoshaping study with a rediscritized step length of 2 cm and 4 cm, respectively. The failure to meet the prerequisites of the correlated random walk model may have been the result of the pigeons moving in a relatively small enclosure (as compared to an animal foraging in the natural environment; Benhamou, personal communication, October, 1990).

During the FT and the FI schedules of reinforcement, sinuosities were calculated for movements during each IRI within a session. Sinuosities were averaged and plotted across blocks of six IRIs. During autoshaping, sinuosities were calculated for movements during each ITI and each CS separately. Sinuosities were averaged and plotted across blocks of six ITIs and across blocks of six CSs.

Information analysis. A program written in Pascal based upon Press et al.'s (1989) algorithm was used to conduct an entropy analysis. The accuracy of the program was tested by analyzing a dataset with known parameters supplied by Vetterling, Teukolsky, Press, and Flannery (1989).

Fundamentally, the data necessary for an entropy analysis of a pigeon's movements were tabulated by counting how often a bird was at a certain distance from a reference point at a certain time within a repeating time sample. The reference point was the feeder for the FT/FI data, and was the response key for the autoshaping data. The time samples used were 15 s from the start of the session or from the previous reinforcer for the FT/FI data, and 8 s from the onset of the CS and 30 s from the onset of the ITI for the autoshaping data. All time samples were analyzed with 0.1-s resolution, and the distances were analyzed to a 1-cm resolution. Thus, for example, it was possible to arrange a distance-by-

time matrix in which each cell contained the sum of how often a bird occupied a particular distance at a particular time in a 15-s interval (i.e., a 60 x 150 matrix, since the farthest distance the bird could occupy from the feeder was 60 cm and there were 15 s [in 0.1-s resolution] in a time sample). The Information analysis program is listed in Appendix B.

During the FT and the FI schedules, (a) the degree to which the pigeon's location could be predicted from the time in the IRI (i.e., the dependency between distance and time) and (b) the degree to which the time in the IRI could be predicted from the pigeon's location (i.e., the dependency between time and distance) were calculated across blocks of six IRIs, where for this analysis, the IRI was defined as 15 s from the start of the session or from the previous reinforcer (see equations [12] and [13] above).

During autoshaping, (a) the degree to which the pigeon's location could be predicted from the time from CS onset and (b) the degree to which the time from CS onset could be predicted from the pigeon's location were calculated across blocks of six CSs. Similar measures were calculated for movements during the ITI; but, because the information analysis program required that all time samples be of equal duration, only the first 30 s as measured from the onset of the ITI were used.

Fourier analysis. A Fourier analysis program based on Crandall and Colgrove's (1986) algorithm was written in Pascal and used to analyze the data. The accuracy of the program was tested by analyzing a dataset with known parameters supplied by Crandall and Colgrove (1986), and by comparing the output of the program with the output of a Fourier analysis performed by *Systat 5.1*. The Fourier analysis program is listed in Appendix C.

In generating a frequency spectrum from a time series, the experimenter must select the length and starting point of the sample series to be transformed. The resulting spectrum will reflect the average frequency composition over the sample. If the sample spanned two or more distinct statistical processes, the result would provide the average composition of the two processes, and it would accurately represent neither (Fox & Hayes, 1985).

Therefore, due to the statistical requirements of the FFT, considerations for the distinctness of the processes, and programming concerns, the following restrictions were made: The number of data points used to calculate a spectrum had to satisfy the power of 2 requirement of the FFT (thus, possible sample lengths were 2, 4, 8, 16, 32, 64, 128, 256, 512, ..., etc data points). Further, any single spectrum had to contain enough points so that slow and fast frequencies could be detected. Finally, the same number of data points were used to calculate each spectrum.

Based on the above restrictions and considerations, 25.6 s of data (i.e., 256 data points) were used to calculate each spectrum. The data points consisted of 0.1-s samples of the bird's distance from the feeder (FT/FI study) and from the response key (autoshaping study). Two hundred and fifty six data points corresponded to the first 15 s from selected IRIs plus the first 10.6 s from the next IRI from the FT/FI data, and three complete CSs plus the first 1.6 s from a fourth CS and the first 25.6 s from selected ITIs from the autoshaping data. The following IRIs were used, where a plus sign (+) denotes that more than one IRI or CS was used to construct a spectrum — 1 + 2, 7 + 8, 13 + 14, 19 + 20, 25 + 26, 31 + 32, 37 + 38, 43 + 44, 49 + 50, and 55 + 56; the following ITIs were used — 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60; and the following CSs were used — 1 + 2 + 3 + 4, 7 + 8 + 9 + 10, 13 + 14 + 15 + 16, 19 + 20 + 21 + 22, 25 + 26 + 27 + 28, 31 + 32 + 33 + 34, 37 + 38 + 39 + 40, 43 + 44 + 45 + 46; 49 + 50 + 51 + 52, and 55 + 56 + 57 + 58. Furthermore, all the resulting amplitudes were squared to accentuate the more important frequencies and minimize the less important frequencies. The outcome of squaring the resulting amplitudes is a *power spectrum* (Fox & Hayes, 1985). Finally, to reduce *leakage* (i.e., when some power or variance accounted for by a frequency "leaks" to an adjacent frequency), all data were smoothed with a Hanning function before going through the mathematics of the FFT (see Press et al., 1989).

Although *phase spectra* are occasionally of primary importance (Oppenheim & Lim, 1981), they are frequently ignored in favor of frequency spectra or periodograms (e.g., Clark, Dooling, & Brunnell, 1983; Fox & Hayes, 1985; Press et al., 1989; Sing, Thorne,

& Hegge, 1985). Phase spectra represent the composite of all component frequencies with their corresponding phases (see text above). Fox (1989) states that whether an investigator calculates periodograms or phase spectra is a matter of choosing to calculate the spectra he/she determines to be more appropriate to address a research question. Ten periodograms were calculated for each bird for each session from the FT/FI study. Ten phase spectra were calculated for each bird in the last session of FT 15-s, FI 15-s, and the reversal to FT 15-s, and in the third session of the reversal to FT 15-s. Ten periodograms were calculated for Birds A1, A2, and A4 during the CSs for each session, and 10 periodograms were calculated for Birds A1, A2, and A4 during the ITIs for each session. Ten phase spectra were calculated for each bird in the last acquisition session during the CSs and during the ITIs.¹

Results

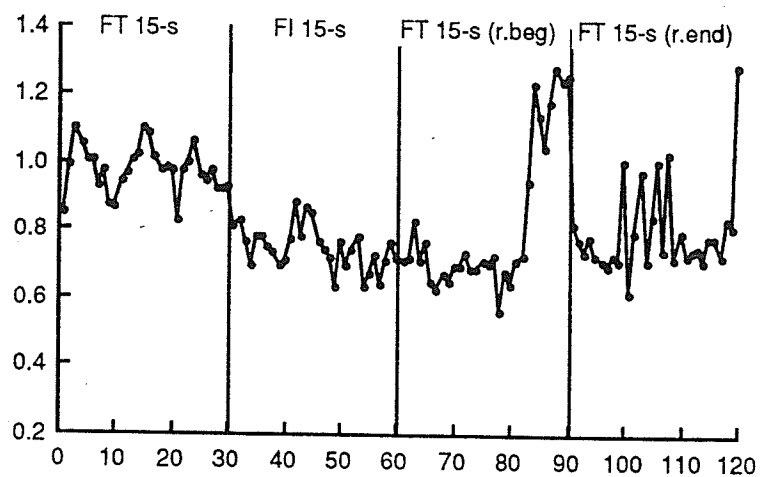
FT/FI Study

Correlated random walk analysis. Figure 5 shows the outcome of the correlated random walk analysis of the FT/FI data. The graphs show the amount of sinuosity averaged and plotted across blocks of six IRIs. The following are illustrated in the figure: (a) all birds show greater sinuosities during FT 15-s than during FI 15-s, (b) all birds show more within-session consistency during FI 15-s than during FT 15-s, (c) all birds show a gradual or at least a delayed increase in sinuosity when the schedule of reinforcement was changed from FI 15-s to FT 15-s, and (d) in the last three sessions of the reversal to FT 15-s all birds show sinuosity levels near but not necessarily at the levels established during the first FT 15-s phase. Furthermore, the data are more variable in the last three sessions of the reversal to FT 15-s than during the first FT 15-s phase.

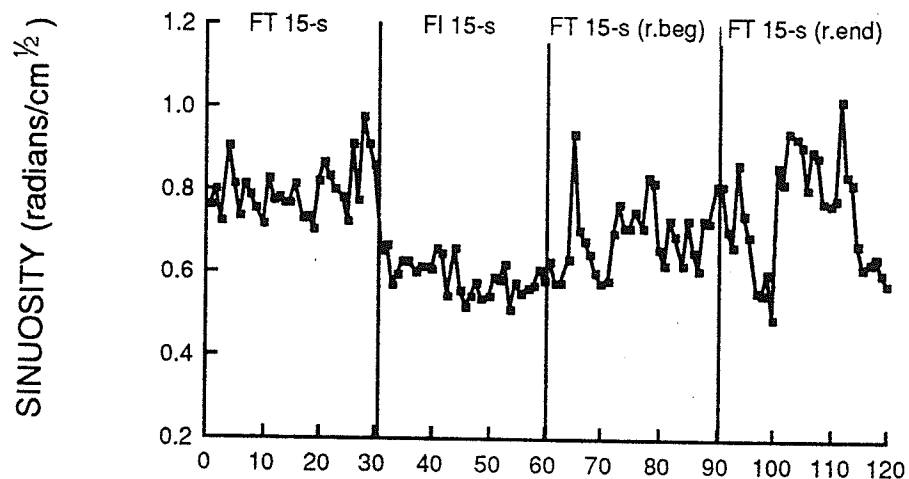
¹Due to an error at the time that Eldridge et al. (1988) collected the data, Bird F3 received 59 (rather than 60) reinforcers during the third session of the reversal to FT 15-s. As a result, five (rather than six) IRIs were used in block 90 for the correlated random walk analysis and for the information analysis. Furthermore, only the first 9 25.6 s samples listed above were used in the Fourier analysis of this session.

Figure 5. Sinuosity averaged and plotted across blocks of six IRIs for each bird in the FT/FI study. The last three sessions of the following phases shown are: (a) FT 15-s, (b) FI 15-s, and the reversal to FT 15-s (FT 15-s [r.end]). To monitor the changes in movements from FI 15-s to FT 15-s, the first three sessions from the reversal to FT 15-s (FT 15-s [r.beg]) are also shown. The arrow pointing to block 70 in Bird F3's graph indicates that sinuosity could not be calculated for this block of IRIs due to insufficient movements. There are 10 blocks per session. An increase in sinuosity indicates an increase in the amount of random turning in a movement pattern. Sinuosity is expressed in units of radians/cm^{1/2}.

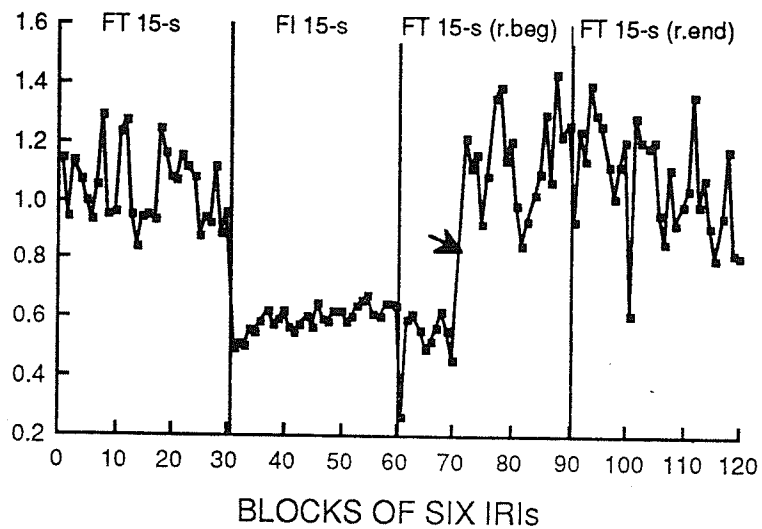
BIRD F1



BIRD F2



BIRD F3



Information analysis. Figure 6 shows the dependency of distance on time or, alternatively, the degree that a bird's distance from the feeder can be predicted by knowing the time in an IRI. The data are averaged and plotted across blocks of six IRIs for each bird in the FT/FI study. The following are illustrated in the figure: (a) all birds show less predictability during the first FT 15-s phase than during FI 15-s, (b) all birds show more within-session consistency during FI 15-s than during the FT 15-s phase, (c) all birds show a decrease in predictability when the schedule of reinforcement was changed from FI 15-s to FT 15-s, and (d) all birds show more predictability during the reversal to FT 15-s than during the first FT 15-s phase, but less than during FI 15-s. Moreover, Bird F1 did not show changes in predictability until approximately block 80 (i.e., nearly two full sessions into the reversal to FT 15-s). Similarly, Bird F3 did not show changes in predictability until approximately block 70. The onset of the change in Bird F2's level of predictability cannot be isolated to any single block, although as stated above, the degree to which its distance from the feeder could be predicted from the time in an IRI decreased during the reversal to FT 15-s.

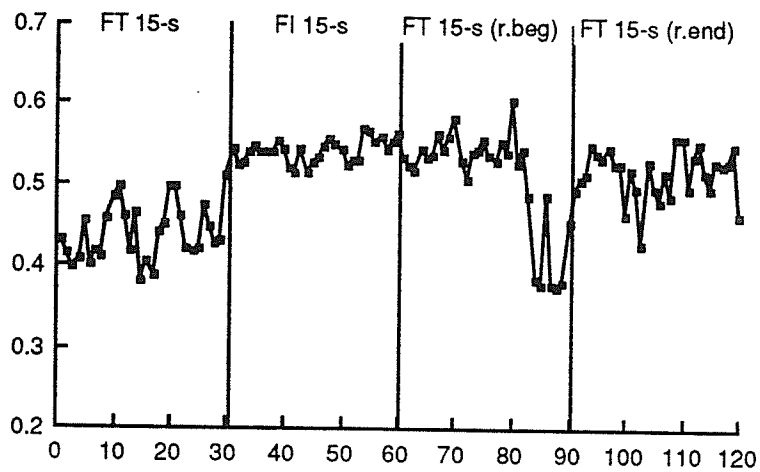
Figure 7 shows the dependency of time on distance or, alternatively, the degree that the time in an IRI can be predicted by knowing a bird's distance from the feeder. The data are averaged and plotted across blocks of six IRIs for each bird in the FT/FI study. The figure shows the same general effects as those described above for Figure 6. However, the dependencies in this figure are less than those in Figure 6; therefore, it is more difficult to predict the time in the time sample by knowing the bird's distance from the response key than predicting the distance by knowing the time.

Fourier analysis. Figure 8 shows frequency spectra (i.e., periodograms) for all birds from the FT/FI study during the first FT 15-s phase plotted across 10 25.6-s samples from the IRIs listed above. (The raw data used in these graphs and those in Figures 9 to 11 are shown in Appendix D.) Each graph contains data from one session. Examining the spectra over the three sessions shows that, in general,

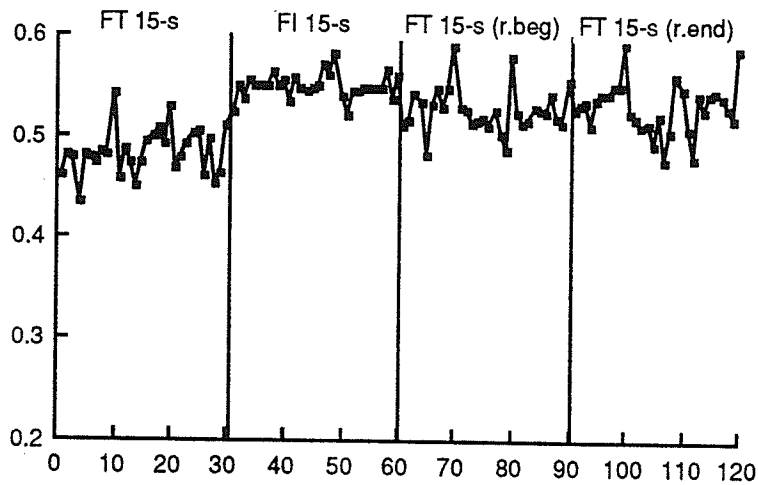
Figure 6. The degree that a bird's distance from the feeder can be predicted by knowing the time in an IRI. The data are averaged and plotted across blocks of six IRIs for each bird in the FT/FI study. The last three sessions of the following phases shown are: (a) FT 15-s, (b) FI 15-s, and the reversal to FT 15-s (FT 15-s [r.end]). To monitor the changes in movements from FI 15-s to FT 15-s, the first three sessions from the reversal to FT 15-s (FT 15-s [r.beg]) are also shown. There are 10 blocks per session. In the terminology of Information Theory, this figure depicts the dependency between distance and time (see equation 12 in the text). This dependency is expressed as a unitless measure.

DEGREE TO WHICH DISTANCE
CAN BE PREDICTED FROM TIME

BIRD F1



BIRD F2



BIRD F3

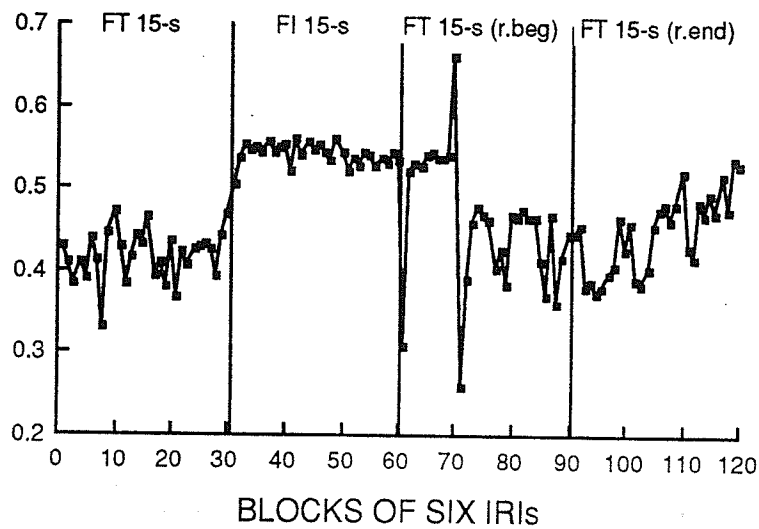
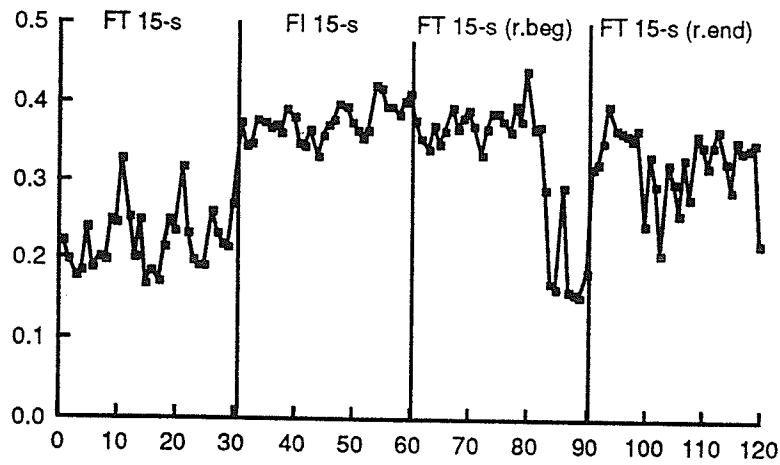
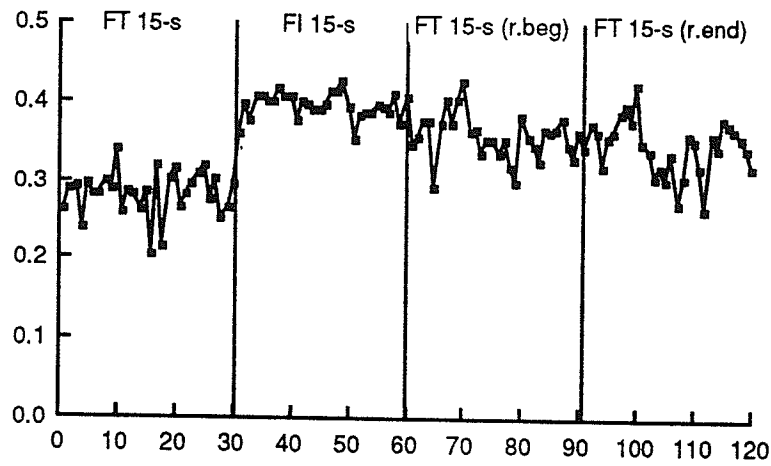


Figure 7. The degree that the time in an IRI can be predicted by knowing a bird's distance from the feeder. In the terminology of Information Theory, this figure depicts the dependency between time and distance (see equation 13 in the text). All other facets of the figure are identical to those described in Figure 6.

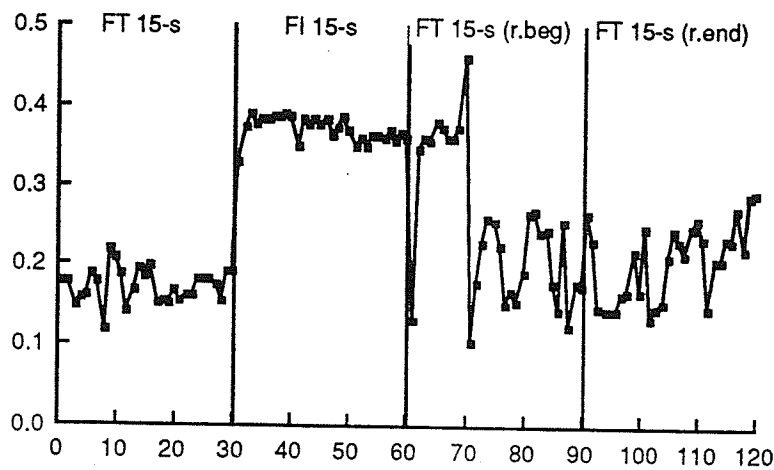
BIRD F1



BIRD F2



BIRD F3

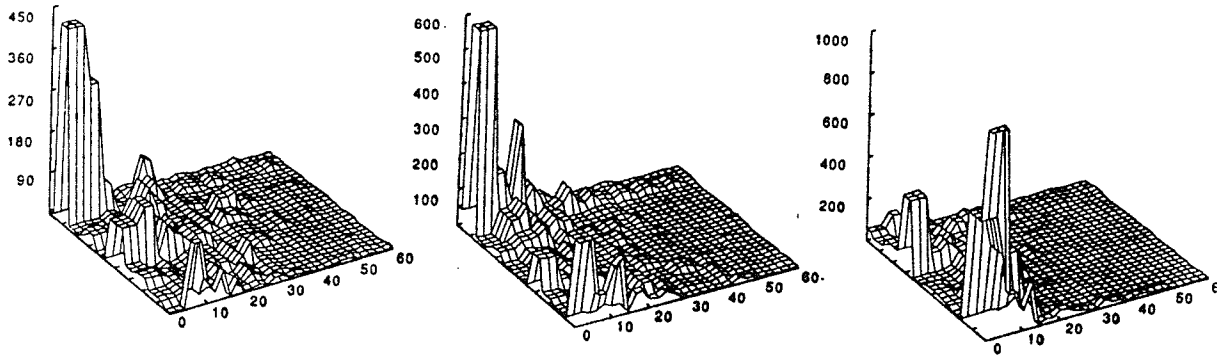


BLOCKS OF SIX IRIs

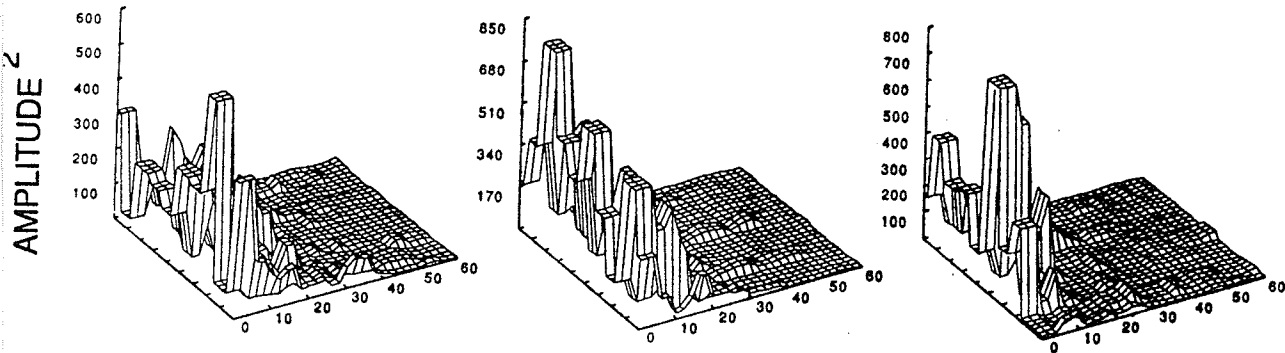
DEGREE TO WHICH TIME CAN
BE PREDICTED FROM DISTANCE

Figure 8. Frequency spectra (periodograms) for each bird in the FT/FI study plotted across 10 25.6-s samples (with 0.1-s resolution) from the IRIs listed in the text. The last three sessions from the first FT 15-s condition are shown. Each graph contains data from one session. For each bird, the left graph is the next-to-the penultimate session, the middle graph is the penultimate session, the right graph is the ultimate session of the phase. All of the resulting amplitudes were squared in order to accentuate the more important frequencies and minimize the less important frequencies.

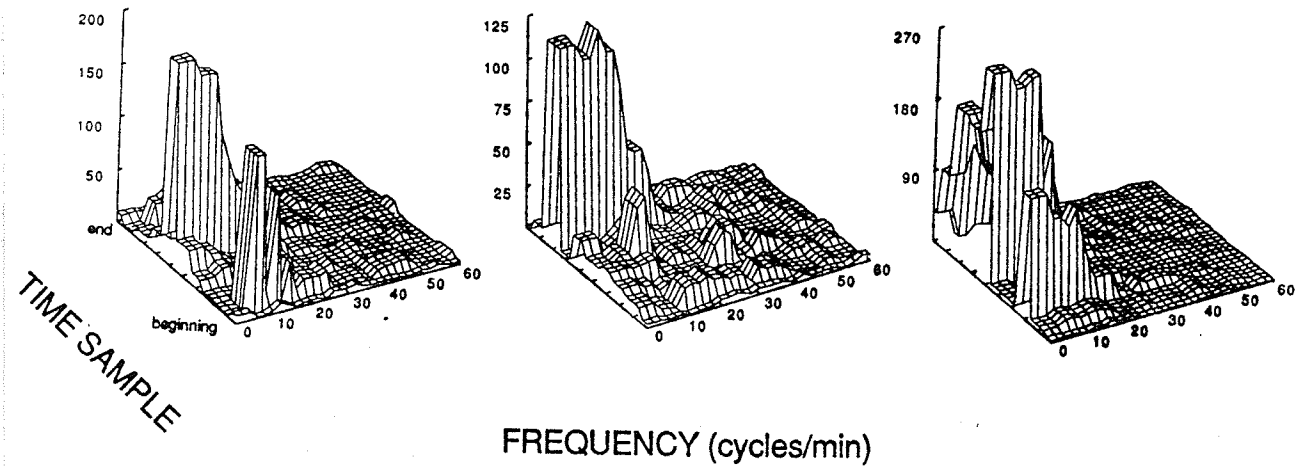
BIRD F1



BIRD F2



BIRD F3



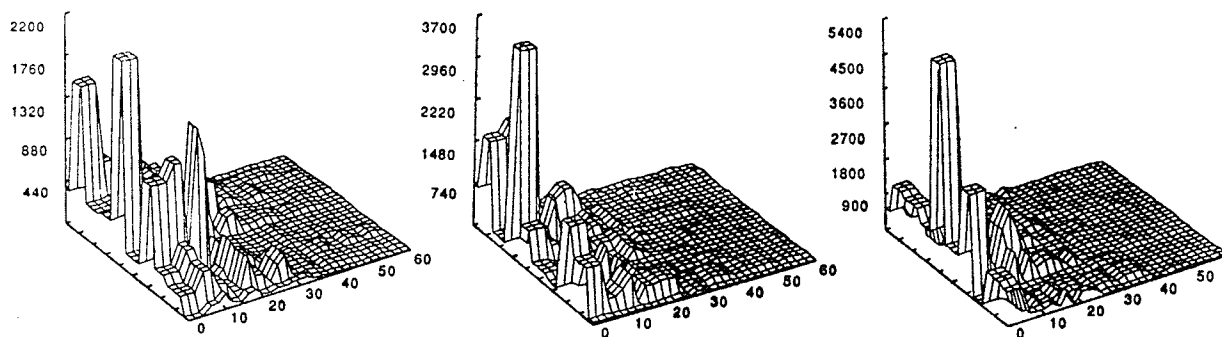
Bird F1's dominant movement occurred at a frequency of approximately 4 cycles/min; however, movements that occurred at approximately 11 cycles/min are also noted. Bird F2's dominant movement occurred at a frequency of approximately 4 cycles/min. Bird F3's dominant movements occurred at frequencies between 4 cycles/min and 16 cycles/min. Finally, for all birds, higher amplitudes generally occurred later in the session for most sessions shown in Figure 8.

Figure 9 shows frequency spectra for all birds from the FT/FI study during the FI 15-s condition plotted across 10 25.6-s samples from the IRIs listed above. Each graph contains data from one session. As in the previous phase, Bird F1's dominant movements continued to occur at a frequency of approximately 4 cycles/min. Bird F2's dominant movement occurred at a frequency of approximately 4 cycles/min, and movement occurring at a frequency of approximately 11 cycles/min accounted for proportionally more variance during FI 15-s than during FT 15-s. Similar to its movements in the previous phase, Bird F3's dominant movements occurred at frequencies of approximately 4 cycles/min and 16 cycles/min; however, other frequencies between 4 cycles/min and 18 cycles/min accounted for a substantial proportion of the variance in this bird's movements. Relative to their spectra from the FT 15-s phase, all birds' spectra during FI 15-s have higher amplitudes; thus, dominant frequencies accounted for more variance in the time series than during FT 15-s. Also, relative to their spectra during FT 15-s, there is more consistency across spectra within a session during FI 15-s. Finally, for all birds, higher amplitudes generally occurred later in the session for most sessions shown in Figure 9.

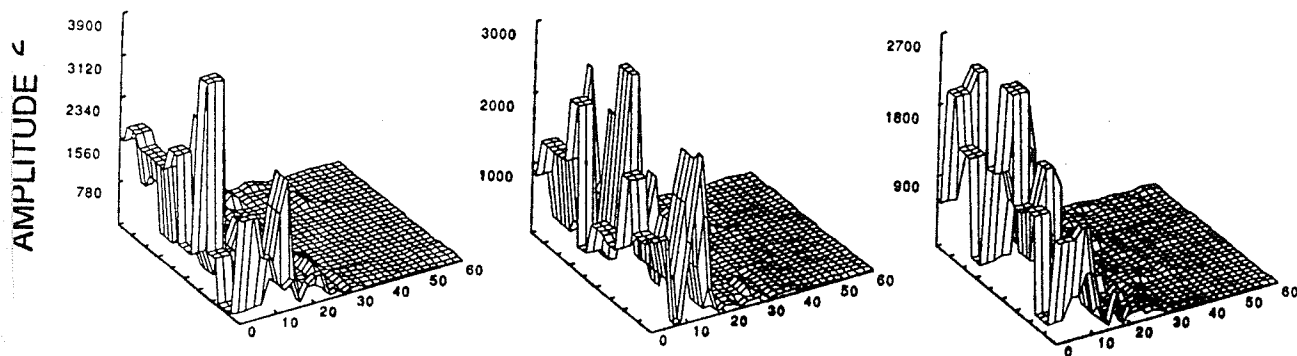
Figure 10 shows frequency spectra for all birds from the FT/FI study in the first three sessions of the reversal to FT 15-s plotted across 10 25.6-s samples from the IRIs listed above, except for Bird F3 (see figure caption for explanation). Each graph contains data from one session. Bird F1's spectra show a transition from the frequencies that dominated its movements during FI 15-s. In the first two sessions, Bird F1's dominant movements occurred at frequencies of approximately 4 cycles/min and 21 cycles/min; however, early in

Figure 9. Frequency spectra (periodograms) for each bird in the FT/FI study plotted across 10 25.6-s samples (with 0.1-s resolution) from the IRIs listed in the text. The last three sessions from the FI 15-s condition are shown. All other facets of the figure are identical to those described in Figure 8.

BIRD F1



BIRD F2



BIRD F3

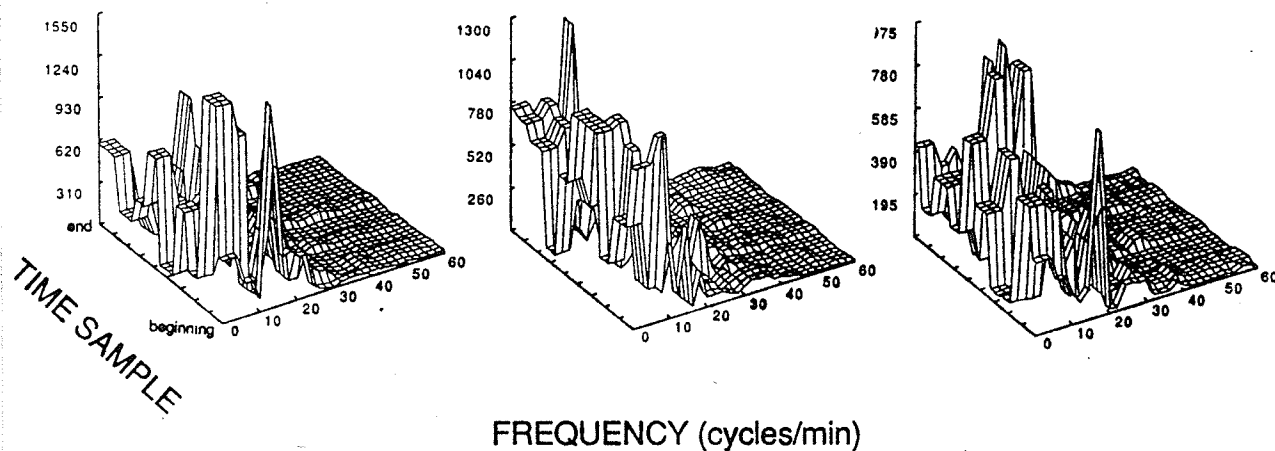
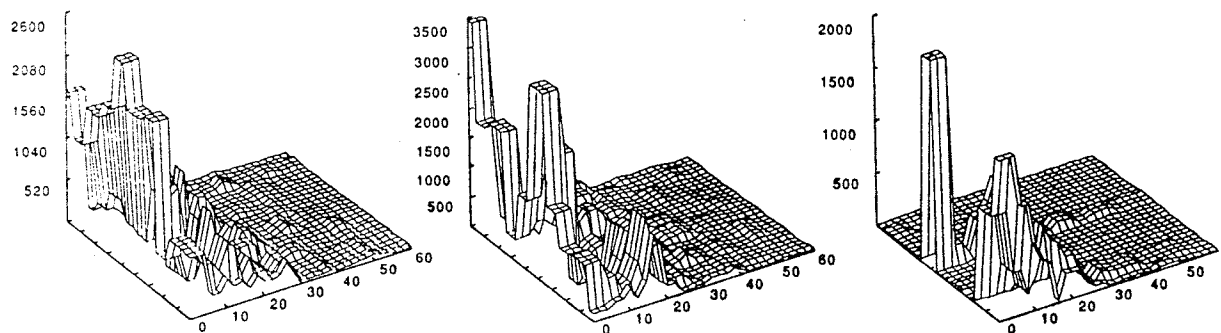
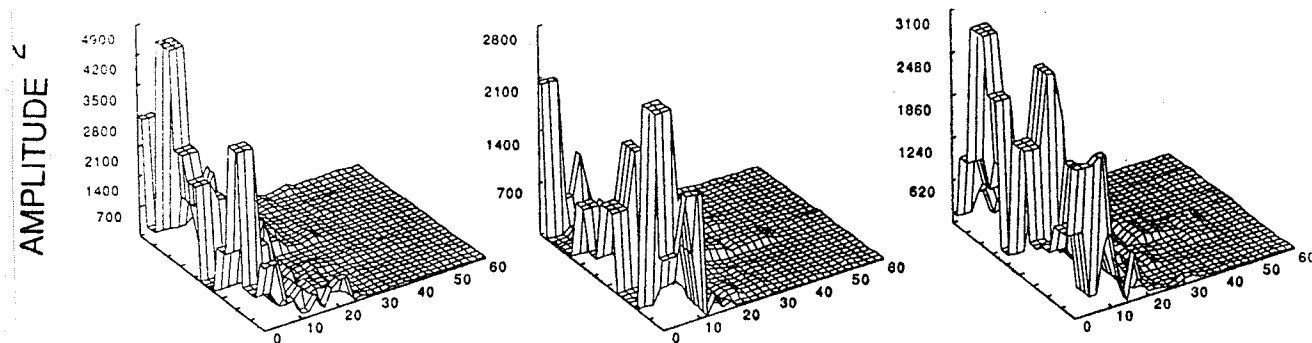


Figure 10. Frequency spectra (periodograms) for each bird in the FT/FI study plotted across 10 25.6-s samples (with 0.1-s resolution) from the IRIs listed in the text. The first three sessions from the reversal to FT 15-s are shown. Each graph contains data from one session. For each bird, the left graph is the first session, the middle graph is the second session, the right graph is the third session of the phase. All of the resulting amplitudes were squared in order to accentuate the more important frequencies and minimize the less important frequencies.

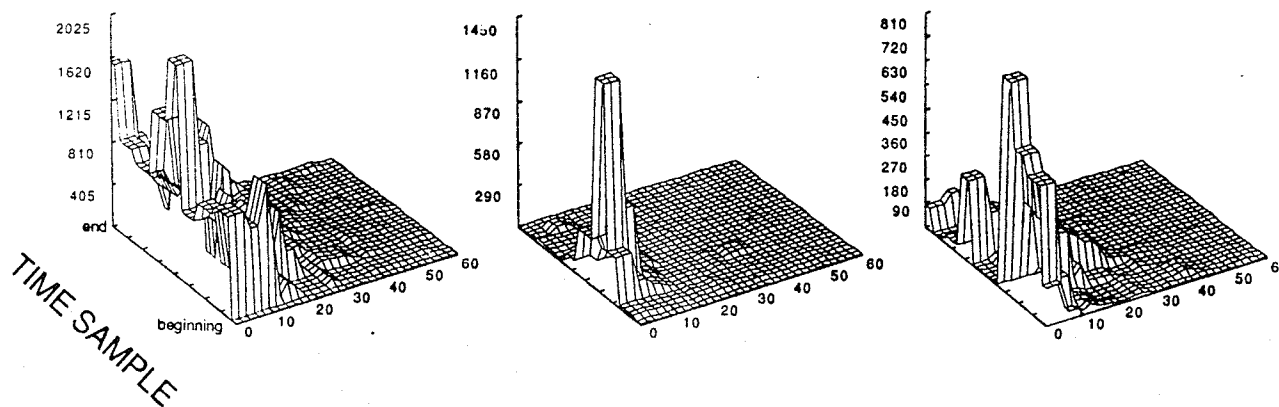
BIRD F1



BIRD F2



BIRD F3



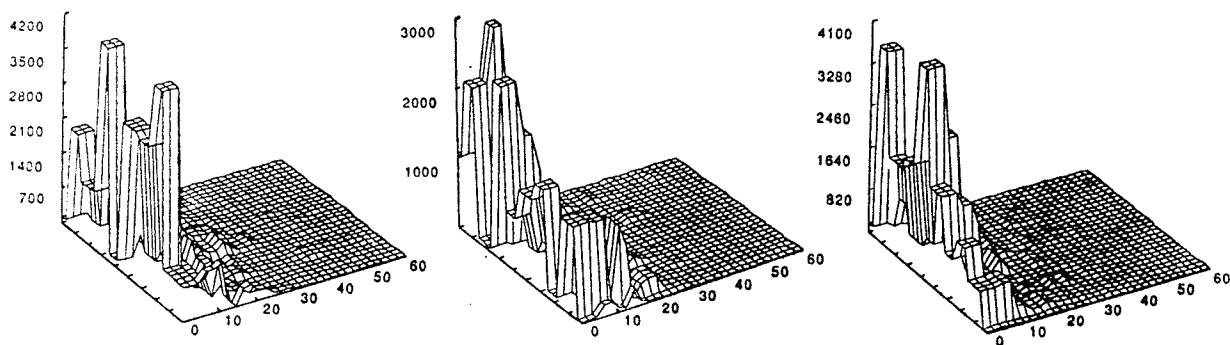
FREQUENCY (cycles/min)

the third session, a frequency of approximately 16 cycles/min accounted for most of the variance in this bird's movements. Approximately three fourths of the way through this session, no frequency within the range plotted on the graph accounted for a significant proportion of the variance in Bird F1's movements. In general, Bird F2's spectra show that the frequencies that dominated its movements during FI 15-s continued to dominate its movements in the first three sessions of the reversal to FT 15-s; however, movements occurring at a frequency of approximately 11 cycles/min accounted for less of the variance in the bird's movements. Bird F3's spectra show a transition from the frequencies that dominated its movements during FI 15-s. In the first session of the reversal to FT 15-s, this bird's dominant movement occurred at frequencies between approximately 4 cycles/min and 18 cycles/min. In the second session, a frequency of approximately 4 cycles/min, occurring approximately in the middle of the session, accounted for most of the variance in the bird's movements; but, no frequency within the range plotted on the graph described the bird's movements in the early and latter portions of the session. In the third session, Bird F3's dominant movement occurred at a frequency of approximately 4 cycles/min. All birds' spectra in the first three sessions of the reversal to FT 15-s have amplitudes similar to those noted during FI 15-s. Also, relative to their spectra from the FI 15-s phase, Bird F1 and F3's spectra from the first three sessions of the reversal to FT 15-s show less consistency across spectra within a session. Finally, for all birds, higher amplitudes generally occurred later in the session for most sessions shown in Figure 10.

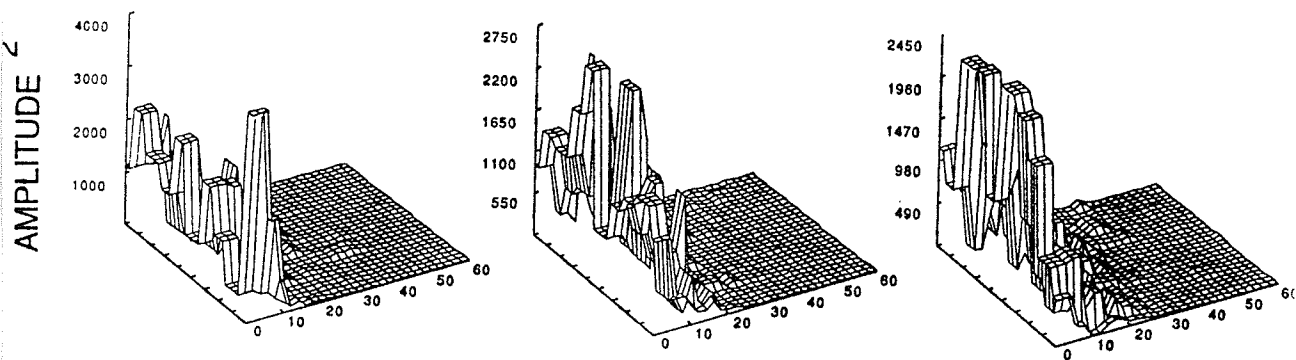
Figure 11 shows frequency spectra for all birds from the FT/FI study in the last three sessions of the reversal to FT 15-s plotted across 10 25.6-s samples from the IRIs listed above. Each graph contains data from one session. As in the previous phases, Bird F1's dominant movement occurred at a frequency of approximately 4 cycles/min, although movements occurring at approximately 11 cycles/min are occasionally evident. As in the previous phases, Bird F2's dominant movements occurred at a frequency of approximately 4 cycles/min. As in the previous phases, Bird F3's dominant movement occurred at a

Figure 11. Frequency spectra (periodograms) for each bird in the FT/FI study plotted across 10 25.6-s samples (with 0.1-s resolution) from the IRIs listed in the text. The last three sessions from the reversal to the FT 15-s condition are shown. All other facets of the figure are identical to those described in Figure 8.

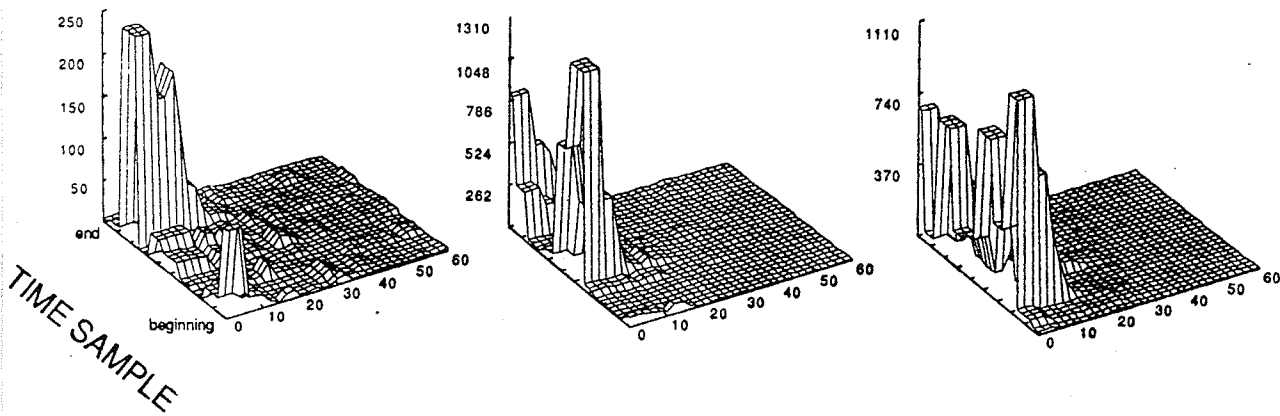
BIRD F1



BIRD F2



BIRD F3



FREQUENCY (cycles/min)

frequency of approximately 4 cycles/min. The dominant frequencies in the last three sessions of the reversal to FT 15-s accounted for more variance in the birds' movements than the same frequencies during the first FT 15-s phase. Furthermore, for all birds, higher amplitudes generally occurred later in the session for most sessions shown in Figure 11.

Figure 12 shows phase spectra for all birds from the FT/FI study plotted across 10 25.6-s samples from the IRIs listed above. Each graph contains data from one session. Recall from the Introduction that two sine waves may differ in frequency, amplitude, and phase (i.e., the angular difference between waves of the same frequency). The only readily apparent effect seen in these plots is that the phase shift appears to be near zero at those frequencies that were dominant in the periodograms (cf. Figures 8, 9, 10, and 11).

In summary, Figures 8 to 12 show the following effects for all birds: (a) Dominant frequencies accounted for more variance later in a session during FT 15-s and FI 15-s; (b) spectra from FI 15-s and from the last three sessions of the reversal to FT 15-s show more within-session consistency than spectra from the first FT 15-s condition and from the first three sessions of the reversal to FT 15-s; (c) frequencies faster than 4 cycles/min during the first FT 15-s condition accounted for more variance during FI 15-s; (d) dominant frequencies accounted for more variance during FI 15-s and the reversal to FT 15-s than during the first FT 15-s condition; and (e) phase shift appears to be near zero at those frequencies that were dominant in the periodograms.

Autoshaping Study

Correlated random walk analysis. Figure 13 shows the outcome of the correlated random walk analysis of the autoshaping data. The graphs show the amount of sinuosity averaged and plotted across blocks of six CSs and six ITIs. During the CS, all three birds showed an increase. For Birds A1 and A2 this was followed by a decrease in sinuosity across blocks. Bird A4's increase occurred later (at approximately block 11) and

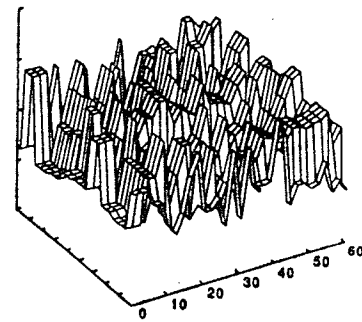
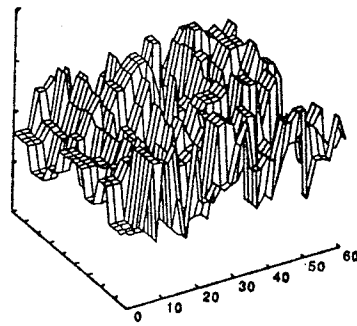
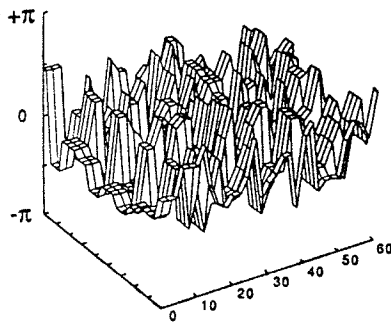
Figure 12. Phase spectra for each bird in the FT/FI study plotted across 10 25.6-s samples (with 0.1-s resolution) from the IRIs listed in the text. The last session from the first FT 15-s, FI 15-s, and the reversal to FT 15-s are shown. Each graph contains data from one session.

BIRD F1

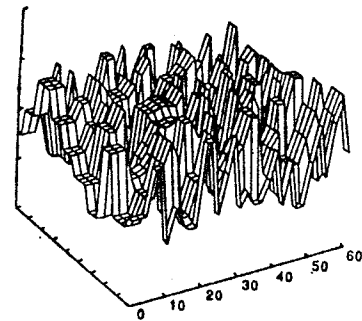
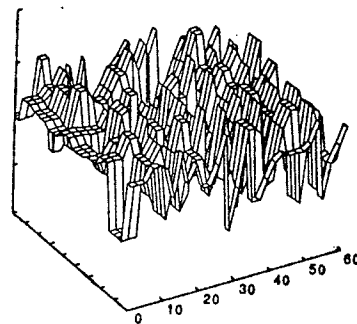
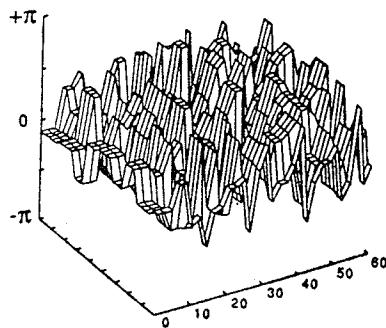
BIRD F2

BIRD F3

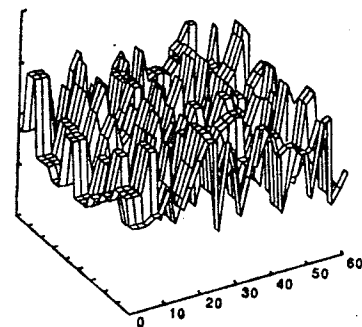
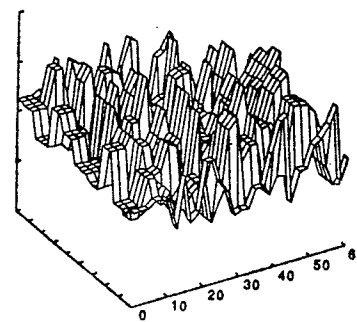
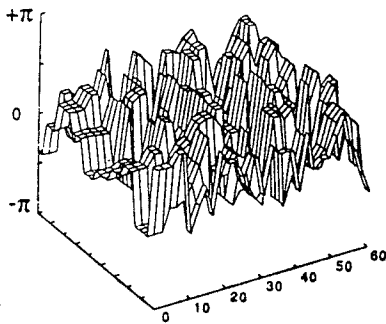
FT 15-s



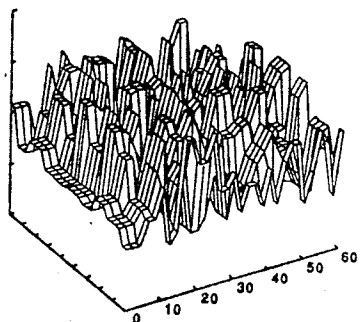
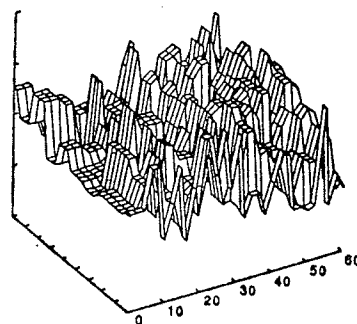
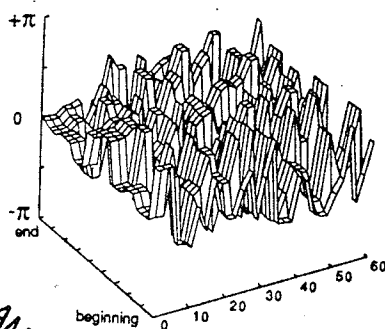
FI 15-s



FT 15-s reversal [beg.]



FT 15-s reversal [end]

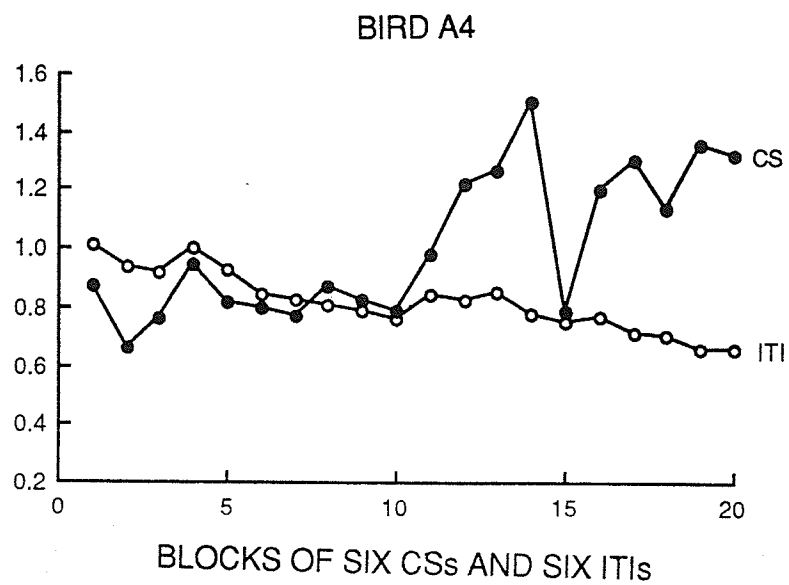
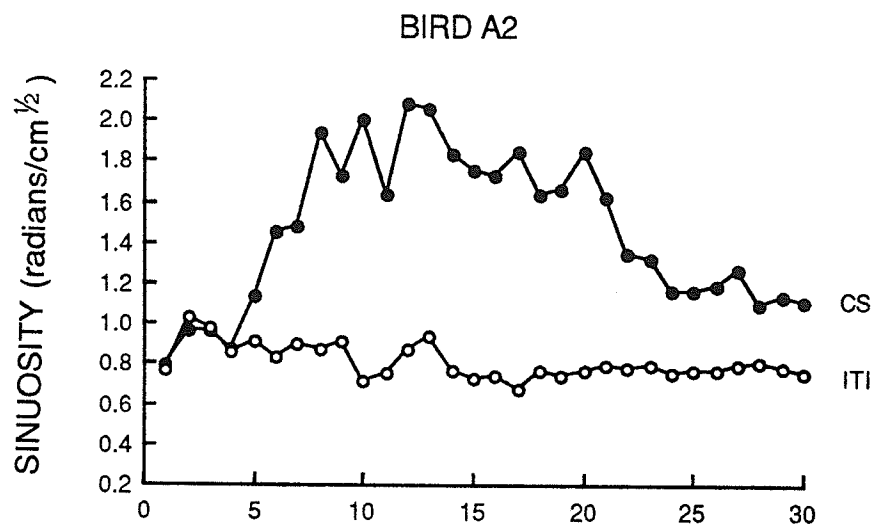
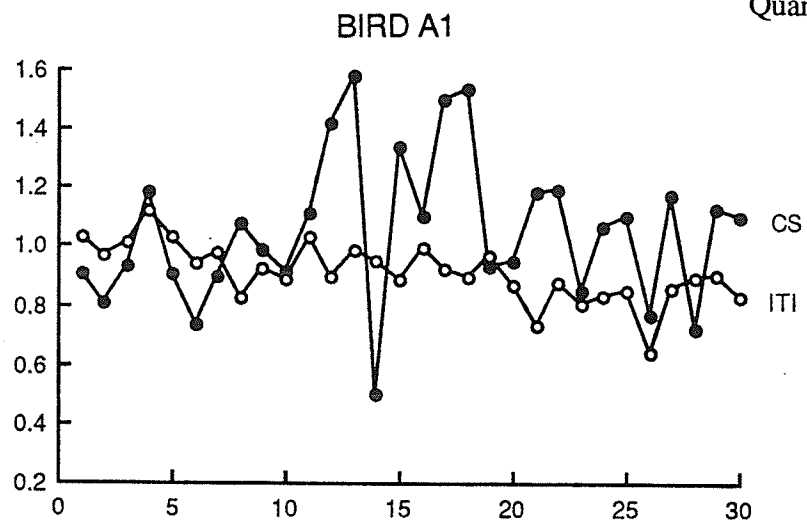


PHASE SHIFT I (radians)

ME SAMPLE

FREQUENCY (cycles/min)

Figure 13. Sinuosity averaged and plotted across blocks of six CSs (solid circles) and six ITIs (open circles) for Birds A1, A2, and A4 in the autoshaping study. There are 10 blocks per session. An increase in sinuosity indicates an increase in the amount of random turning in a movement pattern. Sinuosity is expressed in units of radians/cm^{1/2}.



continued until block 20. During the ITI, all birds showed a fairly linear decrease in sinuosity across blocks.

Information analysis. Figure 14 shows the degree that a bird's distance from the response key can be predicted by knowing the time within a sample of time. The data are averaged and plotted across blocks of six CSs and six ITIs. During the CS, all birds initially showed a decrease in the degree to which distance can be predicted from time, but Birds A1 and A2 subsequently showed increases in predictability as conditioning progressed. During the ITI, Birds A1 and A4 showed fairly constant levels, while Bird A2 showed a fairly linear increase in the degree to which distance can be predicted from time. For all birds, predictability during the ITI was often higher than, and never lower than, predictability during the CS.

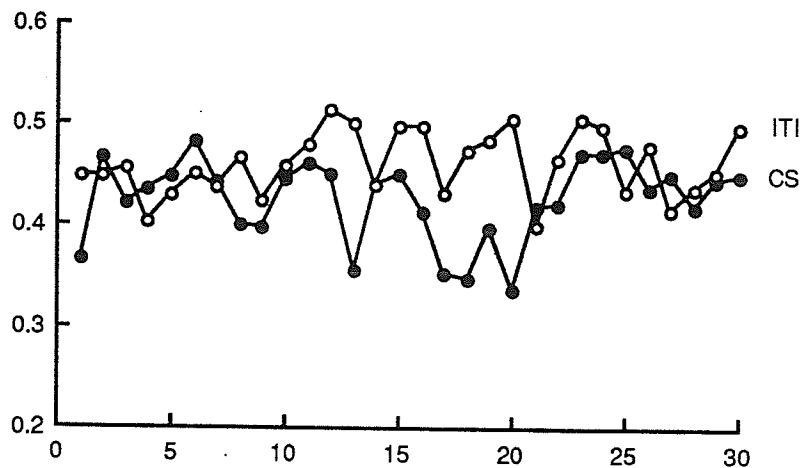
Figure 15 shows the degree that time within a sample of time can be predicted by knowing the bird's distance from the response key. The data are averaged and plotted across blocks of six CSs and six ITIs. The graphs in the figure show the same general effects as those described above for Figure 14. However, the dependencies in this figure are less than those in Figure 14; therefore, it is more difficult to predict the time in the time sample by knowing the bird's distance from the response key than predicting the distance by knowing the time.

Fourier analysis. Figure 16 shows frequency spectra (i.e., periodograms) for Birds A1, A2, and A4 from the autoshaping study plotted across 10 25.6-s samples from the CSs and ITIs listed above. (The raw data used in these graphs are shown in Appendix E.) Each graph contains data from one session. In the first session, Bird A1's dominant movements during the CS occurred at frequencies between 4 cycles/min and 11 cycles/min. In the second session, movement occurring at frequencies between 4 cycles/min and 18 cycles/min during the CS were noted early in the session, but no single frequency dominated this bird's movements subsequently. In the third session, this bird's dominant movement occurred at frequencies

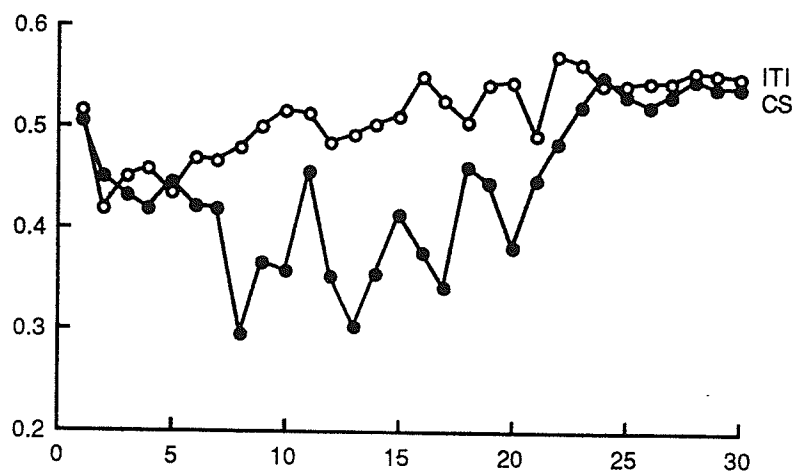
Figure 14. The degree that a bird's distance from the response key can be predicted by knowing the time in an IRI. The data are averaged and plotted across blocks of six CSs and six ITIs for Birds A1, A2, and A4 from the autoshaping study. In the terminology of Information Theory, this figure depicts the dependency between distance and time (see equation 12 in the text). This dependency is expressed as a unitless measure.

DEGREE TO WHICH DISTANCE
CAN BE PREDICTED FROM TIME

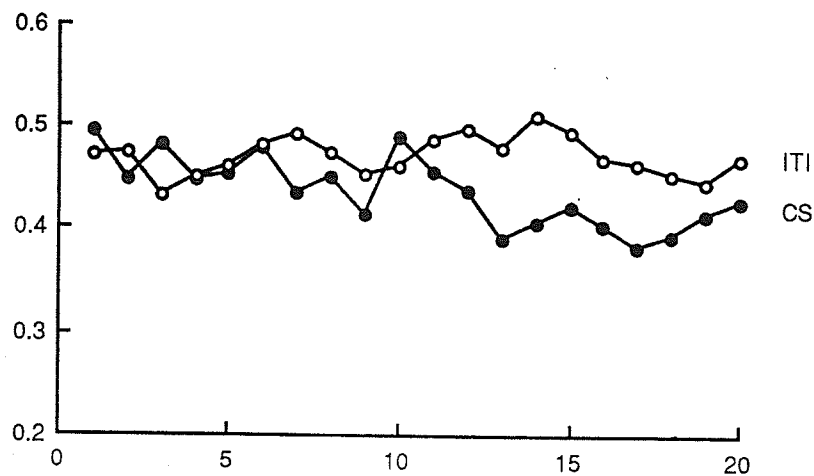
BIRD A1



BIRD A2



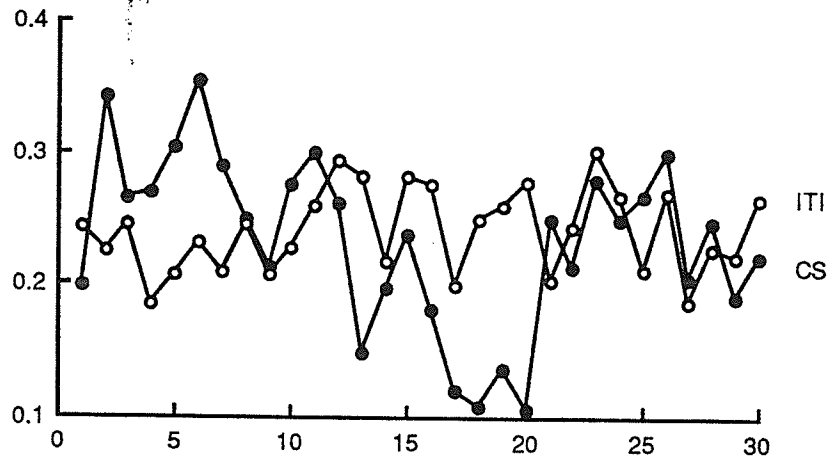
BIRD A4



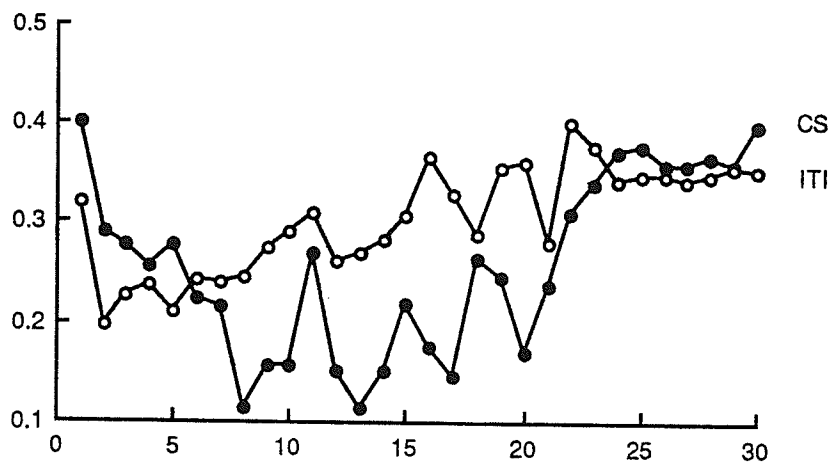
BLOCKS OF SIX CSs AND SIX ITIs

Figure 15. The degree that the time in an IRI can be predicted by knowing a bird's distance from the response key. The data are averaged and plotted across blocks of six CSs and six ITIs for Birds A1, A2, and A4 from the autoshaping study. In the terminology of Information Theory, this figure depicts the dependency between time and distance (see equation 13 in the text). This dependency is expressed as a unitless measure.

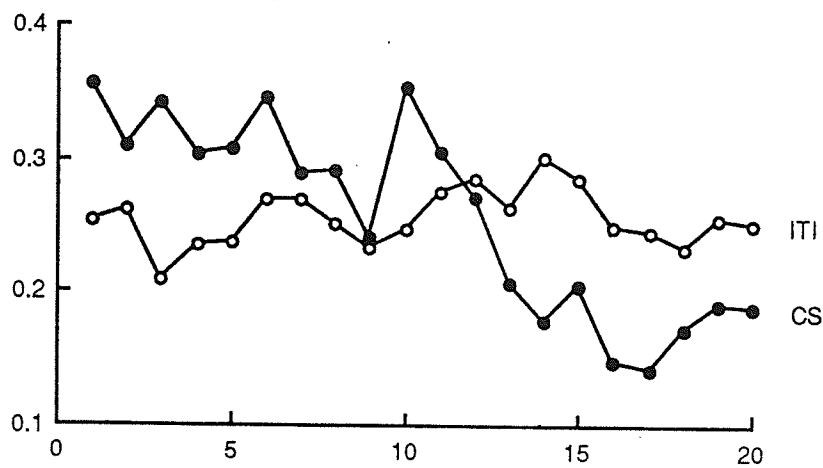
BIRD A1



BIRD A2



BIRD A4

DEGREE TO WHICH TIME CAN
BE PREDICTED FROM DISTANCE

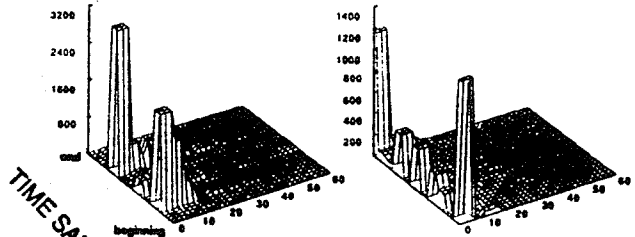
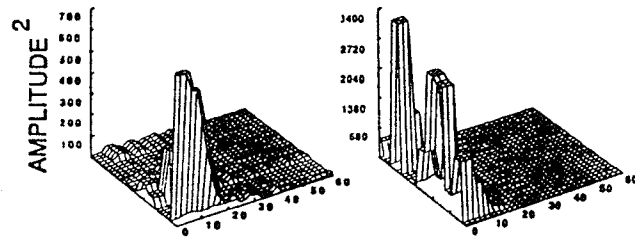
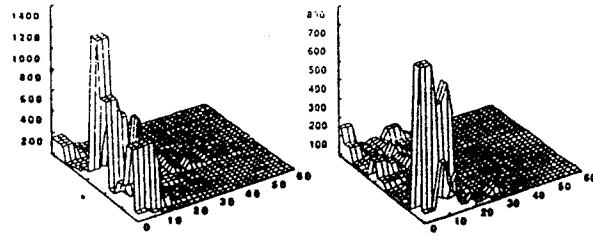
BLOCKS OF SIX CSs AND SIX ITIs

Figure 16. Frequency spectra (periodograms) resulting from analyses of movements during the CS and during the ITI for Birds A1, A2, and A4 from the autoshaping study plotted across 10 25.6-s samples (with 0.1-s resolution) from the CSs and the ITIs listed in the text. The first three sessions of conditioning are shown for Birds A1 and A2, and the first two sessions of conditioning are shown for Bird A4. Each graph contains data from one session. All of the resulting amplitudes were squared in order to accentuate the more important frequencies and minimize the less important frequencies.

BIRD A1

CS

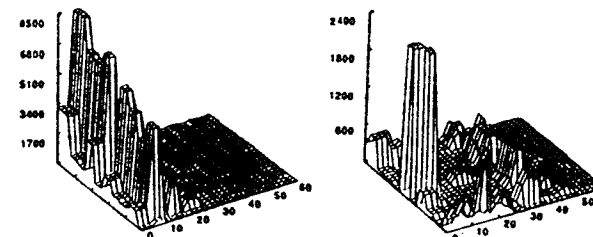
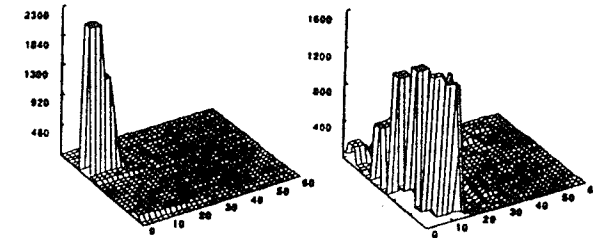
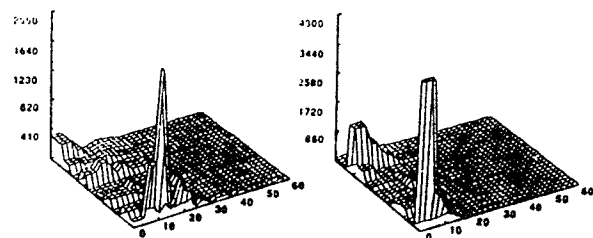
ITI



BIRD A2

CS

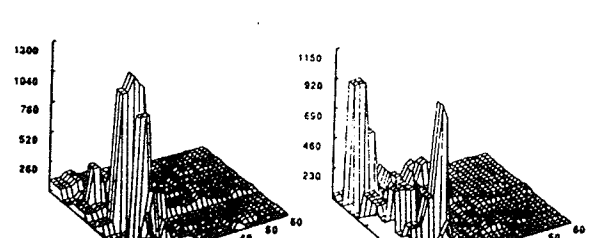
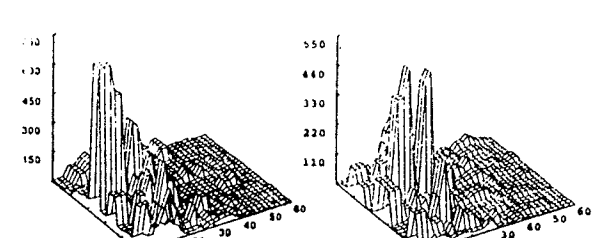
ITI



BIRD A4

CS

ITI



FREQUENCY (cycles/min)

between 4 cycles/min and 9 cycles/min. Furthermore, the aforementioned frequencies accounted for more variance in Bird A1's movements in the third session than in the first session.

Early in the first session, Bird A1's dominant movements during the ITI occurred at frequencies between 4 cycles/min and 18 cycles/min, but no single frequency dominated this bird's movements subsequently in this session. In the second session, Bird A1's dominant movements during the ITI occurred at frequencies between 4 cycles/min and 9 cycles/min. Furthermore, these frequencies accounted for more variance in this bird's movements in the second session than in the first session. In the third session, Bird A1's dominant movement occurred at a frequency of approximately 4 cycles/min.

Early in the first session, Bird A2's dominant movements during the CS occurred at a frequency of approximately 9 cycles/min, but no single frequency dominated this bird's movements subsequently in this session. In the second session, no movements within the frequency range plotted were dominant in most of the session; but, late in the session, Bird A2's dominant movements during the CS occurred at frequencies between 4 cycles/min and 9 cycles/min. The aforementioned frequencies accounted for more variance in Bird A2's movements in the second session than in the first session. In the third session, Bird A2's dominant movements occurred at frequencies of 7 cycles/min and 14 cycles/min; however, the former frequency accounted for substantially more variability than the latter frequency. Note the large amplitudes relative to the previous sessions.

Early in the first session, Bird A2's dominant movements during the ITI occurred at a frequency of approximately 4 cycles/min, but no single frequency dominated this bird's movements subsequently in this session. In the second session, Bird A2's dominant movements occurred at frequencies of approximately 4 cycles/min and 16 cycles/min. In the third session, Bird A2's dominant movements occurred at frequencies of approximately 4 cycles/min, 21 cycles/min, and 35 cycles/min. This frequency occurred more regularly, but accounted for less variance.

In the first session, Bird A4's dominant movement during the CS occurred at frequencies of 4 cycles/min and 11 cycles/min. In the second session, Bird A4's dominant movement during the CS occurred at a frequency of approximately 7 cycles/min and 23 cycles/min.

In the first session, Bird A4's dominant movements during the ITI occurred at frequencies of 9 cycles/min and 16 cycles/min. In the second session, this bird's dominant movements during the ITI occurred at frequencies of 9 cycles/min and 16 cycles/min. Furthermore, these frequencies accounted for more variance in Bird A4's movements in the second session than in the first session.

Figure 17 shows data displayed as phase spectra from the third session of acquisition for Birds A1 and A2 and from the second session of acquisition for Bird A4. The spectra from the analysis of the movements during the CS shows that the only evident effect seen in the plots is that the phase shift appears to be near zero during those frequencies that were dominant in the periodograms (especially Birds A1 and A2; cf. Figure 16). However, the phase spectra from the analysis of the movements during the ITI do not show any consistency between the phase shift, frequency, and time in the sessions shown in the figure.

In summary, Figures 16 and 17 shows the following general effects for the birds in the autoshaping study: (a) Some frequencies accounted for more variance in later sessions than in earlier sessions; (b) spectra from the ITI show more within-session consistency than spectra from the CS; (c) in the first session, the spectra from movements during the CS are similar in shape to the spectra from movements during the ITI; (d) in the latter sessions, frequencies that accounted for a substantial amount of the variance accounted for more variance during the CS than during the ITI; and (e) for movements during the CS, phase shift appears to be near zero at those frequencies that were dominant in the periodograms.

Keypecking. To compare the acquisition of the movement patterns during the CS to the acquisition of the keypeck response, Figure 18 shows the number of pecks during

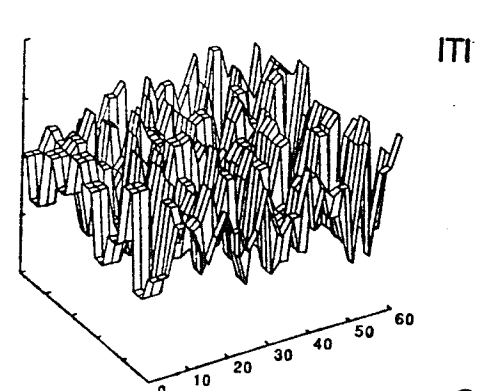
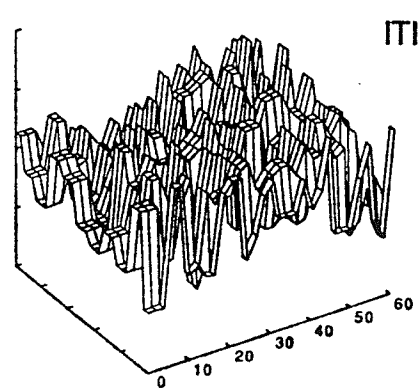
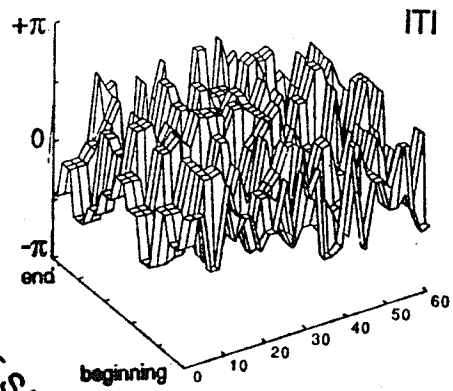
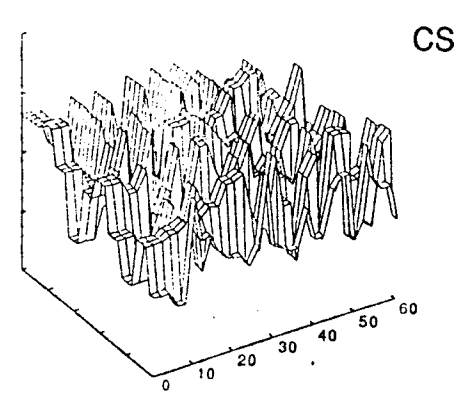
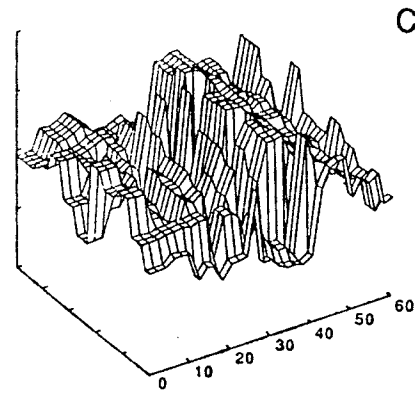
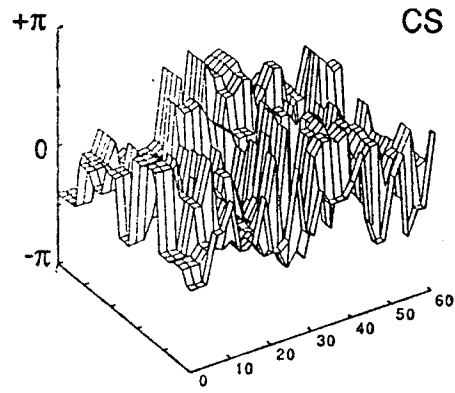
Figure 17. Phase spectra resulting from analyses of movements during the CS and during the ITI for Birds A1, A2, and A4 from the autoshaping study plotted across 10 25.6-s samples (with 0.1-s resolution) from the CSs and the ITIs listed in the text. The third conditioning session is shown for Birds A1 and A2, and the second conditioning session is shown for Bird A4. Each graph contains data from one session.

BIRD A1

BIRD A2

BIRD A4

PHASE SHIFT (radians)

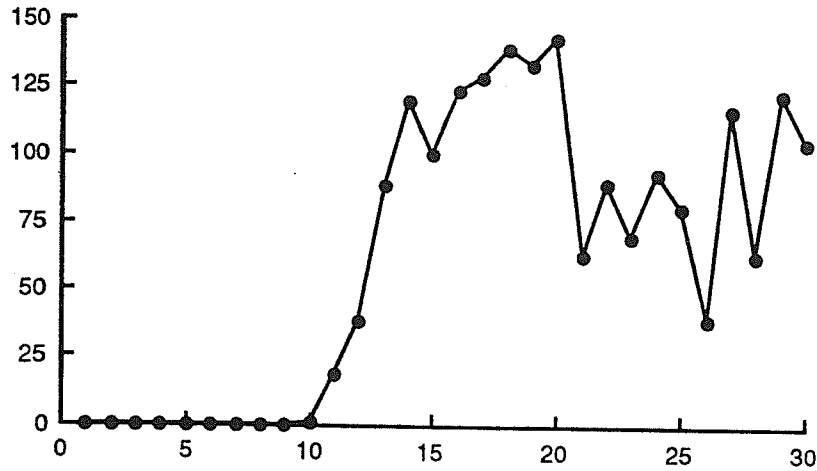


TIME SAMPLE

FREQUENCY (cycles/min)

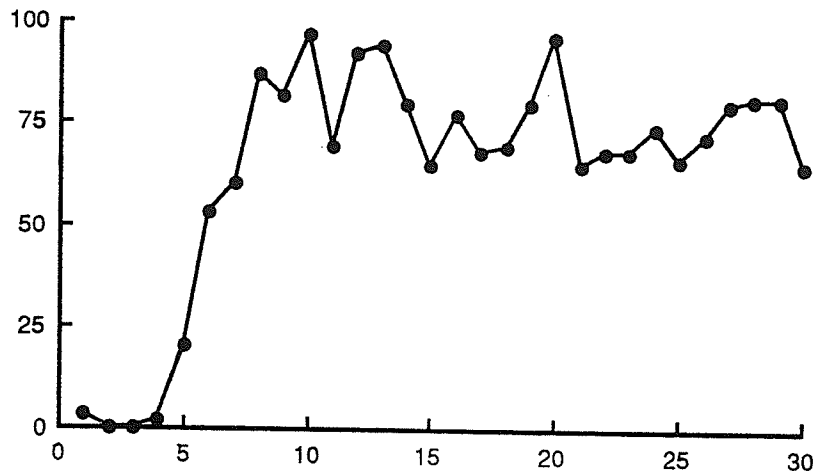
Figure 18. The number of keypecks to the CS plotted across blocks of six CSs for Birds A1, A2, and A4 from the autoshaping study. There are 10 blocks per session.

BIRD A1

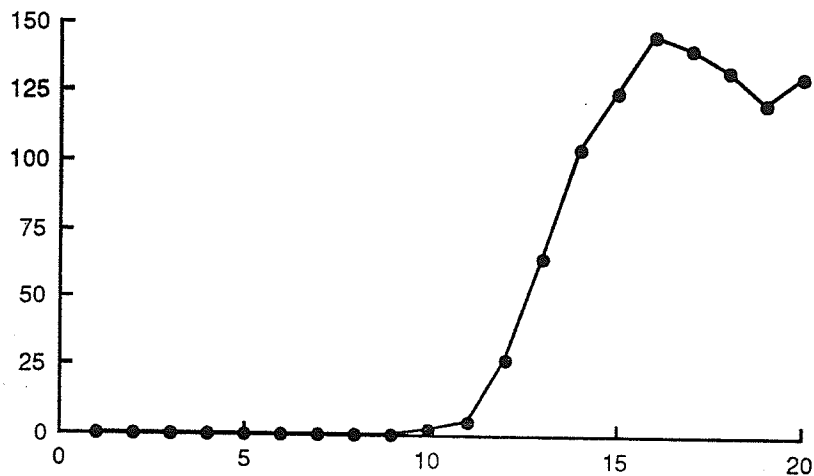


BIRD A2

NUMBER OF PECKS



BIRD A4



BLOCKS OF SIX CSs AND SIX ITIs

the CS plotted across blocks of six CSs in the same sessions as those displayed in Figures 13 to 17. Note the following from this figure. First, all birds showed some period in which they did not peck the CS or pecked it infrequently. Second, there was a steady increase in the number of pecks to the CS over 5 to 10 blocks. Finally, there was a decrease in pecks to the CS for all birds following a maximum amount of pecking. Thus, the S-shaped curve characteristic of learning is evident in the number of pecks to the CS and in the amount of sinuosity and strength of the dependencies between distance and time (cf., Figures 13, 14, and 15).

Discussion

This dissertation was concerned with three broad issues. One was whether the correlated random walk, information, and Fourier analyses could represent changes in the movement patterns generated by pigeons during FT and FI schedules of reinforcement that was consistent with analyses and interpretations of Eldridge et al. (1988). The second was whether quantifying movement patterns resulted in additional information or heuristic advantages about movements during FT and FI schedules and autoshaping that was not provided by analysis of the movement plots. The third was whether the three methods differed in their representations of pigeon movement patterns.

Representation of Movement Patterns

The outcome of this dissertation reveals that the correlated random walk, information, and Fourier analyses were consistent in their representation of the movement patterns of pigeons exposed to FT and FI schedules of reinforcement and autoshaping. The fundamental statistics obtained were (a) sinuosity, which measures the amount of random turning in movement patterns, (b) dependency, which measures the degree to which knowledge of one variable conveys information about a second variable, and (c) frequency spectra of the movement patterns, which measures the degree to which the variability in a

time series can be explained by a sinusoid of a certain frequency. In addition, as part of the Fourier analysis, phase spectra of the movement patterns measured the degree to which a sinusoid of a specific amplitude and frequency is synchronized with a sinusoid of another frequency.

The reason that the information and Fourier analyses yielded consistent results is probably because there are direct mathematical relationships between Fourier theory and Information theory (see Usher, 1984 for a description of the mathematical relationship). In general, both are techniques for analyzing the regularity of data over time. More specifically, a Fourier analysis decomposes a time series into an infinite number of sine waves of different amplitudes and frequencies and assesses which of these waves accounts for most of the variability in a time series. One statistic that can be obtained from an information analysis determines the dependency between two variables. Stated differently, an information analysis determines (in a probabilistic sense) the extent to which knowing something about one variable conveys information about another variable. Thus, if a Fourier analysis reveals that most of the variability in a time series can be accounted for by a single sinusoid with a specific frequency, then it must be the case that the time series is periodic (i.e., repeats itself over time). If a time series is periodic, then it must be the case that knowledge of one variable (e.g., distance from a reference location) will convey information about the other variable (e.g., time). Similarly, if a time series is a white noise process such that no sinusoid of a specific amplitude and frequency can account for a significant portion of the variability in the time series, then knowing something about one variable will convey little information about the other variable. For example, no information about a bird's location is gained by knowing the time in a repeating temporal interval if the bird occupies locations at random.

Although the correlated random walk model is somewhat new and the mathematical relationships between it and more well established models are just beginning to be investigated (Bovet & Benhamou, 1991; Budenberg, 1991; Gapenne, Simon, & Lannou, 1990), it is possible to relate the correlated random walk analysis to Fourier and

information analyses. Unlike the Fourier and the information analyses conducted in the present research that were spatiotemporal analyses, the correlated random walk analysis is a purely spatial analysis. Interestingly, the outcome of the purely spatial analysis (i.e., the correlated random walk analysis) was consistent with the outcomes of the spatiotemporal analyses (i.e., information and Fourier analyses). Since spatiotemporal analyses are also spatial analyses, it might be argued that this result is not surprising. However, the fact that the purely spatial analysis was consistent with the spatiotemporal analysis suggests that similar aspects of the movement patterns are quantified whether a 2-D spatial representation or a 2-D spatiotemporal representation of movements is used. Similar consistencies between spatial and spatiotemporal representations of movements have been noted previously (e.g., Pear, 1985; Eldridge & Pear, 1987).

In order for all three analyses to be consistent with each other, changes in sinuosity had to be *negatively* correlated with changes in the dependency between the animal's distance from a reference point and time within a repeating temporal interval, and with changes in the amplitude (i.e., variability accounted for) at a given frequency. *Negatively* because the correlated random walk analysis quantifies the amount of random turning in a movement pattern; therefore, if sinuosity decreases, predictability and amplitude must increase. The outcomes of the analyses showed this to be the case.

Two implications are derived from this outcome. First, the outcome suggests that any of the three analyses is a suitable method for quantifying movement patterns. However, this does not necessarily imply that the three analyses are interchangeable or substitutable for each other, since they can provide different information (see below). Second, the consistent outcome suggests that the correlated random walk analysis is robust to violations of its assumptions as described by Bovet and Benhamou (1988) and can possibly be used to quantify movements that occur in a relatively small enclosure such as an experimental chamber. Apart from the information presented above, little or nothing is known about violating the assumptions of the correlated random walk model (Benhamou, personal communication, September, 1991). Given that the correlated random walk

analysis has been applied to various facets of animal movements in natural environments, the use of this technique in the laboratory may provide a link between naturalistic and laboratory research, of which there is increasing interest (see Dewsbury, 1990; Shettleworth, 1988).

Quantitative vs. Qualitative Analysis

The outcome of the three analyses used in the present research were consistent with the analysis of the FT/FI data by Eldridge et al. (1988). Eldridge et al. commented that there were differences (as assessed by examining plots of the birds' distance from the feeder over time and plots of the birds' movement in the *xy* plane) between the movement patterns established during the first FT 15-s phase and the FI 15-s phase (pp. 279 - 281). Furthermore, they commented that the movement patterns during the reversal to FT 15-s were to some extent a combination of the patterns established during the first FT 15-s phase and the FI 15-s phase (p. 280).

Because Eldridge (1991) did not specifically examine the acquisition of the movement patterns during autoshaping, comparisons between her observations and the results of the present research are not possible. However, it is possible to cautiously compare the results of the present dissertation to the acquisition of the movement patterns during the CS and during the ITI documented by Eldridge and Pear (1987). Commenting on the development of movements during the ITI, Eldridge and Pear stated that the "main feature to note is the gradual development of excursions away from the area of the feeder and the key during the ITI." (p. 331) Their data also shows the emergence of approaches to the response key during the CS (see Eldridge & Pear, 1987, p. 330). The data presented in Figures 13 to 16 of the present study show a similar gradual development in the stereotypy of movements during the ITI, and the emergence of differential movements during the CS and during the ITI.

In addition to being consistent with Eldridge et al.'s (1988) analyses, the quantitative analyses of the movements from the FT/FI study focuses attention on the degree of

stereotypy of the movement patterns that was neither evident nor commented upon by Eldridge et al. Furthermore, quantification of the movement patterns from the FT/FI study and from the autoshaping study revealed the asymmetric predictability of repetitive movements. Specifically, the information analysis showed that it is easier to predict a bird's distance from a reference location by knowing the time in an interval than by predicting the time in the interval by knowing the bird's distance from a reference location. In terms of predictability, *when* the behavior occurs may be more important than *where* it occurs. Even though this may be true in terms of predictability, behavioral researchers are usually interested in predicting behavior and rather than predicting time. Typically, time is considered an independent variable and behavior (such as distance from a reference point) is considered a dependent variable. Thus, researchers are more interested in predicting distance (a behavioral measure) from time (a nonbehavioral measure) than vice versa. Consider an example of a dog that has been conditioned to salivate to two CSs (a light and a tone). Researchers would be more concerned with predicting the CR from knowing that either of the CSs had occurred than predicting which CS was presented from knowing that the CR had occurred.

One property that makes Fourier analysis such a powerful analytical tool is its ability to express a spatial process (e.g., distance from a reference location) in the frequency domain (i.e., frequency spectra) both exactly and completely. This complete correspondence between domains allows detailed analyses to be made on the spectra with the assurance that there is an exact analog in the spatial domain. In order to maintain this correspondence, it is necessary to retain the complete transform (both the amplitude and the phase components) in the spatial domain. As noted above, the frequency spectra provided information about the changes during FT and FI schedules of reinforcement, and during autoshaping.

However, it is also worth noting that the phase spectra, despite describing exactly half the information of the movement patterns and defining the origin in space of all

component sinusoids of the frequency spectra, added little insight into the structure of the movement patterns. An analysis of the phase spectra presented in Figures 12 and 17 shows that the phase appears to be (if it is not actually so) randomly distributed. This outcome is consistent with Fox and Hayes' (1985) discovery that the phase spectra that resulted from an analysis of the spatial structure of the seafloor contained information that was difficult to interpret, or bared little significance to their research question. Although it is for future

research to determine, it may be the case that key features of spatial phenomena are not captured in phase spectra. Nevertheless, the phase components (and amplitude components) are absolutely necessary for a reconstruction of the original process, and should be included in any Fourier analysis.

Given that the correlated random walk, information, and Fourier analyses were consistent in their outcomes, the remainder of the Discussion will focus on how these techniques (a) permit a quantitative analysis of the movement patterns of animals in their natural environment and in laboratory settings, (b) provide insights into movement patterns during FT and FI schedules of reinforcement and autoshaping, and (c) can be used to examine phenomena other than movement patterns in the field of animal learning.

Quantitative Analysis of Movement Patterns

Field of animal behavior. With a few exceptions (e.g., Pear et al., 1989; Seeley & Brozoski, 1989; Timberlake & Lucas, 1991; Wasserman et al., 1974; Weiss et al., 1989), the field of animal learning has been predominantly interested in measuring discrete responses as indices of learning. Movements, for example, are not typically measured and used as indices of learning. In contrast, the field of animal behavior has devoted considerable study to movement patterns (e.g., Ford & Krumme, 1979; Inoue, 1978; Koepl et al., 1977; Okubo, 1980; Phillips et al., 1991; Pyke, 1978). To aid their work, researchers in animal behavior have developed, tested, and used a variety of quantitative space-use and movement analysis models. Applications of these models have been

predominantly concerned with the experimental analysis and development of general theories of spatial orientation, space-use, and navigation, focussing on the physiological and environmental mechanisms responsible for efficient movements that permit successful exploitation of the environment (e.g., Benhamou, 1990; Benhamou & Bovet, 1989; Wehner & Srinivasan, 1981). All three techniques used in the present research to analyze pigeon movement patterns during basic reinforcement contingencies are suitable for studying the movements of other animals in the natural environment. All that is required is a system – electrical, mechanical, or human – for tracking the animal's movements (e.g., Benhamou, 1990; Phillips et al., 1991).

Field of animal learning. To date the work of Pear and his colleagues has shown that the study of movement patterns may provide insights into the behavior of organisms exposed to basic reinforcement contingencies. For example, Pear (1985) has shown that short variable-interval (VI) schedules of reinforcement (a schedule where reinforcement is presented contingent upon the first target response after successive intervals of time varying around a mean value; e.g., VI 15-s) result in movements that occur close to the response key, while longer VI schedules (e.g., VI 5-min) result in spatiotemporal movements that occur relatively far from the response key. The nature of these movements during VI schedules and the extent to which these movements influence the target behavior remains to be determined. More important, perhaps, is that we can ask higher level questions regarding the quantitative relationships between a given target response, reinforcement, *and* movement patterns.

The potential importance of examining behavior as a continuous spatiotemporal process cannot be overlooked. The response-defining action is only one response in a sequence of several responses. Yet it is the examination of sequential behaviors that is most commonly ignored in the field of animal learning (Weiss et al., 1989). To ignore behavior as a continuous spatiotemporal process means to assume that responses occurring in time are independent of each other (i.e., a discrete response is not influenced by the responses that preceded it). "Surely, if early events did not influence later ones, a science

of behavior would not exist." (Weiss et al., 1989, p. 83) A single response considered in isolation is an abstraction. Spatiotemporal relationships, whether adventitiously reinforced or explicitly programmed, reflect the central elements of behavioral processes based on learning (Weiss et al., 1989).

Experimental analysis of stereotypy. The three techniques used in the present research appear to be suitable techniques for an experimental analysis of stereotypy, about which little is known (Mason, 1991). Stereotypy has long been discussed in the animal learning and behavior literature, but quantitative indices of stereotypy are typically absent (Mason, 1991; Seeley & Brozoski, 1989). Stolba, Baker, and Wood-Gush (1983) state that a behavior pattern classified as stereotyped should always be clearly, ostensibly, and quantitatively defined to avoid confusion. Although the present techniques do not necessarily define stereotypy, they do provide indices with which to monitor changes in the stereotypy of movements. Recuerda et al. (1987) argue that an information analysis is an excellent technique for quantifying stereotypy because (a) it permits many comparisons to be made regardless of the nature of the system, (b) the outcomes are additive, (c) continuous and discrete responses can be analyzed, and (d) a dependency measure is intuitively simple to understand because its limits are between zero and one.

Resonance as a property of movement patterns. Movement patterns may be characterized by the property of resonance, which states that a pattern can be made to occur more easily at one frequency than at another (Hineline, 1986). This property is readily demonstrated in the domain of physical systems. For example, a glass of water will slosh more readily at a high frequency, but water in the Bay of Fundy will slosh more readily at a low frequency. According to Hineline, if the property of resonance is applicable to movement patterns, then varying the frequency of the inducing event should alter the frequency of the movement pattern. This is a testable hypothesis using Fourier analysis. For example, pigeons exposed to different FT schedules of reinforcement (e.g., FT 15-s, FT 60-s, FT 120-s, FT 300-s) should produce different frequency spectra because the inducing event (reinforcement) is occurring at different rates. Thus, the dominant

frequency should be quantitatively related to the schedule. Alternatively, pigeons exposed to FT 15-s and FI 15-s schedules of reinforcement should produce similar frequency spectra because the frequency of the inducing event (reinforcement) in both schedules is almost equal.

The Fourier analysis of the movements during the FT/FI study showed that imposing an explicit contingency (i.e., FI 15-s for contacting the virtual sphere) did not change the dominant frequencies. Instead, the frequencies that accounted for relatively more variability showed more within-session consistency during FI 15-s than during the first FT 15-s condition.

Sampling. The three analytic methods used in the present research also provided insights into sampling subsets of sessions for presenting data (e.g., Eldridge et al., 1988). The present research showed that there are changes that occur within and across sessions of the same experimental condition. For example, examining Bird F1's data from the correlated random walk analysis revealed that during the first exposure to FT 15-s, there was a progressive increase in sinuosity until approximately the middle of a session, after which there was a progressive decrease in sinuosity (see Figure 5). Similar effects are shown in the graphs from the information and Fourier analyses. In addition, the Fourier analyses revealed that all birds in the FT/FI study and in the autoshaping study had higher amplitudes near the end of a session than near the beginning of the session.

Unlike plots of movements in the *xy* plane and plots of the birds' distance from a reference location over time, the present techniques permit many subsets to be quantified and analyzed. Attempting to examine subsets of behavior, Silva et al. (1992) had to plot 25 graphs to show the behavior of a pigeon during 25 CS presentations. These same subsets, if quantified using the correlated random walk, information, or Fourier analysis, could be presented on a single graph. Therefore, from a practical perspective, the graphical displays of the outcomes of the three techniques described above permit concise representations of movements within and across sessions. This outcome is consistent with the present

research's goal of discovering heuristic advantages of quantifying movement patterns.

Response-Independent and Response-Dependent Schedules

The three techniques showed that response-dependent schedules of reinforcement result in movement patterns that are more stereotyped and show more within-session consistency than those during response-independent schedules. In addition, the Fourier analysis revealed that the dominant movement during FT 15-s and FI 15-s occurred at a frequency of approximately 4 cycles/min, although movements that occurred at faster frequencies were evident. Given that food was delivered four times per minute, it is likely that the frequency of 4 cycles/min corresponded to the birds moving toward the feeder when reinforcement was presented and moving away from the feeder immediately after reinforcement. Higher frequency movements likely corresponded to pacing movements during the IRI (see Eldridge et al., 1988). The Fourier analysis showed that these higher frequency movements were more dominant during FI 15-s than during FT 15-s. The results of the analyses can be interpreted from either a behavior systems view or an operant view.

Behavior systems view. It might be argued that periodic delivery of food during the first exposure to FT 15-s elicited preorganized phylogenetic movement patterns related to foraging (Timberlake & Lucas, 1985). According to the behavior systems view, learning evolved as alterations of already functioning systems that permitted closer tracking of these systems with survival-related aspects of the environment. Based on this view, placing an explicit contingency on movements serves to constrain and modify existing behaviors, resulting in an increase in stereotypy and efficiency during response-dependent schedules of reinforcement (Timberlake, 1983). However, if the imposed contingency results in a poorer fit between a behavior system and the demands of the environment, then a decrease in stereotypy may be observed. For example, requiring a pigeon that normally paces in response to periodic delivery of food to remain motionless for reinforcement produces a poor fit between its feeding system and the imposed contingency. Likewise,

requiring a spider that normally lies in wait for its prey to move about for reinforcement produces a poor fit between its feeding system and the imposed contingency.

Operant view. A second view posits that movements during response-independent schedules will be more variable than movements during response-dependent schedules because the response-reinforcer contingency is always changing to some degree. Stated differently, because there is no explicit contingency between movements and the occurrence of reinforcement during response-independent schedules of reinforcement, there is a greater probability that slight variations in movement will be reinforced from reinforcer-to-reinforcer, resulting in a decrease in stereotypy. However, if there is an explicit programmed contingency between a response and reinforcement, then it is likely that similar movements will be reinforced from reinforcer-to-reinforcer, resulting in an increase in stereotypy.

The data from the present study are consistent with both a behavior systems and an operant interpretation, since both assume that behavior during response-dependent schedules can be more stereotyped than behavior during response-independent schedules (although the behavior systems interpretation requires the assumption that the reinforced response fit an existing behavior system better during contingent reinforcement than during noncontingent reinforcement). However, since neither Eldridge et al. (1988) nor the present analyses were designed specifically to test the behavior systems view versus the operant view, important manipulations that may have resulted in a distinction between the two views are absent. For example, future research may be able to distinguish between the behavior systems and the operant view by examining movement patterns in the presence of different reinforcers (e.g., electrical brain stimulation, onset of a heat lamp in a cold chamber, food). The operant view suggests that similar movement patterns would develop across reinforcers, whereas the behavior systems view would predict the emergence of movement patterns that are specific to the behavior system activated by the reinforcer (Justice & Looney, 1990).

Another experiment that could shed some light on the operant vs. behavior systems

view would be to conduct an experiment similar to Eldridge et al.'s (1988). However, instead of reinforcing contact with a virtual target on an FI 15-s schedule, the behavioral tracking system could be used to reinforce contact with a virtual target on a fixed-duration 15-s (FD 15-s) schedule of reinforcement. In an FD schedule, the subject is reinforced only if it engages in the target response for a continuous duration. Thus, to receive reinforcement on an FD 15-s schedule, the subject in the preceding example would have to maintain contact between its head and the virtual sphere for 15 s. The operant view suggests that this should result in an increase in stereotypy relative to the FT 15-s condition. However, the behavior systems view suggests that requiring a pigeon to remain motionless while food is being presented results in a poor fit between a behavior system (related to food procurement) and a contingency; therefore, movements during the FD condition should be less stereotyped than those during the FT condition.

Autoshaping

The quantitative analyses of the movement patterns yielded insights into the processes that may be involved in autoshaping. Specifically, the data support previous findings that feeder training plays a significant role in the development of behavior that emerges during the CS (Downing & Neuringer, 1976; Engberg, Hansen, Welker, & Thomas, 1972) and during the ITI. Examination of Figures 13 to 16 shows that movements during the ITI gradually became more stereotyped. In contrast, movements during the CS initially became less stereotyped early in conditioning, but more stereotyped as conditioning progressed. A question that needs to be addressed is why do movements during the ITI become increasingly more stereotyped while movements during the CS become less stereotyped before becoming more stereotyped?

One possible explanation concerns the role of feeder training (Downing & Neuringer, 1976) and contextual conditioning (Balsam, 1985). Contextual conditioning occurs when a biologically significant stimulus (e.g., food) is presented periodically, usually without a discrete signalling stimulus. As a result, periodic delivery of food during feeder training

will normally result in the context acquiring control over the animal's behavior. Comparing the spectra of a hungry, naive pigeon to the spectra of a hungry, feeder-trained pigeon, Silva, Pear, Tait, and Forest (1991) noted that there is an increase in the stereotypy of movement patterns because of feeder training. At the conclusion of feeder training, the animal is typically engaging in stereotyped movements between deliveries of food.

During the first conditioning session, the animal continues to engage in the stereotyped movements that were conditioned during the feeder training sessions. Simultaneously, the animal is learning (because the CS consistently and reliably preceding the US) that the CS is the best predictor of food. Thus, the following scenario is a plausible description of the performance changes and learning processes that occur during the first conditioning session.

(1) The animal engages in movement patterns that have been conditioned during feeder training. Based upon the results of feeder training, the context is likely to be the best predictor of food.

(2) The CS is presented periodically and is followed by the presentation of food. Initial presentations of the CS have little or no control over the animal's behavior, therefore these presentations do not disrupt the movements occurring between presentations of food. It may be inferred that the animal has not learned that the CS is the best predictor of food.

(3) After several CS-US pairings the CS starts to control the animal's behavior. Thus, when the CS is presented, it disrupts the movements that were occurring during the ITI. It may be inferred that the animal is learning that the CS is the best predictor of food.

(4) Initially, the CS's disruption of the movement patterns is unsystematic, but eventually the CS comes to control specific stereotyped movements. It may be inferred that the animal has learned that the CS is the best predictor of food.

In short, the initial disruption caused by presentations of the CS may be the result of learning that the CS is the best predictor of food. There was limited disruption (if any at all) to the movements that occurred during the ITI because the movements that characterize behavior during the ITI (see Eldridge, 1991; Eldridge & Pear, 1987; Silva et al., 1992)

were previously learned during feeder training.

The view that learning results in an initial disruption of previously learned behaviors is at least partly consistent with the outcome of the analysis of the FT/FI data. As illustrated in Figure 5, there is an increase in sinuosity when the schedule of reinforcement was changed from FI 15-s to FT 15-s. Although this increase in sinuosity is probably due to the removal of the explicit response-reinforcer contingency that was present during FI 15-s, it is unlikely that this is the complete explanation, since the data during blocks 80 to 90 (i.e., the third session of the reversal to FT 15-s) for Bird F1 show that sinuosity was generally higher than during any other blocks plotted in the graph. Birds F2 and F3 show similar, though less compelling, marked increases in sinuosity at blocks 65 and 71, respectively. Future experiments in which marked changes in movement patterns occur between conditions have to be conducted before it is definitive that the process of learning involves an initial decrease in the stereotypy of movement patterns.

Another issue to address concerns the differences in the outcomes of the analyses between the birds from the autoshaping study. Although all analyses revealed the development of increasingly stereotyped movements, the degree of stereotypy varied between birds.

It appears that Bird A2's movement patterns may represent the "ideal" case. Early after the onset of conditioning, this bird's movements during the CS became less stereotyped, but became increasingly stereotyped as conditioning progressed. The emergence of stereotyped movements is similarly evident in the analyses of the movements during the ITI (see Figures 13 to 15). In addition, examination of the spectra resulting from the analysis of Bird A2's movements during the ITI shows that this bird's movement pattern consisted of two clearly distinguishable frequencies. The lower frequency movement may have corresponded with approaching and/or checking the response key, and the higher frequency movement likely corresponded with oscillatory pacing during the ITI (see Eldridge, 1991). The spectra resulting from the analysis of the movements during

the CS also shows two clearly distinguishable frequencies at approximately 4 cycles/min and at 11 cycles/min. It is unclear to which behaviors these frequencies corresponded. Since the CS was presented approximately once per minute, the aforementioned frequencies are too fast to have corresponded to approaching the CS, although they may have corresponded to vascillations during the CS. Moreover, these frequencies are too slow to have corresponded to keypecking during the CS (see Eldridge, 1991, and Figure 18 from the present study).

The absence of equally distinguishable effects for Birds A1 and A4 may be the result of analyzing an insufficient amount of data. It may be the case that continued analyses of these birds' movements during the CS and during the ITI would reveal effects similar to those of Bird A2. In other words, Birds A1 and A4 may not have progressed sufficiently through conditioning such that their movement patterns passed completely through the less-stereotypy to more-stereotypy sequence evident for Bird A2.

This seems like a reasonable possibility if we consider the following. Asymptotic responding was not rigorously defined in the present research. For the present analyses, asymptote was loosely defined as the session when the bird pecked at least 90% of the CSs presented. However, if asymptote is defined as pecking at least 90% of the CSs presented in a session over three consecutive sessions, then it becomes evident that Bird A2's behavior during the CS is closest to asymptote. Using this criterion, it would be necessary to analyze seven sessions for Bird A1, four sessions for Bird A2, and four sessions for Bird A4. Recall that three sessions were analyzed for Birds A1 and A2, and two sessions for Bird A4. A continuation of the research of this dissertation should examine the acquisition of the movement patterns during the CS according to a rigorous definition of asymptotic responding.

Finally, the present results showed that the first major increases in pecking the CS coincide with significant changes in the quantitative indices of the movement patterns. This effect is especially evident when the graphs in Figures 13 and 18 are compared. These figures show that the onset of keypecking at approximately blocks 11, 5, and 11 for Birds

A1, A2, and A4, respectively, is correlated with notable increases in sinuosity at the same blocks. (This same effect is evident to a lesser degree in Figures 14 and 15, which measure the dependencies between distance from the CS and the time during the CS.) It appears that the acquisition of the movement patterns during the CS is closely tied with the acquisition of keypecking. Again, the strength of a quantitative examination of the movement patterns is that we can now explore increasingly complex relationships between movement patterns and pecking during the CS.

General Uses of Correlated Random Walk, Information, and Fourier Analyses in Animal Learning

Learning as the organization of behavior. The present research permits the study of learning as not only the *acquisition of new responses* but as the *organization of existing responses* (see Gallistel, 1990; Timberlake & Lucas, 1989; see also Morgan, 1896; Skinner, 1953), where the responses are thought to reflect changes in the strength of synaptic connections between neurons in the brain (Hebb, 1949). For example, the acquisition of the movements toward the CS may have emerged from the movements that were occurring during feeder training and during the ITI. Similarly, according to the data presented in Eldridge et al. (1988), the contingency of contacting the virtual target sphere on an FI 15-s schedule seemed to restrict and redirect movements away from one area of the experimental chamber and toward another. The effect of the explicit response-reinforcer contingency was to redirect where the birds paced to an area that would increase the probability of reinforcement. Stated more explicitly, the birds could have stood motionless under the virtual target and contacted it by alternately raising and lowering their heads; instead, they engaged in behavior that was similar to the behavior that they engaged in during FT 15-s. The Fourier analysis showed that an effect of the explicit contingency during FI 15-s was to increase the probability of movements that occurred at important frequencies (i.e., frequencies that were dominant during the first FT 15-s condition). An issue that remains to be addressed is the mechanism(s) that underlie the pacing behavior (see Cohen & Campagnoni, 1989; Eldridge et al., 1988; Matthews, Bordi, & Depollo,

1990; Matthews & Lerer, 1987; Staddon & Simmelhag, 1971; Timberlake & Lucas, 1985).

Ecological validity. Although perhaps not as generally applicable as information and Fourier analyses, the correlated random walk analysis can be used to analyze large classes of movements in which spatial data are available. For example, the correlated random walk model could be used to analyze the movement of rats in a radial arm maze (e.g., Timberlake & White, 1990) or the movements of birds foraging for seeds in an aviary (e.g., Krebs, Healy, & Shettleworth, 1990). Presently, many researchers simulate foraging environments in the laboratory using preparations in which several sources of food (patches) are available (e.g., Mellgren & Brown, 1987) or in which schedules of reinforcement mimic the depletion of patches (e.g., progressive ratio schedules; Timberlake, Gawley, & Lucas, 1987). In a laboratory, a patch may consist of two keys programmed to deliver reinforcement on two different schedules, or two halves of an experimental chamber each correlated with different types of food. Laboratory simulations of natural foraging situations typically involve measuring discrete responses such as the number of barpresses or the number of times that a patch was visited. However, "foraging behavior often cannot readily be analyzed into the discrete responses that are the foundation of the operant world view because this behavior consists mostly of moving around attentively scanning the terrain." (Gallistel, 1990, p. 361) In fact, it is the rule rather than the exception that the field of animal behavior is predominantly concerned with continuous sequences, cycles, and topographical variations of behavior (Lehrer, 1979). A better method of assessing the degree of fit between a simulated foraging environment in a laboratory and a natural foraging environment is to track animals in both settings and quantify their movements in terms of sinuosity. According to Bovet and Benhamou (1988), animal movements should be high in sinuosity when they are foraging in a patch, but low in sinuosity when they are moving between patches. The extent that the natural environment and its laboratory analogs are similar could be assessed by comparing the outcome of a quantitative analysis of movement patterns of an animal visiting a patch in the lab with the movement patterns of the same animal visiting a patch in the natural

environment. In this way, the ecological validity of a laboratory foraging preparation can be ascertained.

Related to foraging is the behavior of animals during concurrent schedules of reinforcement. In one variation of concurrent schedules, an animal obtains reinforcement by responding on one or the other of two operanda, each programmed to deliver reinforcement after varying amounts of time and/or behavior. The animal "chooses" how much behavior it allocates to each schedule of reinforcement.

In a classic experiment involving concurrent schedules of reinforcement, Herrnstein (1961) noted that the relative frequency of responding on the two operanda "matched" the relative frequency of reinforcement of the two schedules in operation. This effect is known as the *matching law*. The impact of the matching law on operant theory cannot be exaggerated. Numerous studies and theoretical discussions resulting from Herrnstein's discovery form an important cornerstone in the study of choice behavior and laboratory simulations of foraging environments (see any volume of the *Journal of the Experimental Analysis of Behavior*).

If movement patterns bear a closer fit with natural foraging responses than discrete responses such as keypecks, then the correlated random walk and information analyses (and to a lesser degree, the Fourier analysis) could be used to ascertain whether the relative stereotypy of two movement patterns match the relative frequency of reinforcement of two concurrently operative schedules of reinforcement. The presence of "movement matching" would perhaps pave the way for a higher level examination of the mechanisms responsible for matching.

Despite the preceding discussion, it should be made clear that a quantitative analysis of movement patterns should supplement, not replace, distance vs. time plots or plots of movements in the xy plane (see Eldridge et al., 1988). Important information about direction and location are conveyed in plots of the movements of animals in the xy plane. For example, although quantifying movement patterns conveyed information about the

stereotypy of the patterns, none of the three analyses used in the present dissertation conveyed how far a bird was from the feeder or the response key. A comprehensive study of the continuity of behavior will likely require not only a quantitative analysis of movement patterns, but also information about where these patterns were executed. Two patterns may have identical amounts of sinuosity or be equally predictable, but one pattern may occur 1 cm from the feeder and the other may occur 60 cm from the feeder. Where the pattern is executed may be as important as its stereotypy.

Correlated Random Walk, Information, and Fourier Analysis: Limitations and Concerns

Discrete responses. Although it is possible to apply the correlated random walk, information, and Fourier analysis to behavior that is continuous (e.g., movements), these techniques are less appropriate for discrete responses such as the rabbit's nictitating membrane response. The correlated random walk analysis, developed specifically for movement patterns, cannot be used on data containing less than two spatial dimensions. Fourier analysis cannot be used on data in which there are insufficient periodicities. However, information theory has been applied with limited success to Pavlovian responses (Cantor, 1981).

Multiple processes. The correlated random walk, information, and Fourier analyses all presuppose that the researcher has existing information about the behavioral processes to be analyzed. Recalling Fox and Hayes' (1985) warning, it would be inappropriate to conduct a Fourier analysis across more than one statistical process such as across movements during the CS and the ITI. In this case, the resulting spectrum would not accurately reflect behavior during the CS and during the ITI; rather, the resulting spectrum would be a composite of movements across stimulus conditions.

The solution to this problem is to have a data window that would slide or move across the time series in small steps. Presumably, if the process is stable, spectra within a process should be similar while spectra from different processes should be different. In this manner, Fourier analysis could assist in the identification of different behavioral

processes. Similar, though less obvious, sliding windows could be used with the correlated random walk and information analyses.

"Perhaps it would be better not to know everything". It was argued above that complex data analyses like those used in this dissertation can serve several important functions such as identifying effects that are unnoticed by our perceptual processes. Baer (1977) has pointed out that perhaps psychologists do not want to know about effects that are unseen by our perceptual processes. Robust, meaningful effects will inevitably reveal themselves. If researchers suspect the existence of certain effects, then they should carefully control independent variables so that these effects are readily apparent.

Similarly, Michael (1974) argues that complex data transformations inevitably require researchers to invest time learning to conduct and interpret the results generated by these techniques. The time spent learning about complex data transformations could be better spent on activities relevant to the researcher's subject matter. (Although it could be argued that the data analyses presented in this dissertation are relevant to the subject matter [e.g., stereotypy] in animal learning and behavior.)

Conclusions

The present research quantified the movement patterns of pigeons during FT schedules and FI schedules of reinforcement and autoshaping using a correlated random walk, an information, and a Fourier analysis. These techniques represented changes in the movement patterns generated by pigeons during FT and FI schedules of reinforcement that was consistent with the analyses and interpretations of Eldridge et al. (1988). Furthermore, the discussion above attempted to illustrate that a quantitative analysis of movement patterns can be a powerful approach in the field of animal learning by providing information about the stereotypy of movements during basic reinforcement contingencies. Additional quantitative studies of animal movement may lead to higher level theories of behavior that refer to complex causal systems between the response-defining action, contingencies of reinforcement, and movement patterns. The quantitative techniques used

in this research may also be used to study of learning as the organization of existing responses and permit a more direct evaluation of the ecological validity of laboratory analogs of natural environments. Finally, the techniques were consistent in their representation of the changes in the movement patterns of pigeons.

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```

PROGRAM path;
{analysis of random turning in movement paths }
{IBM version of program supplied by Simon Benhamou}
{current version 2.0.0 modified for the Macintosh }

```

TYPE

```

    tableau = ARRAY[1..7000] OF real;

```

LABEL

```

    99;

```

CONST

```

    pi = 3.141592656;
    fState = 2;

```

VAR

```

    BufferFile1, BufferFile2: text;
    ang: tableau;
    hist: ARRAY[1..36] OF integer;
    i, n, nr, ncl, nucl, j, state: integer;
    aState, cc, distance, passes: integer;
    rb, alp, r, r2, ri, rs, x, y, z, time: real;
    xt, xdp, ydp, xdt, ydt, c: real;
    s, d, de, t, u, cbp, tx, ty, xd, yd: real;
    tx2, ty2, sxy, sco, ssi, ap, as, val, xs: real;
    ys, xp, yp, k, moy, ect, ft, fte, ds, dp: real;
    dsup, dma, dmi, sx, sx2, sy, sy2, ar, arp, pd, pr, fo, it, sinu: real;

```

```

FUNCTION atan (y, x: real): real;

```

BEGIN

```

    IF x = 0 THEN
        IF y < 0 THEN
            atan := -pi / 2
        ELSE
            atan := pi / 2
        ELSE IF x > 0 THEN
            atan := arctan(y / x)
        ELSE IF y < 0 THEN
            atan := arctan(y / x) - pi
        ELSE
            atan := arctan(y / x) + pi;

```

```

END;

```

```

FUNCTION mod2pi (a: real): real;

```

BEGIN

```

    IF a > pi THEN
        mod2pi := a - 2 * pi
    ELSE IF a < -pi THEN
        mod2pi := a + 2 * pi
    ELSE
        mod2pi := a;

```

```

END;

```

```

FUNCTION fn (z: real): real;
  VAR
    fna, fnb, fnc, az, t: real;
  BEGIN
    az := abs(z);
    t := 1 / (1 + 0.2316419 * az);
    fna := -1.82125598 + t * 1.33027443;
    fnb := 0.3989423 * t * exp(-az * az / 2);
    fnc := fnb * (0.31938153 + t * (-0.35656378 + t * (1.78147794 + t * fna)));
    IF (z > 0) THEN
      fn := 1 - fnc
    ELSE
      fn := fnc;
    END;

```

```

FUNCTION fne (alp, rb: real): real;
  VAR
    sig, z1, z2, z3: real;
  BEGIN
    sig := sqrt(-2 * ln(rb));
    z1 := alp / sig;
    z2 := (alp + 2 * pi) / sig;
    z3 := (alp - 2 * pi) / sig;
    fne := fn(z1) + fn(z2) + fn(z3) - 1;
  END;

```

```

FUNCTION rbp (tx, tx2, ty, ty2, txy: real; nv: integer): real;
  VAR
    s, s1, s2: real;
  BEGIN
    s := tx * ty / nv;
    s1 := tx2 - (tx * tx) / nv;
    s2 := ty2 - (ty * ty) / nv;
    rbp := (txy - s) / sqrt(s1 * s2);
  END;

```

```

PROCEDURE tri (VAR tab: tableau; n: integer);
  VAR
    i, j: integer;
    x: real;
  BEGIN
    FOR i := 1 TO n - 1 DO
      FOR j := i + 1 TO n DO
        IF tab[j] < tab[i] THEN
          BEGIN
            x := tab[j];
            tab[j] := tab[i];
            tab[i] := x;
          END;
        END;
      END;
    END;

```

```

PROCEDURE initialization;
  VAR

```

```

WindowRect: rect;
BEGIN
  SetRect(WindowRect, 2, 40, 390, 280);    {parameters for display window}
  SetTextRect(WindowRect);
  write('rediscrretization step length in cm ? ');
  readln(r);
  write('value for flag indicating alternate (non-analysis) state? ');
  readln(aState);
  reset(BufferFile1, OldFileName('Please open a file to read:'));
  rewrite(BufferFile2, NewFileName('Enter name of file to write to:'));
  writeln;
  writeln('Analyzing data');
  ncl := 9;           {number of classes set to 9}
  cc := 0;
  passes := 0;
END;

```

```

{-----}
{Main Program                               }
{-----}

```

```

BEGIN
  initialization;
  WHILE NOT eof(BufferFile1) DO
    BEGIN
      readln(BufferFile1, time, xd, yd);
      xd := xd * 0.25;    {converts BSA units to cm}
      yd := yd * 0.25;    {converts BSA units to cm}
      FOR i := 1 TO ncl DO
        hist[i] := 0;
        val := 2 * pi / ncl;
        sco := 0;
        ssi := 0;
        tx := 0;
        tx2 := 0;
        sxy := 0;
        ar := 0;
        r2 := sqr(r);
        ri := 0.99 * r;
        rs := 1.01 * r;
        xp := xd;
        yp := yd;
        n := 1;
        nr := -1;
        as := 0;
99:  WHILE (cc < 1) AND NOT eof(BufferFile1) DO
        BEGIN
          readln(BufferFile1, time, x, y, z, distance, state);
          IF (state = aState) THEN
            GOTO 99;
          IF (state = fState) AND (time = 0.0) THEN
            GOTO 99;
          IF (state = fState) THEN

```

```

BEGIN
  cc := cc + 1; {counts no. of food}
  GOTO 99;
END;
x := x * 0.25; {converts BSA units to cm}
y := y * 0.25; {converts BSA units to cm}
n := n + 1;
d := sqrt(sqrt(x - xd) + sqrt(y - yd));
WHILE d > ri DO
  BEGIN
    xdp := xd;
    ydp := yd;
    ap := as;
    nr := nr + 1;
    IF d < rs THEN
      BEGIN
        xd := x;
        yd := y;
        d := 0;
      END
    ELSE
      BEGIN
        alp := atan(y - yp, x - xp);
        c := cos(alp);
        s := sin(alp);
        xdt := (xd - xp) * c + (yd - yp) * s;
        ydt := (yd - yp) * c - (xd - xp) * s;
        xt := sqrt(r2 - sqrt(ydt)) + xdt;
        xd := xp + xt * c;
        yd := yp + xt * s;
        d := sqrt(sqrt(x - xd) + sqrt(y - yd));
      END;
    as := atan(yd - ydp, xd - xdp);
    IF nr > 0 THEN
      BEGIN
        ang[nr] := mod2pi(as - ap);
        arp := ar;
        ar := ang[nr];
        nucl := trunc((ar + pi) / val) + 1;
        hist[nucl] := hist[nucl] + 1;
        sco := sco + cos(ar);
        ssi := ssi + sin(ar);
        tx := tx + ar;
        tx2 := tx2 + ar * ar;
        sxy := sxy + arp * ar;
      END;
    END;
    xp := x;
    yp := y;
  END;
BEGIN
  cc := 0; {keeps track of no. of IRIs}
  writeln;

```

```

writeln(BufferFile2, 'num input pts:', n : 8, ' num rotations:', nr : 8);
rb := sqrt(sco * sco + ssi * ssi) / nr;
pr := atan(ssi, sco);
pd := 180 * pr / pi;
moy := tx / nr;
ect := sqrt(tx2 / (nr - 1) - moy * tx / (nr - 1));
sinu := 1.18 * ect / sqrt(r);
u := rb * cos(pr) * sqrt(2 * nr);
sx := tx - ar;
sx2 := tx2 - ar * ar;
sy := tx - ang[1];
sy2 := tx2 - sqr(ang[1]);
cbp := rbp(sx, sx2, sy, sy2, sxy, nr - 1);
writeln(BufferFile2, 'mean, st. dev., and auto correl.:', moy : 10 : 3, ect : 10 : 3, cbp : 7 : 3);
writeln(BufferFile2, 'r, phi(deg.) and u(v-test):', rb : 7 : 3, pd : 7 : 2, u : 7 : 3);
writeln(BufferFile2, 'SINUOSITY', sinu : 8 : 3);
writeln;
writeln('histogram of the angular distribution.');
```

FOR i := 1 **TO** ncl **DO**

```

    write(hist[i] : 6);
    writeln;
    t := abs(moy) * sqrt(nr) / ect;
    writeln;
    writeln(BufferFile2, 't-test on the mean: t= ', t : 6 : 3);
    fo := 0;
    tri(ang, nr);
    it := 1 / nr;
    dmi := -fne(ang[1], rb);
    dma := 0;
    dsup := 0;
    FOR i := 1 TO nr DO
        BEGIN
            ft := fn(ang[i] / ect);
            fte := fne(ang[i], rb);
            dp := abs(fo - ft);
            fo := fo + it;
            ds := abs(fo - ft);
            de := fo - fte;
            IF de > dma THEN
                dma := de
            ELSE IF (de - it) < dmi THEN
                dmi := de - it;
            IF dp > dsup THEN
                dsup := dp;
            IF ds > dsup THEN
                dsup := ds;
        END;
    k := sqrt(nr) * (dma - dmi);
    writeln(BufferFile2, 'kolmogorof test:  dmax= ', dsup : 8 : 3);
    writeln(BufferFile2, 'kuiper test:      k= ', k : 8 : 3);
    writeln(BufferFile2);
    passes := passes + 1;
    writeln;

```

```
        writeln('curent number of passes ', passes);  
    END;  
    END;  
    Close(BufferFile1);  
    Close(BufferFile2);  
END.    {program path}
```

PROGRAM Information_Analysis;

```
{The following program analyzes the relationship between }
{sets of data according to the algorithm supplied in    }
{"Numerical Recipes in Pascal".                        }
{date: 01 August 1991                                }
{version: 3.1.0                                        }
```

CONST

```
maxi = 256;      {maximum number of rows}
nj = 60;         {maximum number of columns}
fState = 2;      {value of flag indicating food}
duration = 6;    {value for length of system beep}
```

LABEL

```
99, 100;         {locations used in goto statements}
                 {99 is label used in while loop that controls which}
                 {data are read, and 100 is the label corresponding}
                 {to the data summary section and the last lines of}
                 {code that the program executes upon encountering}
                 {the eof marker.}
```

TYPE

```
IntegerArrayNIbyNJ = ARRAY[1..maxi, 1..nj] OF integer;
RealArrayNI = ARRAY[1..maxi] OF real;
RealArrayNJ = ARRAY[1..nj] OF real;
```

VAR

```
h, hx, hxgy, hy, hygx, uxgy, uxy, uyx, time: real;
i, j, ni, nni, x, y, z, dist, state: integer;
cmdist, cc1, passes, aState: integer;
nmbr: IntegerArrayNIbyNJ;
BufferFile1, BufferFile2: text;      {buffer files}
```

```
{----- }
{Numerical Recipes in Pascal routine for calculating entropy }
{----- }
```

```
PROCEDURE entropy (VAR nn: IntegerArrayNIbyNJ; ni, nj: integer; VAR h, hx, hy, hygx, hxgy: real; VAR
    uyx, uxgy, uxy: real);
```

CONST

```
tiny = 1.0e-30;
```

VAR

```
j, i: integer;
sum, p: real;
sumi: RealArrayNI;
sumj: RealArrayNJ;
```

BEGIN

```
sum := 0;
FOR i := 1 TO ni DO
```

```

BEGIN
  sumi[i] := 0.0;
  FOR j := 1 TO nj DO
    BEGIN
      sumi[i] := sumi[i] + nn[i, j];
      sum := sum + nn[i, j]
    END
  END;
  FOR j := 1 TO nj DO
    BEGIN
      sumj[j] := 0.0;
      FOR i := 1 TO ni DO
        sumj[j] := sumj[j] + nn[i, j]
      END;
      hx := 0.0;
      FOR i := 1 TO ni DO
        BEGIN
          IF sumi[i] <> 0.0 THEN
            BEGIN
              p := sumi[i] / sum;
              hx := hx - p * ln(p)
            END
          END;
        END;
      hy := 0.0;
      FOR j := 1 TO nj DO
        BEGIN
          IF sumj[j] <> 0.0 THEN
            BEGIN
              p := sumj[j] / sum;
              hy := hy - p * ln(p)
            END
          END;
        END;
      h := 0.0;
      FOR i := 1 TO ni DO
        BEGIN
          FOR j := 1 TO nj DO
            BEGIN
              IF nn[i, j] <> 0 THEN
                BEGIN
                  p := nn[i, j] / sum;
                  h := h - p * ln(p)
                END
              END
            END
          END;
        END;
      END;
      hygx := h - hx;
      hxgy := h - hy;
      uygx := (hy - hygx) / (hy + tiny);
      uxgy := (hx - hxgy) / (hx + tiny);
      uxy := 2.0 * (hx + hy - h) / (hx + hy + tiny);
    END; {entropy}
  
```

{-----}


```
{Routine for initializing variables and setting data files
{-----}
PROCEDURE initialization;
```

```
VAR
```

```
WindowRect: rect;
```

```
BEGIN
```

```
reset(BufferFile1, OldFileName('File to analyze? '));
rewrite(BufferFile2, NewFileName('File for output? '));
SetRect(WindowRect, 2, 40, 390, 280);
SetTextRect(WindowRect);
write('value for flag indicating alternate (non-analysis) state? ');
readln(aState);
writeln('No. of rows? ');
write(' [enter: 256 for ITI; 150 for superstition; 80 for CS] ');
readln(nni);
ni := nni;
passes := 0;
cc1 := 0;
END; {initialization}
```

```
{-----}
{MAIN PROGRAM: Calls "initialization" & "entropy"}
{-----}
```

```
BEGIN
```

```
initialization;
```

```
WHILE NOT eof(BufferFile1) DO {major control loop}
```

```
BEGIN
```

```
FOR j := 1 TO nj DO {initializes all elements of array to zeros}
```

```
FOR i := 1 TO ni DO
```

```
nmb[r[i, j]] := 0;
```

```
i := 0;
```

```
j := 0;
```

```
{Data from 6 successive stimulus conditions of the same type}
{are used in each analysis (e.g., ITIs 7,8,9,10,11,12). }
```

```
99:
```

```
WHILE (cc1 < 6) DO
```

```
BEGIN
```

```
IF eof(BufferFile1) THEN
```

```
GOTO 100;
```

```
readln(BufferFile1, time, x, y, z, dist, state);
```

```
IF (state = fState) AND (time = 0.0) OR (state = aState) THEN  
GOTO 99;
```

```
IF (state = fState) THEN
```

```
BEGIN
```

```
i := 0;
```

```

    cc1 := cc1 + 1;
    GOTO 99;
END;      {if state = fState}

cmdist := dist DIV 4; {converts distance to cm}
IF cmdist > 60 THEN {check to see if distance is within range}
    cmdist := 60;
i := i + 1;

IF (i > ni) THEN {check so value of ni is not exceeded}
    BEGIN
        REPEAT
            IF eof(BufferFile1) THEN
                GOTO 100;
            readln(BufferFile1, time, x, y, z, dist, state);
        UNTIL (state = fState);
        i := 0;
        cc1 := cc1 + 1;
        GOTO 99;
    END;      {if i > ni}

    j := cmdist;
    nmbr[i, j] := nmbr[i, j] + 1;
{writeln(time : 3 : 2, state, i, j, nmbr[i, j]);}
END;      {while cc1 < 6}

100:
entropy(nmbr, ni, nj, h, hx, hy, hygx, hxgy, uyx, uxgy, uxy);
passes := passes + 1;
writeln(BufferFile2);
writeln(BufferFile2, 'entropy of table      ', h : 10 : 4);
writeln(BufferFile2, 'entropy of x-distribution ', hx : 10 : 4);
writeln(BufferFile2, 'entropy of y-distribution ', hy : 10 : 4);
writeln(BufferFile2, 'entropy of y given x      ', hygx : 10 : 4);
writeln(BufferFile2, 'entropy of x given y      ', hxgy : 10 : 4);
writeln(BufferFile2, 'dependency of y on x      ', uyx : 10 : 4);
writeln(BufferFile2, 'dependency of x on y      ', uxgy : 10 : 4);
writeln(BufferFile2, 'symmetrical dependency      ', uxy : 10 : 4);
writeln('number of passes', passes);
cc1 := 0;
END;      {while not eof(BufferFile1)}

close(BufferFile1);
close(BufferFile2);
sysbeep(duration);
writeln('Press <RETURN> to exit program');
readln;
END.      {Main Program}

```

PROGRAM Spectrum;

```
{The following program computes an FFT according to the }
{Sande-Tukey FFT algorithm (i.e., a decimation-in-frequency }
{algorithm). The program is modified from the the one }
{supplied by Crandall & Colgrove (1986) in }
{"Scientific Programming with Macintosh Pascal." }
```

CONST

```
pi = 3.141592653589795;
size = 256; {program analyzes data in blocks of 256 pts. }
fState = 2; {value for flag indicating food state }
```

LABEL

```
88, 99, 100;
```

TYPE

```
complex = RECORD
  re, im: double;
END;
```

VAR

```
c, i, e, m, n, j, k, p, q, xc, yc, zc, state: integer;
cc, ccx, duration, aState, scout: integer;
amp, ampsquare, phase, time, dist, freq: real;
x, exp: ARRAY[0..257] OF complex;
f, f2: text; {Buffer Files}
```

PROCEDURE inplace (**VAR** g, h: complex; f: complex);

```
{Performs in-place computation for data pair (g,h) and }
{exponential multiplier f. }
```

VAR

```
tmp: double;
```

BEGIN

```
g.re := g.re + (f.re * h.re - f.im * h.im);
g.im := g.im + (f.re * h.im + f.im * h.re);
tmp := g.re - 2 * (f.re * h.re - f.im * h.im);
h.im := g.im - 2 * (f.re * h.im + f.im * h.re);
h.re := tmp;
END;
```

PROCEDURE initialization;**VAR**

```
WindowRect: rect;
```

BEGIN

```
reset(f, OldFileName('File to analyze? '));
rewrite(f2, NewFileName('File for output? '));
```

```
SetRect(WindowRect, 2, 40, 390, 280);
SetTextRect(WindowRect);
```

```
write('value for flag indicating alternate (non-analysis) state? ');
readln(aState);
writeln('analyzing superstition or autoshaping data?');
write(' [enter 4 for superstition; 2 for CS; 5 for ITI] ');
readln(ccx);
writeln;
writeln('Now reading data from disk');
```

```
cc := 0;
freq := 0;
scount := 1;
duration := 6;
END; {initialization}
```

```
{-----}
{Main Program: Calls "inplace" and "initialization"}
{-----}
```

BEGIN

```
initialization;
```

```
WHILE NOT eof(f) DO {major control}
```

BEGIN

```
c := 1;
n := round(ln(size) / ln(2));
```

```
88:
```

```
WHILE (cc < ccx) DO {controls which data are analyzed}
```

BEGIN

```
IF eof(f) THEN
```

```
GOTO 100;
```

```
readln(f, time, xc, yc, zc, dist, state);
```

```
IF (state = aState) THEN
```

```
GOTO 88;
```

```
IF (state = fState) THEN
```

```
cc := cc + 1;
```

```
END; {while cc < ccx}
```

```
cc := 0;
```

```
FOR j := 0 TO size - 1 DO
```

BEGIN

```
{Next, fix sin & cos array elements for maximum speed later}
```

```
exp[j].re := cos(2 * pi * j / size);
```

```

exp[j].im := sin(2 * pi * j / size);
{Next, scramble the input order with reverse-complement-binary}
e := size DIV 2;

```

```

i := j;

```

```

k := 0;

```

```

m := 1;

```

```

REPEAT

```

```

  p := i DIV e;

```

```

  i := i MOD e;

```

```

  e := e DIV 2;

```

```

  k := k + m * p;

```

```

  m := m + m;

```

```

UNTIL e = 0;

```

```

{Next, get the actual single-real function of distance data}

```

```

99:

```

```

  IF eof(f) THEN

```

```

    GOTO 100;

```

```

  readln(f, time, xc, yc, zc, dist, state);

```

```

{the if-then-goto loop will terminate when size-1 has been reached}

```

```

  IF (state = fState) OR (state = aState) THEN

```

```

    GOTO 99;

```

```

  dist := dist * 0.25; {converts BSA units to cm}

```

```

  x[k].re := dist; {assign dist value to real number in record}

```

```

  x[k].im := 0; {imaginary values set to zero}

```

```

  x[k].re := x[k].re * (0.5 - 0.5 * cos(2 * pi * j / (size - 1))); {Hanning window}

```

```

END; {for j:=0 to size-1}

```

```

writeln('Now computing FFT');

```

```

e := size;

```

```

FOR j := 0 TO n - 1 DO

```

```

  BEGIN

```

```

    e := e DIV 2;

```

```

{Next, use decimation-in-frequency FFT algorithm}

```

```

{j will be the count of in-place full-vector iterations}

```

```

    FOR k := 0 TO e - 1 DO

```

```

      BEGIN

```

```

        FOR i := 0 TO e - 1 DO

```

```

          BEGIN

```

```

            p := k + e * (2 * i);

```

```

            q := p + e;

```

```

            m := (p * e) MOD size;

```

```

{Next, process the (p-th, q-th) 'butterfly'}

```

```

            inplace(x[p], x[q], exp[m]);

```

```

          END; {for i:=0 to e-1}

```

```

        END; {for k:=0 to e-1}

```

```

      e := e + e;

```

```

    END; {for j:=0 to n-1}

```

```

writeln(f2);

```

```

{Next, output the frequency, amplitude, amplitude squared, & phase}

```

```

FOR j := 2 TO 30 DO
{This for-loop controls what is printed to files f2 and f3.      }
{Data at frequencies j0 and j1 are not printed - j0 is the     }
{mean distance and j1 is the wave created by the windowing.   }
{Originally, loop was FOR j := 2 TO size DIV 2 DO; however, }
{there was never any need to print out more than 20.          }
  BEGIN
    x[j].re := x[j].re / sqrt(size);
    x[j].im := x[j].im / sqrt(size);
    amp := sqrt(sqr(x[j].re) + sqr(x[j].im));
    ampsquare := sqr(amp);
    phase := arctan(x[j].im / x[j].re);
    freq := (60 * j) / (size * 0.1);
    writeln(f2, freq : 3 : 2, ',', ampsquare : 10 : 2, ',', phase : 3 : 2, ',', scout);
  END;    {for j:=1 to size DIV 2}

scout := scout + 1;
writeln('Current number of passes ', scout - 1);

REPEAT
  IF eof(f) THEN
    GOTO 100;
  readln(f, time, xc, yc, zc, dist, state);
UNTIL (state = aState) OR (state = fState);

100:
  END;    {while major}
  close(f);
  close(f2);
  sysbeep(duration);
END.    {Main program}

```

AMPLITUDE SQUARED AT EACH FREQUENCY

Frequency/Phase (cycles/min)	Bird F1				Bird F2				Bird F3			
	FT 15-s	FI 15-s	FT 15-s (r.beg.)	FT 15-s (r. end)	FT 15-s	FI 15-s	FT 15-s (r.beg.)	FT 15-s (r. end)	FT 15-s	FI 15-s	FT 15-s (r.beg.)	FT 15-s (r. end)
Next-to-pentultimate 4.69	1.84	1.57	749.47	683.77	389.92	1898.61	1464.08	1212.79	7.28	448.97	0.91	104.83
(Session 1 of 7.03	135.66	78.80	204.01	871.08	144.17	1090.67	484.03	392.78	0.22	236.33	0.51	17.98
FT 15-s [r.beg]) 9.38	45.65	152.74	348.36	956.08	100.22	532.43	130.08	273.60	3.04	94.68	0.69	15.54
11.72	19.28	37.42	227.38	206.80	74.30	382.94	106.64	123.77	8.09	1464.51	0.14	4.64
14.06	59.69	20.36	261.22	7.55	97.66	515.83	400.60	135.63	3.65	1002.74	0.45	0.78
16.41	0.44	85.31	142.07	322.91	102.62	89.90	74.75	234.94	0.27	347.26	0.45	7.83
18.75	31.55	95.20	264.98	367.22	28.80	385.21	484.53	75.64	1.72	372.96	0.26	10.06
21.09	3.99	21.29	163.04	198.09	35.15	491.30	622.09	49.05	2.18	311.85	0.12	1.37
23.44	7.64	50.48	198.41	55.80	41.83	62.78	52.54	21.42	0.90	63.90	0.11	3.13
25.78	0.00	35.11	334.45	44.74	17.91	83.68	69.71	26.55	5.73	25.32	0.05	1.60
28.12	11.78	54.96	183.08	44.30	19.76	12.37	37.68	5.09	4.58	10.12	0.12	1.47
30.47	11.90	57.44	33.01	18.78	60.67	64.59	17.88	4.57	4.73	1.85	0.06	6.73
32.81	2.85	66.58	13.38	3.30	84.25	78.38	19.95	17.67	7.58	21.02	0.02	9.26
35.16	5.25	24.19	31.38	3.63	73.06	21.93	42.58	3.36	2.88	36.60	0.01	1.46
37.50	2.26	10.62	45.19	7.78	18.63	24.49	52.19	12.09	2.00	32.98	0.01	0.83
39.84	0.69	17.26	18.45	6.82	10.65	32.75	41.64	7.26	2.53	37.35	0.01	1.26
42.19	0.03	6.35	29.80	2.48	6.20	4.08	34.96	0.56	2.27	34.48	0.01	2.00
44.53	2.86	3.13	35.54	1.87	2.48	25.11	52.38	0.42	1.90	25.88	0.00	2.33
46.88	5.17	0.88	53.10	2.16	2.23	21.06	35.51	1.19	1.41	14.57	0.02	1.10
49.22	5.02	0.75	69.11	2.33	0.60	12.78	15.12	4.09	2.65	20.06	0.04	0.86
51.56	0.02	2.56	40.36	4.67	6.16	18.87	26.16	0.71	2.72	16.58	0.03	1.38
53.91	2.33	3.84	27.81	1.84	9.35	1.61	18.35	0.02	4.80	10.65	0.03	2.14
56.25	0.21	0.24	9.28	0.07	3.37	3.12	16.46	1.69	2.89	9.81	0.03	0.38
58.59	0.22	1.37	5.74	1.43	0.05	8.27	8.34	2.53	1.44	14.19	0.01	1.54
60.94	3.23	2.00	20.94	5.37	1.11	4.72	10.71	0.95	2.13	18.11	0.01	2.58
4.69	13.48	174.51	773.46	715.44	51.52	44.18	620.41	1588.23	1.40	1505.36	965.03	17.54
7.03	20.02	358.26	493.35	546.69	17.95	81.84	238.67	277.54	145.41	1252.35	787.94	9.39
9.38	1.77	187.64	370.78	148.05	15.04	515.68	273.52	51.45	14.58	81.78	1160.65	5.66
11.72	12.51	172.36	686.76	349.31	14.45	1680.75	493.29	495.96	103.83	136.60	591.51	3.60
14.06	21.91	51.24	599.67	188.24	11.42	2252.82	327.43	133.39	1.69	457.92	44.75	0.98
16.41	38.38	59.20	220.49	142.83	23.55	770.97	387.86	53.16	36.18	1002.39	156.72	1.43
18.75	26.27	360.63	412.90	117.88	27.06	48.86	337.60	193.06	8.69	497.41	100.87	0.11
21.09	1.11	142.70	194.38	16.57	39.21	159.58	157.70	18.86	16.67	84.33	10.36	0.43
23.44	17.95	44.18	125.96	9.14	15.93	60.77	50.06	27.59	14.96	215.64	9.46	0.98
25.78	8.46	190.71	243.72	3.77	24.61	8.26	38.38	17.08	18.22	136.15	13.14	0.83
28.12	0.12	267.83	247.94	5.18	16.59	26.17	17.96	7.19	2.24	88.96	49.51	5.12
30.47	5.84	47.89	99.51	4.97	4.28	97.97	11.31	11.76	1.83	81.17	8.74	10.79
32.81	6.69	26.58	5.82	5.16	15.65	57.58	26.71	5.70	2.40	31.04	4.42	4.73
35.16	1.05	36.52	23.13	10.47	8.46	48.96	30.65	6.74	3.17	8.99	2.61	0.09
37.50	1.08	1.26	54.41	7.75	3.68	28.93	34.18	3.12	0.44	25.44	8.28	3.79
39.84	1.24	29.09	9.41	2.94	7.24	39.54	36.74	1.61	5.51	43.67	19.21	2.93
42.19	0.30	24.56	14.89	6.56	13.71	22.82	27.68	7.70	7.64	33.89	10.53	0.56
44.53	2.28	18.88	24.91	7.08	14.88	8.78	18.37	5.92	7.82	18.35	7.67	1.24
46.88	1.06	12.24	35.11	0.26	14.96	12.00	10.91	3.71	9.23	25.52	11.85	1.66
49.22	2.00	3.61	57.79	2.70	9.24	9.46	12.86	1.35	4.00	26.07	9.80	0.14
51.56	1.52	6.99	15.38	1.50	0.64	29.99	19.67	4.93	1.88	19.82	5.93	0.03
53.91	4.57	14.90	7.09	0.63	0.02	37.43	17.34	5.70	1.41	19.38	10.84	0.30
56.25	1.39	0.33	6.45	0.07	0.06	19.03	12.09	5.64	0.97	17.71	4.93	0.18
58.59	0.46	8.33	19.08	1.44	0.97	23.57	10.04	1.71	1.28	13.28	0.68	0.35

60.94	0.15	8.99	19.47	3.98	2.49	26.52	13.91	0.11	5.25	15.09	4.11	1.24
4.69	30.98	257.41	484.05	4139.02	556.87	842.42	3663.62	1433.59	2.97	171.74	871.42	0.18
7.03	22.09	449.97	131.51	578.44	168.08	393.73	1362.74	1627.41	1.62	326.49	239.97	5.69
9.38	10.72	166.45	350.54	57.57	34.21	567.58	108.22	620.02	1.71	295.97	106.74	12.64
11.72	4.25	95.33	896.72	482.74	14.41	708.86	471.42	676.99	0.98	435.06	194.19	6.34
14.06	3.13	56.57	77.21	497.86	21.47	407.89	570.38	1357.75	0.55	34.69	211.33	3.46
16.41	33.06	118.55	243.58	34.97	58.12	320.12	118.73	23.40	5.95	8.28	131.78	5.21
18.75	33.97	398.91	274.86	51.83	24.30	283.65	60.29	158.88	9.48	405.37	689.64	17.92
21.09	17.56	232.37	348.85	112.18	92.57	43.46	175.70	105.08	3.80	137.83	281.32	3.33
23.44	3.08	147.62	322.88	40.53	24.32	50.22	19.24	91.14	3.62	24.54	87.54	2.13
25.78	19.43	61.09	116.60	36.79	12.85	235.71	5.76	10.22	0.04	8.29	23.28	1.88
28.12	43.81	29.44	27.36	3.89	20.12	83.08	10.69	55.72	2.23	49.36	53.24	1.09
30.47	7.53	98.38	22.27	16.02	11.69	17.08	16.07	15.55	3.67	3.44	85.77	0.74
32.81	7.32	33.87	45.80	3.66	8.76	11.90	41.20	16.90	7.55	31.54	73.24	0.86
35.16	3.11	35.76	85.35	9.11	6.22	9.96	5.35	7.39	1.33	12.35	59.56	0.68
37.50	1.17	8.85	41.91	13.10	3.57	3.37	10.03	0.70	0.78	10.29	26.05	0.57
39.84	0.94	24.20	16.42	39.88	1.14	12.63	8.81	0.59	4.06	9.85	8.75	3.92
42.19	2.91	36.15	15.97	33.33	0.76	20.36	4.57	1.46	2.40	1.97	30.94	4.74
44.53	3.13	46.72	3.88	25.44	0.25	3.92	9.92	1.21	2.73	16.73	26.93	1.69
46.88	0.05	5.97	4.59	13.54	4.35	4.99	5.79	3.65	2.00	12.74	17.75	2.98
49.22	1.14	43.28	21.03	4.91	23.16	2.88	4.26	8.78	1.10	3.81	16.87	1.60
51.56	1.04	25.41	22.67	12.93	19.16	6.72	3.87	7.34	0.60	1.02	21.98	3.15
53.91	0.10	6.41	0.19	19.25	5.56	0.60	0.46	7.48	0.88	0.81	21.74	0.07
56.25	0.09	37.23	13.54	9.03	6.77	11.04	2.51	2.89	0.82	2.88	27.89	4.58
58.59	0.15	26.21	19.35	6.04	6.57	1.48	4.90	1.93	0.75	8.63	31.10	4.26
60.94	0.38	3.39	18.36	3.87	2.50	6.62	6.25	0.06	1.50	8.03	15.68	2.27
4.69	22.79	1083.13	2043.71	2878.45	275.25	3824.99	1102.52	1223.57	10.57	588.60	674.57	2.38
7.03	3.36	1240.43	118.28	501.73	226.48	398.26	985.83	823.35	16.66	641.87	584.94	1.53
9.38	11.85	166.72	8.17	232.39	52.29	500.34	1588.22	392.80	11.10	225.51	788.52	0.88
11.72	1.40	1545.94	685.36	753.67	274.36	401.06	1040.01	1044.07	5.95	86.45	309.52	7.72
14.06	4.86	1252.52	218.77	38.36	37.21	69.96	234.23	51.26	11.59	270.60	51.78	3.48
16.41	14.96	8.97	338.21	261.42	55.79	553.18	34.75	505.88	9.99	399.17	351.08	0.96
18.75	18.83	281.38	219.57	124.73	61.79	158.37	11.72	106.12	7.79	63.48	124.06	0.38
21.09	17.46	145.95	154.77	4.54	19.82	61.45	36.83	28.57	8.82	153.10	70.27	1.42
23.44	0.12	8.40	378.05	73.77	14.42	62.72	97.97	4.76	10.31	222.75	16.10	2.89
25.78	17.00	30.32	344.36	12.11	0.77	164.73	63.15	22.96	2.00	215.19	117.92	4.05
28.12	4.79	22.04	194.43	14.27	2.58	91.36	59.07	14.50	0.73	98.23	127.44	3.14
30.47	4.76	3.33	124.94	28.05	4.93	14.46	15.63	12.62	0.10	20.25	56.23	5.62
32.81	1.74	3.73	38.43	18.49	12.49	35.25	25.99	25.51	0.23	24.70	32.59	1.60
35.16	11.31	13.47	30.38	7.58	1.06	7.66	48.24	6.42	1.35	50.30	20.73	1.08
37.50	2.00	35.19	39.12	10.17	12.58	17.71	28.10	0.42	2.61	31.78	17.84	1.60
39.84	4.92	21.05	18.99	6.29	2.66	25.58	11.50	2.00	5.15	14.22	20.78	2.43
42.19	1.56	12.92	13.61	1.93	5.26	23.81	21.92	0.83	6.14	24.01	43.63	1.49
44.53	3.26	2.71	23.06	1.31	5.39	2.32	43.12	3.15	2.15	18.07	33.61	2.52
46.88	1.64	18.13	20.23	0.52	0.09	6.81	38.91	9.91	1.79	26.85	21.48	1.45
49.22	0.06	15.80	57.72	3.62	3.90	0.74	23.60	4.53	0.58	15.08	27.77	0.80
51.56	0.37	5.17	52.51	0.73	3.35	6.49	10.38	0.52	1.26	9.05	24.94	0.37
53.91	0.48	6.89	10.39	0.38	0.82	12.69	14.57	1.05	5.56	15.50	16.14	1.51
56.25	1.46	0.18	4.69	0.32	2.32	10.08	10.05	1.32	4.14	8.31	19.80	2.88
58.59	2.00	2.85	8.82	0.70	4.63	12.10	9.96	0.71	0.54	5.87	22.95	1.60
60.94	4.37	5.57	23.67	1.59	3.29	11.46	10.85	0.82	0.11	17.50	12.84	0.07
4.69	94.69	171.63	1967.30	2983.01	290.49	543.27	7.02	726.21	29.39	51.60	2012.96	18.98
7.03	127.32	155.33	918.05	254.68	337.19	26.83	4.03	2557.47	20.14	39.06	1207.78	16.51
9.38	13.78	59.90	992.77	14.01	159.57	384.66	1.91	1899.15	7.52	133.01	74.81	1.43
11.72	77.13	41.54	342.39	409.23	193.69	365.58	15.78	174.78	7.11	142.38	949.83	12.69
14.06	55.26	45.28	235.02	161.50	56.10	797.31	16.13	1363.67	2.92	627.83	867.41	8.91
16.41	43.50	18.61	1.55	108.72	31.50	275.10	8.73	286.41	2.61	522.03	145.53	6.57
18.75	27.24	20.04	41.19	231.35	173.68	72.24	27.11	43.46	8.67	44.30	29.51	4.59
21.09	36.12	17.78	135.18	133.97	124.92	52.25	6.12	68.21	1.58	2.38	46.20	5.28
23.44	25.48	42.72	83.83	273.62	38.07	3.87	3.34	80.36	18.62	4.28	97.25	2.00
25.78	0.19	31.40	196.00	97.06	8.58	12.95	16.97	19.52	12.32	14.38	106.00	3.61

28.12	0.38	18.87	200.11	26.24	0.90	17.37	3.05	6.57	1.83	20.69	127.82	14.19
30.47	3.82	2.00	128.64	27.41	10.71	18.80	16.18	7.68	2.86	46.44	125.82	11.78
32.81	8.67	1.26	37.52	56.59	3.91	28.03	20.49	5.83	3.17	34.68	68.98	5.38
35.16	6.97	12.16	2.00	15.35	5.65	6.46	10.42	7.82	0.82	11.97	34.01	1.17
37.50	1.05	28.63	34.82	7.49	3.05	4.12	15.12	5.56	0.43	0.85	23.24	2.58
39.84	0.36	4.64	82.70	6.11	0.27	0.91	7.50	5.35	0.76	0.32	21.58	3.90
42.19	5.87	1.75	36.33	8.54	0.68	1.25	26.08	3.70	0.22	0.27	19.52	0.16
44.53	9.70	8.78	2.46	11.28	1.89	0.57	12.77	2.70	0.65	1.64	19.66	2.00
46.88	0.59	2.31	27.25	22.43	1.80	0.39	0.16	1.04	2.91	2.64	21.37	1.50
49.22	2.00	4.17	31.12	7.66	2.00	5.29	9.02	1.21	4.66	0.10	24.37	1.41
51.56	5.97	2.43	15.29	2.59	0.44	2.72	16.82	1.53	3.09	4.34	30.25	3.25
53.91	1.82	2.20	9.90	10.26	0.58	0.97	6.70	1.95	0.13	1.42	36.41	2.92
56.25	0.69	1.31	24.64	14.43	2.40	0.57	0.58	6.48	1.51	0.08	30.81	2.54
58.59	1.54	6.31	8.85	9.97	5.87	0.76	5.03	3.36	0.76	0.07	20.95	5.07
60.94	0.55	4.00	6.08	4.24	2.27	1.24	10.06	0.21	0.03	0.67	16.52	4.88
4.69	1.45	2131.68	2510.08	139.08	140.29	2126.23	2164.87	2721.44	192.82	810.00	1415.56	30.93
7.03	2.47	467.02	217.56	533.69	2.00	236.94	1699.79	533.25	176.44	446.85	655.02	30.50
9.38	2.50	26.60	114.07	718.34	80.19	289.70	625.85	381.01	174.23	294.80	966.31	4.05
11.72	2.70	153.59	195.62	470.67	2.94	81.66	60.76	1166.70	117.88	60.04	1221.41	23.34
14.06	18.71	646.27	207.82	501.53	70.78	146.29	209.54	68.45	89.92	65.73	271.85	20.15
16.41	26.33	318.15	934.70	478.13	45.63	418.71	163.93	449.79	67.44	523.44	3.67	0.84
18.75	42.25	132.68	267.90	329.80	13.64	3.76	270.53	11.34	56.89	401.95	28.76	11.83
21.09	6.55	449.91	556.12	188.78	51.87	225.57	304.35	19.10	56.72	54.69	36.11	8.17
23.44	20.61	171.71	344.46	162.20	26.47	43.78	74.60	34.81	53.22	15.47	138.22	3.87
25.78	7.41	20.27	86.97	150.15	8.53	37.31	47.61	2.71	47.93	31.47	115.75	2.62
28.12	14.11	179.29	63.15	46.52	4.40	6.23	29.03	7.67	18.18	112.67	54.38	4.32
30.47	2.49	213.72	17.11	4.89	10.90	1.48	72.21	0.89	12.15	172.48	15.99	5.24
32.81	26.01	60.27	4.36	3.51	4.12	4.84	105.26	0.32	8.08	135.78	42.68	0.80
35.16	17.01	48.25	3.43	9.45	4.63	29.07	24.22	2.34	10.19	61.81	58.05	2.00
37.50	7.92	64.22	6.23	12.78	12.67	12.46	2.35	4.85	4.96	26.73	32.07	2.16
39.84	0.26	61.10	3.98	32.61	7.72	16.58	15.05	0.48	1.35	27.12	18.95	0.05
42.19	1.88	35.72	40.08	34.31	3.30	2.00	5.09	4.01	0.79	42.64	8.43	0.22
44.53	1.84	0.37	39.88	19.73	1.59	5.24	2.26	3.97	1.02	61.43	8.86	1.47
46.88	0.65	28.94	11.42	7.45	5.08	1.33	10.25	4.94	0.12	34.81	19.89	1.31
49.22	4.34	31.92	13.10	2.49	3.19	7.61	14.28	2.95	1.30	15.04	32.94	0.51
51.56	6.62	30.14	11.70	6.16	5.83	8.34	17.96	2.24	2.57	14.66	18.08	3.27
53.91	2.29	19.53	6.69	20.08	4.11	14.05	13.96	3.11	4.20	21.85	9.94	3.84
56.25	2.23	3.41	10.25	11.69	1.05	9.01	4.45	0.45	3.44	32.64	16.50	1.09
58.59	1.42	7.71	8.50	5.10	0.59	1.96	10.96	1.59	1.92	19.18	13.72	2.93
60.94	1.78	10.32	3.35	4.47	0.53	3.12	9.67	1.43	7.63	16.87	13.93	2.77
4.69	29.86	394.18	1824.40	4180.18	182.75	1695.26	2663.69	2048.00	21.43	394.96	785.54	0.55
7.03	13.53	694.39	259.21	1163.52	40.82	157.02	1289.41	2030.41	71.97	78.21	630.91	2.35
9.38	0.45	589.62	270.07	59.49	68.18	222.29	1240.65	1070.63	9.66	173.42	470.39	1.42
11.72	31.70	306.55	565.26	244.98	40.91	100.95	1337.77	541.90	53.93	82.90	422.23	1.38
14.06	67.33	161.08	414.40	385.07	58.60	211.62	785.26	90.94	4.25	140.22	311.28	5.12
16.41	11.74	116.95	581.29	222.46	91.10	15.30	487.77	595.01	20.04	665.66	518.96	1.57
18.75	1.85	126.17	447.99	36.72	30.27	82.11	67.05	25.82	3.19	499.78	271.94	2.21
21.09	4.64	200.85	428.47	43.17	37.93	4.15	343.51	234.61	11.21	32.43	16.28	4.80
23.44	8.01	97.70	36.16	61.71	16.95	327.07	297.19	197.46	2.71	49.86	8.87	0.13
25.78	6.95	493.75	52.23	33.68	37.78	212.69	47.47	4.30	6.07	57.20	94.89	3.11
28.12	11.76	449.82	22.29	13.66	55.81	17.55	16.48	70.97	11.18	6.01	134.52	7.86
30.47	1.02	28.17	4.06	42.56	49.50	24.31	6.72	70.16	4.11	92.76	66.19	4.32
32.81	0.76	67.37	1.11	13.36	24.70	8.92	47.57	5.05	7.25	52.20	42.21	0.33
35.16	33.74	53.36	34.20	3.70	13.09	31.70	41.96	21.58	7.53	45.18	28.59	4.96
37.50	39.78	41.64	18.28	0.82	11.15	3.80	10.05	1.28	3.83	7.92	28.74	1.14
39.84	1.26	14.05	7.30	0.46	5.39	13.84	0.71	4.09	2.86	3.62	45.04	1.70
42.19	9.32	4.40	12.35	0.08	6.42	24.18	19.95	6.53	1.21	11.49	27.70	3.82
44.53	4.49	1.61	46.33	2.80	11.75	4.21	22.52	8.56	6.02	5.90	8.66	3.97
46.88	2.20	8.37	21.29	0.94	7.76	32.05	9.05	0.05	1.86	13.18	13.50	2.97
49.22	5.65	21.72	7.74	1.11	5.93	8.87	9.34	0.37	0.23	14.49	10.96	2.38
51.56	5.57	41.37	12.42	2.72	7.01	18.32	15.34	0.33	0.19	0.18	11.65	2.86

53.91	4.99	24.72	13.88	1.94	6.25	11.97	15.57	0.10	0.19	6.47	19.47	3.12
56.25	6.36	25.32	10.73	0.80	4.71	4.48	11.42	0.29	0.84	5.70	18.64	1.73
58.59	3.26	32.78	9.80	0.15	2.72	8.82	5.59	3.42	2.37	0.87	16.61	2.71
60.94	0.13	23.59	9.87	0.47	4.66	8.62	4.68	4.94	1.55	2.29	9.06	0.28
4.69	6.70	366.47	1612.58	1137.99	204.86	1709.90	4855.67	1356.50	8.39	209.21	895.24	248.23
7.03	6.29	385.03	474.28	2020.78	124.09	12.57	1110.19	760.47	1.68	53.54	743.04	168.50
9.38	19.66	243.24	108.02	1829.21	78.46	56.62	5.72	357.17	5.14	21.87	452.42	195.06
11.72	12.82	352.74	404.15	409.52	35.93	516.47	167.20	834.66	1.02	63.82	306.03	128.10
14.06	3.53	530.22	638.30	13.20	37.57	2070.24	378.75	1089.71	2.52	456.12	832.00	59.10
16.41	32.81	566.16	642.37	73.39	19.68	736.59	254.10	316.81	7.48	970.85	609.24	51.14
18.75	71.41	484.34	232.79	108.48	10.05	10.56	72.39	518.13	3.68	122.20	45.71	23.58
21.09	30.56	196.96	138.48	133.54	17.20	54.86	140.99	455.89	6.78	29.23	0.04	10.63
23.44	2.18	29.06	136.46	97.74	63.17	113.06	64.10	148.80	7.85	7.58	65.30	8.61
25.78	5.91	166.16	49.55	28.45	29.02	41.32	115.27	45.73	2.53	2.80	94.55	4.08
28.12	13.01	159.68	28.04	14.63	6.84	34.48	50.00	71.49	4.29	0.72	57.45	0.15
30.47	7.54	41.11	43.83	23.93	3.37	10.43	32.54	50.48	0.48	6.68	6.68	1.30
32.81	5.58	31.93	4.36	13.20	2.42	12.89	38.07	14.02	2.00	1.84	43.90	0.28
35.16	1.40	110.46	8.90	3.35	1.88	27.19	23.55	7.44	0.29	3.70	42.96	1.96
37.50	3.47	46.47	19.33	19.93	8.48	11.27	4.68	10.23	2.90	0.33	36.97	1.57
39.84	1.77	16.25	1.98	9.90	6.23	49.66	36.11	20.04	7.49	1.67	39.24	3.44
42.19	0.25	36.72	28.87	2.00	0.75	104.17	28.96	7.34	6.32	1.97	48.49	1.50
44.53	3.66	59.68	58.31	9.78	4.28	25.62	26.86	0.90	1.48	8.81	53.35	0.47
46.88	3.86	18.43	34.93	4.07	5.22	8.90	31.08	3.92	0.44	11.20	21.41	1.89
49.22	1.54	6.12	4.25	9.90	2.40	14.23	30.82	0.92	1.28	1.48	6.30	3.32
51.56	1.95	13.50	16.95	3.18	0.49	8.93	24.92	2.50	0.41	0.20	13.47	2.44
53.91	2.00	21.13	9.86	3.07	0.85	11.74	13.61	12.88	0.22	1.60	12.14	0.71
56.25	0.79	34.74	6.84	1.85	2.00	13.30	8.25	7.35	0.36	0.53	7.51	0.65
58.59	0.35	33.45	13.16	0.84	1.33	8.64	9.50	4.14	0.75	0.83	12.24	0.69
60.94	1.24	8.49	10.67	2.00	0.56	10.21	9.11	7.37	0.30	0.79	17.10	5.28
4.69	428.51	1552.30	1106.60	2023.60	33.56	1912.62	347.56	1455.52	1.99	592.88	1579.56	8.04
7.03	297.29	705.49	208.94	39.20	116.03	908.25	328.21	628.38	23.00	103.09	836.67	3.81
9.38	81.04	145.88	131.63	171.80	24.80	91.83	469.37	1334.71	28.55	190.38	380.17	2.28
11.72	64.75	963.27	290.58	98.50	32.55	205.98	431.48	433.74	32.85	7.44	280.16	2.94
14.06	12.13	294.94	648.27	44.52	8.11	124.85	958.12	410.36	19.39	257.37	25.14	5.58
16.41	7.84	92.59	252.81	87.04	152.19	507.38	1330.29	1231.55	5.22	123.78	556.39	2.74
18.75	8.16	521.73	284.13	7.24	52.69	552.15	77.99	197.82	9.81	267.03	364.54	0.33
21.09	27.06	434.94	536.87	133.60	2.20	144.55	24.78	19.84	9.87	69.55	74.50	6.96
23.44	43.87	135.22	360.58	9.46	1.32	127.08	88.34	120.93	23.49	62.40	11.19	8.82
25.78	17.17	49.84	48.30	75.65	1.42	267.31	90.71	74.00	20.93	12.01	8.85	0.18
28.12	0.73	0.53	7.15	15.29	5.34	181.55	14.40	61.83	25.18	27.17	61.73	3.96
30.47	1.30	49.44	31.00	2.32	16.39	7.38	55.34	41.09	16.07	31.05	107.00	3.09
32.81	12.18	124.38	8.34	4.31	22.66	49.08	85.24	45.68	8.17	54.84	103.46	3.19
35.16	9.55	118.87	31.16	7.08	13.29	45.43	15.32	31.99	5.06	70.13	41.72	1.60
37.50	2.68	66.62	106.98	3.38	12.64	16.66	4.01	57.76	3.69	64.74	12.34	0.63
39.84	13.24	20.28	61.04	8.99	30.96	39.34	6.40	34.36	1.29	27.97	23.48	0.08
42.19	9.31	23.64	20.50	4.52	3.23	40.13	6.23	5.62	1.23	10.60	34.05	0.44
44.53	2.00	29.58	21.40	2.20	1.64	20.09	0.40	6.25	0.29	9.04	21.60	3.35
46.88	0.41	44.43	31.38	2.00	0.64	15.81	2.19	25.50	0.58	14.18	19.57	6.19
49.22	0.03	48.44	61.24	0.08	5.92	27.81	1.08	13.76	2.36	16.41	24.91	2.39
51.56	0.69	32.55	44.47	1.92	7.99	9.73	4.68	4.76	2.00	6.23	36.05	0.09
53.91	3.30	11.13	26.24	2.00	1.16	1.03	9.66	0.41	1.22	7.84	34.29	0.05
56.25	10.36	5.32	25.39	0.07	0.76	8.76	8.75	0.14	0.05	7.80	17.05	0.40
58.59	3.78	8.33	26.05	0.37	4.65	15.46	1.79	0.62	0.73	5.81	10.84	0.17
60.94	1.65	6.66	27.43	1.09	2.57	12.42	1.34	4.06	0.08	5.10	15.98	0.12
4.69	6.30	369.81	1653.00	111.52	309.87	1602.21	2775.81	918.91	8.52	599.27	5.94	3.11
7.03	28.25	206.88	86.70	95.91	136.24	657.36	2035.75	227.00	6.70	378.49	2.00	3.46
9.38	35.57	174.20	183.32	18.51	15.27	1175.93	739.16	83.21	1.04	59.62	1.06	5.10
11.72	3.64	96.95	642.28	62.81	71.90	908.78	339.49	1403.71	3.81	48.34	1.65	1.55
14.06	5.39	92.71	1152.43	6.44	226.26	853.28	822.46	2201.63	4.23	125.63	0.31	1.68
16.41	0.86	13.82	703.75	1.01	184.59	631.73	106.55	571.99	9.67	6.45	0.19	6.90
18.75	13.34	1.86	98.55	2.00	64.11	273.56	223.69	233.21	8.45	113.36	0.40	2.22

	21.09	16.63	139.86	102.71	2.62	64.37	168.77	360.77	154.27	5.16	54.30	0.02	0.84
	23.44	74.98	101.56	111.54	3.15	99.01	231.53	99.29	95.16	6.28	457.42	0.17	0.89
	25.78	65.04	48.49	79.37	1.21	46.21	171.42	58.94	170.69	3.74	318.04	0.15	4.14
	28.12	3.92	34.25	9.67	0.79	18.82	46.87	55.81	52.97	0.21	7.86	0.01	4.59
	30.47	5.92	4.24	4.86	1.30	2.33	34.96	35.60	0.88	2.70	28.13	0.01	1.56
	32.81	1.29	9.96	38.47	1.67	6.37	53.38	54.83	2.13	0.11	46.87	0.08	1.46
	35.16	7.96	3.54	16.81	2.30	5.61	102.94	14.88	8.20	0.71	6.98	0.01	0.22
	37.50	2.66	0.24	25.91	4.59	1.94	54.12	48.01	10.91	1.70	7.47	0.03	0.40
	39.84	0.28	1.55	47.17	3.51	0.17	13.77	85.90	3.81	2.41	8.36	0.02	0.62
	42.19	3.16	0.72	31.22	0.40	0.45	22.96	29.83	31.72	2.92	35.84	0.00	1.91
	44.53	0.78	0.89	14.07	3.30	2.62	4.15	13.00	21.91	1.81	25.44	0.01	0.73
	46.88	4.19	4.84	11.42	2.88	5.30	5.61	24.45	1.67	0.75	1.66	0.01	2.72
	49.22	10.66	18.16	9.79	0.93	2.00	26.42	29.24	3.01	1.76	10.38	0.00	2.22
	51.56	0.55	7.75	10.99	0.02	1.12	43.91	23.97	13.83	3.56	9.90	0.01	1.78
	53.91	1.19	2.84	17.08	0.89	0.06	25.54	37.33	5.17	6.68	3.83	0.02	0.12
	56.25	0.52	1.51	13.52	0.17	0.65	12.45	16.59	4.42	5.78	6.65	0.01	1.64
	58.59	1.60	4.15	12.04	0.03	1.56	10.26	8.59	3.24	4.52	4.05	0.00	0.49
	60.94	0.91	0.35	5.73	0.34	6.00	22.49	16.55	4.12	0.26	3.56	0.06	0.02
Pentultimate	4.69	242.45	33.91	130.89	15.49	282.77	1292.03	924.62	3910.94	2.00	971.54	20.22	58.42
(Session 2 of	7.03	72.74	26.17	221.35	162.72	97.73	32.58	1678.61	1838.27	1.26	1118.69	14.86	43.26
FT 15-s [r.beg]]	9.38	144.76	8.63	376.57	64.02	23.91	1132.21	1656.44	589.17	1.09	446.51	8.68	23.77
	11.72	166.01	15.56	160.51	22.60	25.92	2334.57	2.21	70.09	0.06	129.20	5.11	62.02
	14.06	4.16	31.00	400.65	262.49	69.34	1437.61	233.08	149.30	0.60	523.75	8.37	60.75
	16.41	51.44	0.42	1130.92	41.20	147.84	368.67	49.49	14.38	0.81	25.90	0.44	19.17
	18.75	55.22	4.58	917.09	9.67	146.77	23.14	84.40	30.38	1.24	225.34	8.80	4.52
	21.09	21.77	5.93	207.69	10.91	49.79	90.69	10.37	32.41	3.18	63.50	5.49	2.24
	23.44	31.44	36.06	19.36	10.21	50.25	18.66	3.25	4.01	4.26	61.50	14.85	10.81
	25.78	23.99	4.58	1.83	19.19	61.71	78.12	3.99	16.03	2.77	43.48	11.19	2.40
	28.12	5.60	70.53	34.84	20.93	38.26	64.93	0.08	7.78	1.83	22.74	7.15	2.91
	30.47	0.22	58.15	33.98	15.90	16.95	102.61	9.88	1.94	3.50	50.59	7.08	6.31
	32.81	0.34	2.29	91.61	1.27	17.72	24.63	3.85	0.83	2.85	76.38	5.88	1.21
	35.16	1.90	14.93	96.21	3.57	15.11	55.65	4.06	2.58	3.22	73.52	8.90	3.95
	37.50	1.68	21.13	128.98	2.66	12.71	63.55	6.31	3.16	1.69	43.03	1.97	8.55
	39.84	0.63	6.06	74.00	0.26	2.00	38.23	9.49	0.28	1.67	42.66	0.43	2.54
	42.19	3.61	1.28	17.57	7.89	1.82	23.50	11.32	5.68	3.60	27.85	1.93	0.97
	44.53	18.42	8.08	5.49	2.00	2.51	15.67	0.60	3.24	1.55	23.78	6.48	0.78
	46.88	8.22	0.82	2.25	0.23	1.29	24.73	0.16	1.51	1.59	7.63	7.32	0.62
	49.22	0.32	6.94	18.49	0.07	2.40	16.65	0.17	1.61	1.91	10.82	8.91	0.06
	51.56	1.32	5.91	42.38	0.60	3.30	0.65	0.30	0.29	0.95	4.22	5.79	0.22
	53.91	0.25	3.95	21.41	1.26	3.29	5.15	1.44	0.05	0.28	9.19	0.20	0.20
	56.25	0.98	1.44	25.51	2.23	5.63	9.63	0.70	0.56	2.25	12.54	0.21	0.12
	58.59	0.78	1.43	21.06	4.36	3.14	16.13	1.38	0.38	4.34	6.98	1.47	0.75
	60.94	1.45	1.27	22.42	3.90	0.25	12.09	0.15	0.85	3.49	7.04	1.42	0.64
	4.69	9.44	876.50	840.73	1271.99	532.06	1173.46	2766.45	412.26	7.96	582.00	325.63	8.32
	7.03	1.97	215.86	505.15	1249.01	350.17	577.15	1544.83	300.20	2.79	162.19	120.57	1.33
	9.38	17.20	317.92	213.89	108.83	417.36	1627.59	774.83	144.20	1.28	109.63	60.41	4.36
	11.72	6.71	525.21	312.73	1082.91	301.23	2218.60	15.52	29.08	11.04	353.14	47.88	3.31
	14.06	4.60	0.98	611.79	779.95	228.29	628.96	167.35	17.63	13.05	421.35	23.84	2.20
	16.41	0.13	269.72	1302.79	0.81	69.11	5.61	14.27	20.43	11.18	23.64	2.55	2.98
	18.75	24.35	239.08	753.67	152.98	2.80	21.80	38.60	5.85	13.90	243.74	6.71	0.99
	21.09	48.94	288.31	172.18	204.95	12.43	105.00	67.47	7.38	11.33	91.10	10.80	4.65
	23.44	19.31	267.10	146.89	32.37	14.51	85.41	19.37	24.08	8.49	75.77	7.04	5.10
	25.78	28.89	18.89	164.05	25.67	11.31	83.08	22.74	16.85	9.76	6.65	2.55	4.23
	28.12	8.11	58.98	46.99	18.94	0.21	154.97	23.62	2.51	8.74	45.29	11.01	2.53
	30.47	0.05	54.28	5.63	5.39	1.81	67.38	33.15	13.41	3.68	62.82	14.09	2.80
	32.81	4.82	35.65	1.86	2.00	2.87	35.84	4.72	0.98	10.81	3.85	1.76	2.82
	35.16	2.31	86.47	17.94	0.87	0.86	58.03	4.09	0.79	8.34	25.70	1.85	0.28
	37.50	0.06	59.40	37.79	4.04	1.30	33.17	9.35	1.83	6.78	28.40	0.27	1.99
	39.84	5.13	6.78	37.22	0.58	1.23	36.70	4.51	3.37	3.66	15.00	2.19	0.47
	42.19	11.90	14.45	12.05	7.15	1.53	36.98	6.17	0.11	1.85	3.24	0.81	0.13
	44.53	1.65	32.86	36.82	1.37	0.54	23.61	8.85	2.45	1.29	6.52	0.94	1.03

46.88	2.61	28.99	25.78	4.73	0.58	29.81	0.73	5.54	0.37	2.72	2.39	0.23
49.22	4.75	33.48	11.22	6.49	1.49	27.89	3.20	0.33	3.10	9.35	1.38	1.39
51.56	1.79	3.33	24.35	0.03	0.46	23.13	12.78	1.05	3.39	22.11	0.06	1.30
53.91	0.87	22.38	13.08	5.40	0.10	17.55	4.97	2.00	0.98	6.95	0.16	0.03
56.25	0.64	29.28	11.51	6.10	0.22	12.41	1.40	1.40	0.36	4.42	2.27	0.73
58.59	2.82	21.47	16.60	4.33	0.13	9.35	1.64	1.26	0.71	5.57	2.28	0.45
60.94	4.05	19.32	3.33	1.70	0.44	9.43	1.47	0.94	0.34	1.20	1.19	0.09
4.69	18.57	1377.28	800.00	99.59	104.06	1885.45	9.41	1178.07	10.56	280.56	1438.20	9.42
7.03	7.10	477.98	182.21	8.91	1.03	580.92	188.29	283.18	8.14	916.59	554.03	1.47
9.38	2.99	799.88	224.96	4.96	1.63	1189.25	239.91	476.88	3.40	297.99	87.69	1.43
11.72	55.17	68.67	132.89	17.38	34.69	1247.39	102.60	234.52	5.87	41.65	54.12	0.36
14.06	43.03	494.23	409.41	7.72	116.09	79.66	0.47	176.07	4.22	126.28	41.45	0.54
16.41	0.06	147.02	853.05	19.87	52.54	675.91	12.82	112.36	5.46	306.13	6.35	0.04
18.75	0.65	267.73	308.46	15.28	13.44	75.26	89.02	87.01	2.85	372.36	5.21	1.69
21.09	0.37	97.86	479.11	7.02	24.36	4.11	39.72	17.25	4.46	122.13	5.90	6.04
23.44	3.98	21.10	148.28	14.55	20.41	15.46	19.51	42.20	4.90	379.03	13.10	2.85
25.78	1.19	108.27	124.58	1.10	10.32	29.98	13.58	24.39	0.65	254.03	1.85	1.96
28.12	0.57	91.21	65.29	10.31	20.55	2.00	36.70	18.97	1.80	61.94	9.18	7.90
30.47	3.53	8.83	98.97	16.86	22.21	18.50	4.71	13.19	1.54	37.04	11.78	4.47
32.81	0.81	20.43	171.73	22.83	31.13	9.14	13.21	0.82	0.07	76.69	2.72	1.31
35.16	14.83	25.19	61.22	3.17	34.58	54.15	13.56	0.74	0.53	40.14	19.60	1.60
37.50	9.51	52.50	9.59	10.07	14.02	42.46	15.54	1.21	0.11	22.04	19.80	0.27
39.84	1.22	49.81	31.79	11.55	6.52	21.67	1.86	0.58	2.00	18.25	4.53	0.87
42.19	8.62	29.91	64.38	8.59	9.53	3.36	2.60	2.59	0.27	17.54	5.47	0.78
44.53	4.45	7.08	38.81	7.80	12.71	10.23	5.28	1.57	1.50	6.01	1.19	2.00
46.88	1.77	3.65	9.18	3.79	17.10	22.66	0.90	0.01	4.08	19.10	0.18	0.80
49.22	5.41	15.51	10.10	1.69	15.77	17.07	3.58	4.08	5.89	11.64	0.73	0.57
51.56	1.22	6.16	53.86	0.66	6.57	3.99	2.00	3.61	4.01	6.30	0.37	1.53
53.91	0.45	4.19	42.19	1.02	1.73	5.91	1.98	2.42	1.02	6.01	1.40	3.19
56.25	1.55	13.11	8.24	0.58	0.62	3.49	0.63	2.87	4.25	3.39	3.83	1.16
58.59	1.71	28.71	12.07	0.98	0.04	8.35	2.83	0.42	3.82	5.15	2.60	0.03
60.94	4.61	11.24	15.51	2.94	1.05	16.04	9.05	3.26	1.21	5.22	3.22	0.57
4.69	105.29	113.97	1323.63	1477.49	328.37	754.96	1.41	2033.37	14.07	1005.27	319.22	32.76
7.03	30.17	21.32	15.68	95.65	471.58	847.26	9.85	1935.78	12.71	1027.31	145.41	22.34
9.38	13.07	21.35	28.90	591.89	135.46	1655.44	15.93	49.87	14.06	459.31	90.18	26.35
11.72	4.34	114.46	159.74	48.31	38.36	57.33	13.24	588.16	14.47	168.48	37.91	6.91
14.06	19.05	33.88	71.05	169.72	2.97	593.35	2.00	188.71	5.49	35.14	54.03	19.50
16.41	10.04	9.53	797.79	20.60	59.82	198.75	18.06	107.24	2.14	251.52	43.20	17.11
18.75	7.17	99.72	565.87	96.95	17.57	114.70	0.23	109.95	2.88	294.80	5.00	19.33
21.09	3.46	50.21	295.76	22.41	15.01	33.69	59.31	10.96	1.54	65.26	0.88	0.92
23.44	6.51	22.89	274.19	99.86	5.77	8.94	47.57	6.52	1.94	11.47	3.37	0.22
25.78	0.34	15.82	87.82	44.49	38.31	6.54	17.08	16.26	1.37	71.16	5.02	6.01
28.12	11.14	24.24	116.73	14.63	17.16	9.42	1.31	6.52	11.64	103.09	1.21	3.61
30.47	10.80	7.81	115.98	16.74	7.82	4.86	0.35	32.81	20.58	106.84	2.19	2.30
32.81	4.74	18.16	12.76	13.66	4.65	26.01	0.05	33.31	16.61	97.14	5.42	10.99
35.16	4.16	27.80	21.06	6.58	0.57	3.41	0.58	61.71	2.00	58.28	2.18	6.42
37.50	3.86	13.81	4.93	13.44	1.77	4.18	0.46	88.74	4.60	39.66	1.95	0.30
39.84	5.02	11.99	9.00	16.13	2.44	6.24	0.54	41.87	11.19	49.39	0.61	0.43
42.19	2.82	7.12	44.88	0.75	9.82	31.97	3.06	10.44	8.81	33.75	0.06	0.22
44.53	0.30	5.75	33.08	1.48	4.04	0.90	0.49	6.53	6.57	29.20	0.52	0.55
46.88	0.93	5.20	13.42	1.71	0.11	3.87	1.26	3.08	4.20	32.27	7.06	0.75
49.22	0.30	9.96	37.36	0.30	0.17	5.76	2.00	0.79	1.50	24.07	8.75	0.90
51.56	5.34	8.58	80.23	2.19	2.40	7.85	1.82	2.32	0.68	9.32	8.65	2.48
53.91	3.06	0.07	38.84	0.41	2.00	5.57	3.40	3.64	0.33	19.33	0.96	4.18
56.25	0.87	10.32	3.57	0.48	1.05	1.07	1.56	1.02	0.39	15.94	0.71	0.04
58.59	0.17	6.16	2.45	2.28	4.23	1.08	5.05	2.53	2.55	12.92	2.96	0.51
60.94	0.63	0.81	11.81	4.01	0.50	1.98	3.24	2.55	3.52	19.08	1.49	0.87
4.69	2.42	186.52	3154.46	1205.90	621.63	822.31	1045.03	727.35	10.74	1005.62	83.53	1309.55
7.03	5.96	104.40	2061.68	375.44	175.43	2977.49	1776.79	1201.48	14.27	916.54	28.02	498.00
9.38	1.14	82.96	190.59	208.93	197.76	1149.84	649.28	2014.41	40.25	59.10	22.11	246.34
11.72	16.83	59.09	205.16	59.60	148.31	216.98	766.01	434.78	46.21	91.71	3.20	73.13

14.06	6.96	30.99	292.91	71.32	109.46	134.42	355.55	752.57	19.22	178.74	5.50	50.66
16.41	3.86	98.43	346.99	64.10	142.88	342.12	39.17	447.56	4.11	127.51	3.05	30.95
18.75	5.50	72.15	269.61	24.18	48.43	151.05	14.11	201.93	2.36	59.10	0.24	58.79
21.09	1.37	3.85	116.69	11.62	74.09	52.34	74.93	111.84	6.35	236.95	1.18	26.75
23.44	5.37	159.84	63.97	20.22	39.64	37.74	158.35	31.15	3.03	73.73	3.92	14.37
25.78	13.51	96.84	57.64	11.26	12.82	18.63	155.44	111.66	3.36	43.53	3.19	5.19
28.12	2.61	30.82	54.26	3.41	1.09	4.17	123.36	24.21	7.11	108.34	10.57	4.19
30.47	7.48	14.11	107.18	4.01	6.61	8.43	110.57	8.30	1.69	53.85	2.78	0.20
32.81	0.76	0.47	29.33	0.95	4.85	40.78	29.48	16.05	9.39	38.91	2.40	2.68
35.16	6.56	2.00	75.85	5.35	0.43	22.98	65.04	8.29	14.29	36.90	4.22	0.54
37.50	6.78	23.10	106.73	9.29	2.76	4.60	73.25	18.85	8.83	21.71	6.39	1.53
39.84	2.76	56.97	52.15	4.58	4.14	2.68	77.35	30.88	2.36	16.76	3.81	5.71
42.19	1.25	11.75	6.00	3.61	6.28	3.25	74.65	11.21	0.10	22.41	1.93	9.38
44.53	0.13	34.46	25.35	11.19	5.62	2.00	31.93	0.78	0.43	31.03	0.49	3.75
46.88	1.58	24.92	32.13	7.51	0.43	4.36	6.63	1.52	0.33	16.38	0.32	2.18
49.22	0.13	6.33	33.53	1.00	0.53	1.88	4.69	10.49	0.07	13.37	0.44	1.16
51.56	0.85	19.88	24.95	3.70	2.80	0.33	13.12	9.39	0.96	20.02	0.29	0.40
53.91	1.24	0.20	8.41	0.42	2.22	1.71	20.15	8.64	4.16	17.25	0.71	1.20
56.25	1.68	11.86	13.76	0.53	2.00	1.00	23.02	6.14	4.42	8.13	2.22	0.85
58.59	2.30	7.88	19.41	2.51	7.82	0.09	16.47	1.50	1.81	8.06	0.44	0.85
60.94	3.39	5.69	8.17	2.58	6.66	0.60	15.77	0.12	0.95	11.19	0.28	0.20
4.69	2.85	700.81	1164.81	761.08	375.47	361.49	258.46	2406.46	18.61	578.72	13.65	769.43
7.03	29.42	327.44	2038.81	157.97	50.39	173.85	243.98	1177.17	3.26	388.13	24.24	368.53
9.38	19.25	25.71	665.45	91.53	185.62	825.21	219.89	82.98	4.22	645.00	14.91	48.87
11.72	16.40	81.04	213.43	54.28	240.21	2020.16	172.13	267.88	6.44	549.66	13.76	18.61
14.06	3.97	118.69	529.79	35.72	23.17	1146.92	150.61	309.97	2.45	385.72	4.80	18.92
16.41	21.83	256.86	669.49	109.20	225.20	27.48	207.44	57.83	20.23	402.67	1.64	41.24
18.75	9.73	113.26	65.01	72.10	195.84	455.94	38.13	194.69	0.46	604.13	2.26	34.36
21.09	2.22	114.69	24.88	5.77	121.02	409.87	28.91	43.05	2.00	228.28	3.95	11.74
23.44	6.48	187.91	53.71	24.06	77.66	47.76	38.14	74.74	1.97	34.99	3.99	1.00
25.78	9.14	152.20	180.61	28.98	17.48	9.04	13.21	154.06	2.00	33.51	6.77	13.35
28.12	11.26	12.98	231.10	23.94	7.12	29.99	4.82	73.46	1.38	21.18	5.15	6.14
30.47	14.77	85.08	141.78	5.78	10.82	86.63	3.45	7.13	1.41	30.27	4.86	0.10
32.81	0.86	42.18	80.42	2.00	18.84	11.15	10.97	6.33	0.85	36.87	5.12	8.96
35.16	3.89	28.73	36.42	8.83	31.25	18.79	0.06	0.20	0.54	24.62	2.49	10.32
37.50	3.44	2.46	45.00	9.34	24.84	2.46	5.95	12.66	2.00	34.03	2.66	2.38
39.84	1.19	13.16	39.91	2.98	21.90	23.48	8.23	11.56	2.35	52.12	2.97	0.59
42.19	0.69	11.01	1.32	1.17	4.12	30.76	4.35	9.07	1.51	62.05	0.02	4.08
44.53	0.66	8.68	3.43	1.58	19.99	12.25	4.08	2.43	0.07	49.30	2.25	0.62
46.88	0.09	18.15	4.26	2.53	30.02	10.37	11.05	2.78	0.23	22.22	2.58	7.82
49.22	0.65	0.10	13.92	0.81	9.93	14.01	9.29	0.87	0.02	18.52	1.23	3.32
51.56	0.32	24.65	27.42	0.85	4.94	9.11	1.13	0.59	2.68	13.41	0.12	0.79
53.91	0.94	11.19	46.91	2.00	6.41	7.08	2.59	3.86	3.89	11.13	1.02	1.11
56.25	3.00	3.79	27.94	0.16	7.45	7.75	3.37	15.99	0.72	14.17	2.61	2.00
58.59	0.05	9.85	8.82	0.04	2.36	4.32	2.13	8.16	1.25	10.48	0.65	3.49
60.94	1.18	0.47	4.91	3.32	1.90	1.77	0.61	2.21	1.56	17.09	2.40	2.00
4.69	25.71	3666.70	348.94	2499.18	490.46	2310.94	798.89	1244.86	2.33	69.20	22.65	53.67
7.03	43.29	441.90	535.29	1699.43	525.85	382.92	164.64	233.72	8.02	372.17	17.29	1.41
9.38	46.85	868.96	403.33	1144.61	190.06	2047.17	682.39	84.29	2.76	468.01	17.41	25.94
11.72	64.04	213.60	333.44	71.83	74.64	1007.08	47.91	599.07	5.76	306.40	13.02	0.83
14.06	24.30	219.51	551.19	168.71	222.39	206.57	85.31	7.81	9.62	60.40	6.10	13.12
16.41	2.00	245.26	312.19	271.70	37.03	174.72	45.21	485.79	14.96	172.61	3.26	6.58
18.75	27.32	96.20	174.68	161.07	12.30	46.91	87.27	37.43	1.80	185.00	1.76	4.53
21.09	7.97	227.37	438.73	17.45	32.40	33.93	3.53	41.75	6.45	9.07	1.80	6.20
23.44	5.18	57.79	272.62	0.13	8.72	58.48	7.62	12.92	3.20	54.05	1.33	1.37
25.78	9.97	29.07	124.42	40.19	10.45	23.08	15.85	23.60	2.40	5.50	0.83	0.53
28.12	0.37	129.14	18.76	66.58	6.88	60.04	10.58	9.42	1.11	2.28	0.81	2.65
30.47	8.51	26.01	28.30	16.22	4.56	32.44	7.38	6.99	2.68	6.54	0.20	0.35
32.81	16.10	7.35	105.04	0.59	6.21	55.98	14.09	6.34	5.33	16.13	0.03	2.00
35.16	1.31	22.95	20.82	38.47	3.23	106.98	41.38	1.05	7.62	11.08	1.18	1.14
37.50	8.90	23.70	8.26	35.30	3.19	35.38	17.90	2.47	4.46	6.78	1.82	2.62

39.84	0.50	45.72	1.00	8.55	4.28	7.41	6.48	0.34	7.41	6.00	0.01	3.61
42.19	1.84	47.02	12.60	1.97	2.63	8.14	5.22	0.85	4.85	2.22	0.54	1.01
44.53	0.74	38.47	23.39	0.04	5.87	13.67	2.38	0.91	1.34	8.39	2.21	3.83
46.88	0.34	41.16	16.84	0.83	5.46	21.16	7.59	1.01	3.02	7.71	0.50	0.63
49.22	0.07	13.04	38.83	1.47	0.63	20.83	1.40	4.20	3.47	0.10	0.75	0.15
51.56	1.55	1.61	9.75	0.30	0.86	15.76	0.16	10.04	5.62	6.93	2.25	0.48
53.91	1.41	2.00	14.95	0.72	2.47	2.21	1.38	3.26	1.67	12.80	1.29	0.33
56.25	0.27	6.13	18.68	0.93	2.60	12.99	1.60	1.79	0.14	0.48	1.76	1.05
58.59	0.12	20.59	7.45	1.96	4.47	16.44	1.13	1.44	0.22	8.90	0.86	0.65
60.94	0.45	17.88	0.05	0.66	3.49	15.59	0.22	1.67	0.03	0.57	0.14	0.84
4.69	9.66	148.26	1995.05	55.51	816.24	1410.43	30.16	1665.01	120.42	645.17	1.57	15.18
7.03	71.22	18.40	265.10	5.18	383.57	320.31	5.69	220.57	110.40	744.90	41.75	8.14
9.38	100.20	60.82	76.92	1.88	23.68	640.52	13.21	545.67	124.75	92.94	21.45	8.88
11.72	14.45	34.97	750.40	5.36	401.30	653.48	43.99	282.48	111.79	12.82	0.61	3.42
14.06	47.24	216.68	396.91	4.56	165.22	521.08	9.77	134.77	111.38	125.80	2.94	3.86
16.41	25.43	34.98	291.69	0.95	26.80	105.16	12.88	116.95	90.01	677.92	1.86	4.18
18.75	46.27	0.58	296.95	2.00	159.15	547.24	7.36	46.54	51.17	386.61	0.30	1.88
21.09	30.13	21.05	124.68	0.96	85.38	375.54	16.54	24.26	48.46	65.65	2.19	3.17
23.44	1.53	112.47	109.98	1.71	36.54	7.51	9.56	47.50	34.30	238.34	7.37	1.62
25.78	3.13	57.41	151.46	0.70	6.98	94.23	2.61	0.20	13.96	136.48	4.96	1.05
28.12	0.85	133.78	54.48	1.37	38.07	70.91	0.68	26.04	7.88	34.66	4.39	0.72
30.47	4.34	4.34	84.51	3.83	12.17	72.35	0.54	5.52	4.84	50.72	2.32	2.56
32.81	5.48	0.75	71.19	11.67	2.50	32.35	2.63	6.77	3.45	62.43	4.53	0.40
35.16	7.51	24.34	20.70	4.28	4.32	35.15	3.39	20.70	0.16	9.61	1.59	0.52
37.50	0.04	7.51	2.23	1.85	5.73	63.58	6.26	20.80	2.74	48.71	1.98	0.95
39.84	2.00	3.77	11.95	1.93	7.05	12.83	11.03	13.95	6.26	53.10	2.87	1.99
42.19	0.81	5.27	48.66	0.96	0.26	15.80	5.95	8.12	8.84	13.25	4.80	0.83
44.53	0.18	2.36	61.41	0.36	6.24	29.60	11.98	10.54	0.91	5.50	4.59	0.46
46.88	2.86	5.52	18.32	2.00	9.53	4.00	12.76	0.92	6.09	15.09	0.74	2.35
49.22	0.89	3.03	24.79	2.60	5.02	9.89	7.61	5.06	6.61	12.45	2.30	2.80
51.56	0.20	1.90	15.64	0.72	4.75	8.92	4.98	4.39	1.18	5.16	1.04	2.39
53.91	0.59	3.63	6.69	0.92	3.34	2.49	1.86	3.29	1.41	5.47	1.40	0.80
56.25	0.61	0.28	4.53	0.21	2.56	3.91	0.21	1.62	1.91	13.57	1.76	1.94
58.59	0.51	0.04	4.16	0.90	2.54	3.36	4.50	0.78	1.67	18.84	0.42	0.29
60.94	0.03	2.19	6.02	0.33	1.63	26.32	4.32	1.08	1.05	11.71	0.99	0.29
4.69	588.85	1694.58	1867.30	2181.81	388.53	1414.69	12.53	2345.20	7.59	730.32	2.28	298.28
7.03	164.31	1893.95	138.47	2936.58	84.85	118.56	99.42	1269.41	5.73	801.19	5.19	182.36
9.38	76.31	1633.95	70.39	693.67	103.58	105.57	55.26	542.43	0.19	523.34	4.00	141.17
11.72	286.53	1335.34	423.41	404.71	45.78	660.54	16.66	133.41	0.96	1259.66	2.42	132.35
14.06	65.16	130.04	279.05	503.40	135.06	432.83	71.21	681.48	6.37	650.44	5.31	70.86
16.41	102.78	144.30	226.78	235.87	106.48	617.97	21.19	187.42	0.69	201.69	3.31	41.60
18.75	67.28	356.83	345.06	19.34	109.25	170.36	62.53	204.08	0.28	179.70	7.63	26.62
21.09	19.19	491.85	647.12	12.07	68.21	91.62	82.20	159.85	3.73	10.56	2.00	2.53
23.44	31.79	245.07	219.33	67.05	37.43	17.65	48.54	19.02	0.25	36.44	6.01	4.75
25.78	67.94	55.22	221.36	34.75	47.34	10.44	36.80	38.13	0.37	84.21	5.79	4.26
28.12	26.25	55.73	211.40	2.37	39.84	6.43	28.32	7.44	3.25	154.97	2.33	0.72
30.47	18.04	28.17	0.29	9.99	38.88	32.90	21.30	39.79	1.43	80.23	1.32	2.78
32.81	37.21	1.05	73.68	40.11	39.69	23.23	10.79	17.25	4.62	53.73	4.41	0.29
35.16	14.60	24.38	47.61	14.81	20.14	0.96	5.20	29.75	9.65	81.83	5.43	1.61
37.50	7.16	65.22	35.11	0.09	12.24	15.33	8.50	9.43	9.24	43.87	4.78	1.74
39.84	20.41	56.86	14.13	0.90	5.51	3.99	5.64	7.96	7.27	9.14	1.29	10.02
42.19	15.15	19.25	12.37	1.84	9.21	25.23	3.34	15.19	2.61	16.37	0.20	11.68
44.53	5.89	29.52	17.38	3.31	10.70	11.01	0.21	5.00	1.94	28.99	1.82	5.79
46.88	16.27	41.28	23.44	1.55	13.16	10.03	8.95	2.63	0.69	21.54	4.59	5.38
49.22	6.75	15.30	46.94	18.48	11.54	1.61	16.51	13.23	0.01	24.41	3.43	2.97
51.56	4.33	11.61	56.47	20.68	3.12	6.38	2.85	8.99	1.02	28.82	0.37	1.17
53.91	12.23	18.78	36.04	0.82	0.17	3.97	1.39	3.90	0.07	24.48	1.45	0.01
56.25	4.75	17.18	17.84	0.80	1.96	4.10	0.30	2.27	1.01	22.18	0.80	0.25
58.59	1.41	29.27	16.79	0.33	2.58	3.13	0.79	0.16	2.00	20.36	1.77	0.59
60.94	4.49	29.65	31.26	0.35	4.70	1.33	1.60	1.84	3.97	18.33	1.05	0.39
4.69	50.89	728.19	3458.76	1075.71	190.61	877.44	2055.96	1135.67	1.01	759.36	145.16	834.81

	7.03	20.65	109.89	1632.24	528.37	649.10	131.88	429.26	1090.90	1.71	592.13	30.05	494.39
	9.38	0.44	353.29	272.40	158.93	451.67	6.84	963.74	1926.24	1.55	178.28	13.09	422.06
	11.72	31.63	45.07	570.06	200.80	118.09	1009.62	526.66	277.00	1.34	121.25	30.88	251.87
	14.06	36.37	22.43	225.49	80.98	47.62	2208.46	88.13	442.21	2.52	304.72	18.64	170.05
	16.41	27.61	396.39	169.81	67.33	77.96	1122.28	228.10	482.08	4.51	793.87	10.61	86.82
	18.75	4.00	83.40	108.48	2.00	124.02	153.85	119.63	301.50	4.05	233.42	10.73	55.72
	21.09	36.63	177.33	91.07	8.21	59.52	21.70	8.30	112.80	2.00	15.43	5.07	30.67
	23.44	18.05	12.36	30.58	38.24	0.08	20.16	12.70	141.22	0.84	74.04	12.40	24.18
	25.78	1.90	115.03	103.26	20.75	17.41	76.11	22.76	58.21	0.30	98.32	16.17	4.10
	28.12	5.22	10.27	255.72	16.87	40.75	154.90	46.35	23.15	1.36	102.34	6.84	1.26
	30.47	6.29	40.62	170.86	31.26	52.33	82.53	16.13	34.02	3.40	90.92	0.92	1.25
	32.81	6.67	38.70	10.41	13.87	18.02	26.36	0.49	3.16	2.73	31.70	0.71	0.40
	35.16	7.29	7.14	3.85	0.73	1.98	25.01	7.10	19.31	4.06	67.10	3.25	0.21
	37.50	11.48	7.63	8.09	1.43	1.92	16.62	31.37	8.60	2.80	61.83	2.78	1.30
	39.84	10.55	15.31	42.99	11.77	4.17	2.44	11.49	1.26	0.33	33.67	0.56	4.11
	42.19	4.04	37.89	36.68	6.24	4.48	23.75	1.88	9.08	0.60	24.89	4.07	8.64
	44.53	0.55	18.84	17.38	0.21	5.04	11.35	1.91	6.12	1.47	18.10	6.10	5.70
	46.88	0.69	9.64	25.23	8.06	6.70	4.43	0.02	2.28	2.83	32.25	1.42	2.34
	49.22	0.52	8.35	43.24	4.23	12.09	8.54	0.88	3.47	2.19	46.49	0.24	0.41
	51.56	1.84	19.23	24.04	0.10	6.57	14.97	4.53	2.52	0.67	37.25	0.26	2.35
	53.91	2.95	27.42	6.99	1.84	6.84	23.34	0.81	0.04	0.65	20.70	1.03	3.82
	56.25	2.00	7.18	5.66	1.64	3.81	12.80	2.00	4.24	1.31	8.56	2.71	2.17
	58.59	1.90	4.04	17.75	2.59	4.66	8.95	1.16	4.81	0.64	9.39	1.94	0.63
	60.94	2.89	4.30	10.89	1.84	5.48	9.50	2.91	2.65	0.45	11.02	1.47	0.09
Ultimate	4.69	976.35	883.51	1508.12	25.36	8.83	1312.64	2165.41	540.84	2.33	337.40	505.08	15.35
(Session 3 of	7.03	190.26	147.62	1022.97	16.26	49.11	1440.72	2239.41	148.44	1.75	221.76	133.74	5.19
FT 15-s [r.beg])	9.38	93.45	146.93	612.39	0.85	62.84	768.85	1032.07	11.64	0.02	140.09	27.19	3.37
	11.72	210.23	219.77	451.93	0.55	5.08	285.47	371.78	3.32	3.15	94.14	24.68	0.93
	14.06	5.93	73.50	402.85	4.00	12.47	53.51	30.24	84.15	1.45	135.45	17.99	2.44
	16.41	21.29	396.75	19.73	0.61	13.99	460.54	682.44	114.40	6.09	838.57	1.49	2.96
	18.75	19.74	16.66	268.53	22.76	22.40	31.39	227.74	87.51	2.56	481.20	0.03	0.19
	21.09	42.52	275.42	248.75	9.84	14.91	206.92	64.53	42.43	3.51	16.67	2.37	4.56
	23.44	22.72	176.31	103.97	0.68	29.79	85.69	39.01	33.34	0.44	105.51	10.72	1.85
	25.78	14.82	3.68	52.12	1.17	23.34	106.30	8.94	32.74	0.65	111.15	14.63	4.78
	28.12	7.48	37.79	48.34	1.25	6.82	73.75	29.48	12.17	0.23	99.47	6.27	3.54
	30.47	4.77	20.03	16.09	3.77	6.81	7.67	88.04	16.39	0.14	103.80	1.77	0.07
	32.81	36.05	5.79	3.67	7.05	3.23	13.62	83.78	22.56	0.07	23.30	3.23	1.17
	35.16	15.64	15.34	19.01	20.16	2.40	27.98	34.37	2.35	0.00	14.89	6.92	0.22
	37.50	1.44	5.62	25.36	5.70	3.27	29.80	12.83	8.37	0.20	45.24	12.03	2.97
	39.84	14.30	24.59	12.74	1.86	0.34	23.32	12.38	9.47	0.89	20.90	18.14	0.27
	42.19	16.70	9.56	5.46	2.54	0.72	1.69	28.30	9.29	2.31	11.45	8.55	0.52
	44.53	10.24	1.58	24.98	2.13	3.72	0.95	22.67	0.64	0.95	7.21	1.84	2.28
	46.88	9.11	47.22	28.45	4.40	8.97	2.56	9.91	1.26	3.25	7.81	0.69	1.28
	49.22	1.25	37.79	17.04	5.77	5.34	7.16	7.83	0.32	1.88	8.51	1.50	1.42
	51.56	0.43	28.08	2.00	4.92	5.27	7.74	9.51	0.74	0.29	13.26	3.59	0.48
	53.91	1.83	29.04	1.89	2.00	10.33	8.23	17.54	4.74	0.16	2.79	3.97	2.00
	56.25	1.54	3.64	3.39	6.08	4.10	9.29	17.82	3.85	0.10	26.95	2.75	1.38
	58.59	0.44	34.58	1.00	2.68	0.23	13.16	14.85	0.01	1.47	20.75	2.52	0.15
	60.94	0.16	18.57	0.01	1.70	1.21	1.60	12.39	0.49	0.25	3.18	1.32	0.10
	4.69	537.47	974.14	934.53	682.90	10.62	163.54	1123.63	837.01	6.31	558.01	568.16	42.48
	7.03	347.63	28.80	343.54	716.69	0.15	439.41	126.14	871.47	12.36	506.95	289.86	12.76
	9.38	352.29	206.67	100.74	197.64	13.98	698.41	775.37	228.95	9.43	249.99	238.22	6.11
	11.72	137.29	41.80	242.60	170.06	6.11	147.50	329.68	401.13	11.42	346.82	233.59	10.22
	14.06	67.19	83.84	688.82	39.58	2.26	45.74	213.47	379.16	14.34	73.00	48.12	6.59
	16.41	72.44	213.97	546.28	48.54	7.33	88.08	120.51	37.33	11.58	314.79	81.77	10.29
	18.75	3.76	142.11	494.73	103.66	15.44	95.89	44.82	255.52	9.72	420.05	17.70	4.94
	21.09	10.99	157.23	343.32	46.96	27.42	3.94	50.03	141.86	2.76	53.97	16.61	7.35
	23.44	1.26	16.19	200.70	46.06	36.36	35.05	4.68	36.71	1.11	61.59	14.79	11.39
	25.78	2.55	62.71	48.14	11.36	58.71	78.41	11.69	47.93	2.32	59.59	2.52	1.86
	28.12	3.21	102.63	5.81	17.11	21.00	54.86	9.97	1.46	3.88	120.99	2.70	6.15
	30.47	4.73	100.19	80.90	12.03	5.72	14.77	8.19	10.24	0.47	103.03	2.48	0.96

32.81	8.86	5.46	61.86	6.60	3.01	1.75	6.49	15.26	1.80	66.89	14.96	0.81
35.16	4.65	101.28	47.82	8.71	4.00	2.15	13.97	6.05	1.37	23.42	6.62	0.56
37.50	1.28	108.40	57.27	2.41	21.00	0.68	8.68	13.46	0.32	23.29	2.91	0.49
39.84	2.00	35.36	43.89	1.21	8.29	0.72	15.93	1.44	4.77	43.50	0.66	1.41
42.19	1.76	3.65	6.39	2.55	1.85	1.45	3.44	3.28	6.27	25.24	1.01	0.29
44.53	1.24	3.14	6.80	2.31	8.14	4.88	0.47	7.21	1.81	10.59	5.73	0.84
46.88	2.55	8.32	14.67	0.12	12.81	9.24	0.88	1.18	0.55	13.65	2.48	0.78
49.22	1.41	9.76	20.87	1.17	11.79	5.99	1.41	6.40	2.82	20.41	1.52	0.03
51.56	1.24	10.60	24.29	0.50	1.78	1.98	3.11	7.18	2.90	15.98	0.04	0.63
53.91	0.14	23.01	12.47	2.38	0.73	1.73	1.96	0.64	1.55	22.58	1.55	0.57
56.25	1.26	4.91	2.42	2.00	0.48	2.86	1.61	2.22	0.04	15.27	0.35	0.08
58.59	1.27	8.35	2.17	1.46	3.27	3.97	1.48	3.83	0.72	16.06	0.46	0.07
60.94	0.73	5.45	0.28	1.40	9.12	2.40	0.18	0.15	1.16	18.65	1.75	0.36
4.69	7.02	76.39	4.79	1247.16	341.74	1412.04	693.46	1830.81	156.28	55.46	800.53	1102.11
7.03	7.93	20.91	1.66	229.50	39.71	567.26	1813.19	74.05	123.48	49.92	305.35	693.85
9.38	0.57	0.38	2.35	441.06	133.54	208.00	940.56	46.83	108.49	373.67	39.99	371.64
11.72	9.38	2.18	14.35	37.61	11.26	837.48	227.70	107.72	128.87	451.35	14.97	210.64
14.06	35.65	3.37	25.02	124.21	26.24	790.26	508.00	14.47	89.73	121.39	117.50	91.79
16.41	20.46	14.20	11.10	12.94	9.86	3.36	462.19	376.23	52.64	3.48	172.07	31.66
18.75	26.51	9.67	3.44	49.88	2.35	114.53	246.85	103.98	32.84	146.27	151.32	20.17
21.09	6.56	16.38	3.88	5.49	2.51	30.97	54.40	93.69	33.59	205.31	117.18	8.46
23.44	10.72	8.07	0.85	82.46	25.89	116.78	77.35	101.64	8.54	234.29	85.13	0.10
25.78	5.05	26.30	0.97	14.06	27.44	2.36	42.98	8.40	5.01	1.85	36.92	2.14
28.12	1.50	6.93	7.99	63.22	10.73	62.40	79.72	23.85	2.00	32.95	27.54	1.41
30.47	0.75	19.33	5.72	2.00	3.44	37.47	25.41	10.16	11.66	2.78	22.73	0.14
32.81	6.66	61.99	2.94	2.00	2.00	2.33	3.66	7.19	7.45	1.25	11.76	2.61
35.16	2.26	74.35	1.30	28.85	0.30	5.55	6.95	2.19	10.63	13.91	13.02	1.17
37.50	5.80	44.20	2.00	15.58	2.86	14.57	5.24	8.42	8.88	14.95	9.03	2.23
39.84	1.73	4.30	0.02	0.18	2.57	18.70	3.02	2.29	6.50	19.29	3.56	3.18
42.19	2.86	1.95	3.24	4.49	0.56	8.22	8.82	2.00	3.88	1.35	3.68	0.69
44.53	2.21	2.53	0.72	0.37	2.68	15.99	1.92	5.95	5.26	3.64	0.52	0.52
46.88	2.58	4.09	0.78	2.50	1.26	8.46	1.14	20.55	3.72	6.23	1.05	1.27
49.22	2.72	11.63	1.88	0.71	1.13	12.83	4.92	18.81	1.11	7.66	1.41	3.37
51.56	1.47	3.63	0.84	1.03	2.75	22.56	2.17	4.29	0.69	2.00	3.74	0.73
53.91	2.00	3.37	1.32	0.22	3.31	2.99	1.12	1.23	1.37	1.28	3.66	0.42
56.25	0.65	2.00	1.38	0.37	3.70	2.64	2.44	0.48	0.71	2.78	0.10	0.76
58.59	1.21	0.75	0.63	2.74	1.11	2.00	3.14	1.38	0.85	1.04	0.74	0.52
60.94	1.67	4.83	0.98	3.06	0.20	6.99	1.24	2.20	1.90	0.74	1.37	0.02
4.69	17.74	2614.80	23.69	839.79	209.53	1321.20	599.55	2233.11	6.62	42.07	2.83	397.08
7.03	64.76	33.65	46.34	374.73	4.00	1796.33	452.05	332.08	5.44	13.69	0.32	53.10
9.38	99.86	163.66	24.56	180.44	92.27	1545.16	242.29	395.14	0.80	51.99	0.05	124.48
11.72	15.27	751.62	14.22	90.66	18.25	16.90	554.17	8.72	4.11	456.77	2.34	57.90
14.06	64.24	43.14	12.25	74.66	0.83	259.97	642.22	19.25	6.00	457.00	3.34	6.65
16.41	19.61	570.48	7.21	47.88	0.70	70.90	172.79	200.94	10.27	65.58	5.81	26.54
18.75	0.04	220.41	0.81	0.55	0.88	172.54	1071.16	54.78	4.35	78.70	6.42	1.20
21.09	4.80	335.57	6.74	6.73	0.82	222.50	139.93	123.67	17.39	103.08	9.04	4.98
23.44	0.36	194.81	2.00	0.06	9.40	28.25	14.92	109.06	12.62	4.06	4.73	0.49
25.78	2.71	46.63	24.07	8.17	10.62	45.20	70.14	107.13	14.59	41.86	1.57	4.91
28.12	0.02	205.86	34.71	6.62	2.80	54.25	71.36	21.72	13.17	100.44	3.91	1.86
30.47	2.00	17.57	14.46	16.57	8.51	72.75	54.11	16.00	2.41	82.07	0.85	3.48
32.81	1.28	27.86	11.34	25.01	1.43	78.72	21.63	35.20	2.42	21.08	0.73	1.78
35.16	2.28	27.85	4.04	17.96	0.66	23.37	23.63	15.51	1.66	3.35	0.19	1.41
37.50	0.52	26.82	4.39	3.31	1.30	22.60	29.73	0.12	1.74	3.44	0.75	2.94
39.84	0.36	24.25	10.53	6.23	11.12	52.56	16.16	10.16	1.63	2.00	1.61	1.15
42.19	0.73	20.27	12.92	3.03	6.94	36.01	47.32	2.28	0.20	1.26	4.72	3.01
44.53	1.06	54.29	2.71	1.60	4.23	22.04	51.37	3.26	0.32	0.68	0.47	1.76
46.88	2.16	36.15	2.00	3.86	6.62	12.86	30.38	2.44	0.31	1.92	2.00	1.10
49.22	3.15	5.58	5.66	2.55	8.67	7.61	9.16	0.63	1.59	0.92	1.70	1.28
51.56	0.72	36.85	0.21	1.70	4.73	17.57	5.39	0.29	2.00	0.48	0.02	1.40
53.91	0.05	15.30	1.41	3.19	1.14	15.44	10.19	0.14	3.27	0.26	0.33	1.61
56.25	0.35	14.00	0.46	0.26	1.96	12.05	7.54	1.59	2.99	0.88	0.84	0.02

58.59	0.33	15.20	1.45	0.83	2.43	13.71	12.14	2.96	1.45	0.48	0.79	0.67
60.94	1.57	0.64	2.52	0.08	1.02	11.86	6.60	8.08	0.37	1.22	1.95	1.30
4.69	25.91	821.95	10.13	1834.29	784.87	2654.84	1875.72	2407.89	6.94	374.12	4.55	804.60
7.03	7.42	633.97	9.40	1544.82	629.15	486.09	2859.31	843.13	0.04	591.69	24.69	483.33
9.38	31.34	198.76	28.99	1110.25	105.22	877.51	2178.41	15.90	2.23	339.24	23.04	427.89
11.72	21.13	1121.70	3.35	122.67	218.29	952.08	328.80	355.41	1.87	185.91	5.28	268.35
14.06	40.00	1537.30	4.77	89.63	327.92	721.43	722.81	374.69	4.62	147.25	0.06	171.37
16.41	12.32	967.45	0.48	323.33	56.11	335.64	406.59	70.60	3.26	487.43	0.01	113.01
18.75	15.20	75.99	14.25	119.96	14.11	98.52	168.04	287.12	2.00	444.81	1.69	75.29
21.09	53.05	40.52	21.38	6.81	1.04	62.81	119.89	269.00	0.39	121.71	1.69	52.36
23.44	17.71	35.10	5.25	10.93	1.46	39.23	69.88	41.84	2.54	52.82	2.59	23.42
25.78	0.46	29.90	9.52	51.59	9.28	96.52	71.72	129.02	6.03	175.38	2.15	16.23
28.12	2.25	45.82	30.17	17.50	25.66	55.83	6.11	66.02	5.31	80.46	7.02	11.78
30.47	7.05	50.59	17.70	10.37	6.16	15.77	97.01	4.81	2.71	89.79	3.28	10.75
32.81	2.71	18.21	3.84	12.52	2.89	9.95	139.73	13.33	0.00	54.28	0.30	1.43
35.16	4.75	73.33	4.33	3.22	7.41	11.59	99.37	17.69	1.68	28.80	0.75	0.17
37.50	0.07	46.25	1.02	3.78	4.33	33.88	58.01	4.89	2.14	10.16	0.65	0.19
39.84	5.38	38.11	4.23	0.35	1.72	19.69	50.48	0.31	1.12	43.28	3.34	0.70
42.19	4.43	36.86	4.51	5.45	6.28	34.17	26.15	0.04	1.29	54.25	1.99	0.72
44.53	4.24	22.07	8.06	3.74	12.46	16.21	55.73	2.98	4.10	20.11	3.05	3.55
46.88	2.26	24.68	10.51	0.15	7.71	12.01	58.96	2.00	4.16	16.25	3.34	1.73
49.22	0.05	39.48	2.68	0.68	0.74	7.54	12.81	0.49	1.24	14.23	0.27	0.40
51.56	1.90	35.77	1.72	0.46	6.73	15.63	6.23	0.31	0.63	16.01	0.34	0.14
53.91	2.65	24.09	3.01	0.50	7.51	14.61	19.60	2.00	1.08	4.62	0.84	0.50
56.25	1.34	9.47	4.18	0.77	8.49	11.24	22.55	0.89	0.93	12.32	0.77	2.35
58.59	1.47	9.70	3.28	1.69	17.86	19.45	13.77	3.61	0.11	4.79	0.12	3.27
60.94	1.01	24.49	5.33	2.00	18.46	6.28	17.70	15.09	0.75	8.74	1.26	0.58
4.69	7.83	5314.63	1968.25	4012.62	121.77	1511.26	165.13	1047.40	268.45	630.68	313.24	218.74
7.03	6.47	969.99	170.06	2597.94	4.62	1047.42	797.19	1345.21	243.13	890.24	165.24	7.14
9.38	22.57	56.52	65.62	1058.89	50.85	1701.87	452.41	902.39	251.47	277.33	139.68	88.71
11.72	74.81	11.35	336.14	223.52	17.28	631.16	374.49	122.95	252.71	41.56	91.54	8.46
14.06	5.85	273.14	345.47	16.89	34.83	379.79	416.35	357.43	118.29	101.21	47.50	13.87
16.41	3.24	257.37	438.26	222.84	22.82	222.27	169.35	364.16	163.52	495.84	40.42	9.86
18.75	2.54	47.71	631.78	307.91	5.78	166.94	143.44	311.67	45.16	54.21	40.64	2.63
21.09	2.26	285.04	308.49	56.64	6.08	212.77	240.50	13.67	42.78	86.99	48.69	5.60
23.44	14.65	261.74	26.68	17.61	5.98	58.79	147.48	291.07	24.66	163.70	54.03	0.18
25.78	27.21	70.52	119.52	6.08	13.09	1.77	102.35	110.87	12.44	181.02	17.95	5.37
28.12	2.45	69.25	158.31	13.89	9.62	21.22	71.07	38.12	13.76	30.76	11.04	3.41
30.47	16.31	113.59	14.36	43.97	5.81	20.17	123.40	56.87	5.45	17.96	12.99	6.12
32.81	4.08	6.60	18.23	14.27	2.00	19.36	126.36	3.59	3.70	50.67	11.10	2.75
35.16	1.88	39.82	76.76	22.01	0.30	43.52	114.29	15.65	3.26	29.14	1.59	0.94
37.50	0.18	77.93	60.78	20.82	5.55	27.12	29.36	20.26	3.72	18.36	0.37	3.34
39.84	0.29	20.64	16.37	5.07	6.05	17.36	4.07	9.72	2.00	17.64	0.02	1.66
42.19	0.47	17.39	11.08	19.88	5.91	26.03	11.93	7.41	3.05	14.51	0.33	1.50
44.53	0.82	28.72	40.01	0.23	3.73	23.29	1.43	10.36	1.93	12.89	1.11	0.40
46.88	0.72	15.72	50.47	3.18	3.18	32.06	0.34	9.49	1.97	14.93	0.91	0.77
49.22	2.48	10.20	22.62	7.95	3.30	23.39	2.00	4.59	0.59	10.28	0.08	0.65
51.56	0.95	34.59	13.17	3.82	0.87	5.20	5.26	9.42	3.70	3.70	0.29	1.10
53.91	0.87	31.21	17.42	1.16	0.04	12.84	14.03	2.47	5.88	11.30	0.88	0.70
56.25	2.62	3.58	11.30	2.46	0.60	21.91	13.95	0.92	4.15	17.85	3.08	0.08
58.59	0.96	20.85	11.90	0.29	0.47	21.27	20.81	2.19	0.43	10.38	4.48	0.93
60.94	1.83	5.59	16.81	0.79	0.81	7.43	16.44	1.97	1.31	7.03	1.05	0.65
4.69	364.08	870.08	20.61	2013.81	305.48	217.41	2267.95	2368.67	184.88	177.83	27.93	178.46
7.03	81.16	298.78	23.40	335.55	154.94	253.47	608.98	1061.01	121.88	23.34	12.31	15.55
9.38	120.76	520.56	20.08	433.10	174.35	832.16	505.96	19.54	140.55	367.71	9.08	36.71
11.72	81.40	296.39	12.64	148.25	117.17	2094.79	890.27	190.05	95.89	964.40	10.52	1.89
14.06	51.65	193.01	10.45	181.87	72.03	1485.46	67.80	79.28	69.63	726.17	11.93	14.86
16.41	62.26	693.44	19.09	32.84	87.43	91.32	298.42	101.85	70.62	62.11	6.09	7.67
18.75	9.64	327.80	1.20	36.82	57.74	133.49	65.67	166.52	58.20	177.19	2.73	8.47
21.09	9.78	279.41	0.10	41.45	69.63	41.13	43.14	443.46	52.47	114.61	0.50	1.63
23.44	1.06	119.18	1.79	19.33	80.78	65.97	0.39	75.23	41.37	7.76	3.37	5.44

25.78	1.50	161.72	7.07	14.24	45.30	4.18	22.01	152.88	22.80	53.99	2.18	0.25
28.12	4.61	205.76	20.82	24.81	26.55	40.10	27.82	148.49	13.33	41.82	1.05	5.17
30.47	4.53	127.94	16.01	10.15	13.94	115.11	2.63	61.43	12.60	26.24	1.89	5.23
32.81	0.79	33.04	1.65	5.12	0.94	131.40	10.94	57.17	8.94	10.72	0.36	1.85
35.16	8.29	2.27	3.39	5.35	13.89	49.77	0.24	45.40	4.17	1.62	2.51	0.37
37.50	6.52	0.25	7.03	1.40	13.94	27.49	4.77	38.46	0.31	1.87	1.92	0.01
39.84	0.14	16.95	3.78	1.09	6.74	47.90	1.36	47.45	3.11	12.71	0.54	1.06
42.19	3.50	57.03	0.52	0.41	4.62	38.24	4.21	24.83	4.24	12.44	1.43	0.40
44.53	4.11	29.45	1.21	8.50	0.92	26.57	4.73	5.74	1.86	1.66	0.02	0.49
46.88	0.47	19.32	4.56	6.17	0.60	28.92	2.28	6.79	7.23	1.09	0.06	0.30
49.22	0.85	48.80	1.60	3.96	3.20	16.69	3.00	7.65	4.22	0.22	0.12	1.25
51.56	0.31	33.98	1.26	3.12	5.44	15.14	7.48	14.19	0.24	9.91	0.05	0.92
53.91	0.13	22.98	2.62	4.01	1.29	23.57	6.07	15.53	1.49	2.40	0.21	0.68
56.25	0.60	23.39	3.34	2.42	1.72	29.68	0.66	4.83	2.45	0.91	1.92	0.26
58.59	1.57	7.32	2.14	1.54	1.81	12.20	0.54	4.95	3.73	0.19	1.65	0.85
60.94	0.85	0.23	1.04	0.39	3.03	14.50	1.87	11.94	3.35	1.72	0.40	0.90
4.69	77.72	1200.49	16.57	1757.71	275.03	1459.83	3065.09	2326.88	192.86	347.90	0.46	690.00
7.03	24.28	52.67	27.05	128.27	180.53	619.73	1034.51	1317.69	126.33	348.64	1.99	350.56
9.38	27.74	90.00	12.36	596.76	143.40	388.15	108.58	617.77	160.17	187.48	0.70	259.70
11.72	52.03	399.04	19.92	62.00	86.33	1215.53	84.09	1182.88	127.31	12.38	0.34	169.06
14.06	85.25	106.02	0.44	209.31	25.96	187.47	133.01	799.10	140.97	65.43	4.44	82.58
16.41	16.53	289.80	12.84	220.66	14.38	42.67	112.39	112.17	95.92	141.32	5.26	35.36
18.75	13.77	33.94	9.60	35.17	16.63	90.64	78.77	320.25	88.73	423.27	9.62	9.09
21.09	16.67	367.13	5.32	58.35	42.77	194.83	313.00	136.65	75.65	771.18	6.65	2.00
23.44	3.89	207.28	11.28	2.35	65.56	120.47	339.60	130.42	74.75	277.62	4.40	3.37
25.78	8.90	204.72	3.18	18.53	61.27	2.62	206.23	48.93	32.31	67.07	1.71	8.05
28.12	1.41	205.73	3.49	1.09	20.30	76.59	98.76	26.04	23.07	184.89	0.38	9.54
30.47	5.56	15.68	5.13	42.73	3.62	45.87	160.78	15.50	12.61	109.66	0.25	9.43
32.81	3.82	37.55	6.44	27.00	1.26	15.18	158.86	54.46	8.44	38.78	0.94	6.57
35.16	0.14	52.16	3.85	23.31	1.04	17.23	26.70	110.08	0.86	56.09	0.08	6.71
37.50	2.54	13.22	2.60	2.35	4.90	10.34	9.46	46.21	5.14	53.65	2.47	0.59
39.84	1.84	16.31	9.10	4.88	5.31	17.73	6.01	7.86	2.41	23.77	6.53	1.35
42.19	0.75	20.37	5.48	1.39	6.25	3.95	6.55	9.20	0.07	11.21	6.36	0.60
44.53	0.05	10.77	4.49	0.12	10.08	8.79	14.34	12.53	0.71	28.25	1.95	0.00
46.88	1.00	17.77	1.48	0.50	5.27	7.96	12.16	4.81	0.05	28.20	1.71	0.29
49.22	0.42	10.58	3.67	2.44	3.31	18.81	5.77	5.11	2.00	9.85	2.90	1.06
51.56	0.99	12.97	2.25	1.78	6.29	29.34	31.34	14.11	1.89	10.22	6.23	0.08
53.91	0.28	11.83	0.61	4.50	9.87	9.34	37.80	15.80	3.79	12.39	3.31	0.07
56.25	0.87	8.47	0.96	0.16	3.77	11.47	30.31	15.87	6.18	13.65	1.85	0.82
58.59	0.31	8.62	3.69	1.80	0.66	2.15	24.66	8.61	2.78	14.90	1.46	0.27
60.94	0.22	7.16	1.38	1.88	2.41	2.00	25.30	7.48	1.16	15.56	0.06	0.62
4.69	35.56	1293.89	21.95	3737.66	413.26	2063.63	1055.10	800.35	100.59	155.94	81.87	50.40
7.03	7.54	690.69	5.52	640.15	46.98	2299.31	575.51	17.75	132.03	89.11	114.79	0.21
9.38	20.10	155.69	26.66	445.44	79.26	176.31	261.05	413.26	98.96	139.96	62.98	14.78
11.72	17.19	151.63	16.65	824.95	135.54	190.89	243.67	129.25	81.85	4.09	29.62	5.56
14.06	25.08	278.89	13.74	39.69	113.03	627.23	28.21	632.09	97.93	106.71	38.94	4.61
16.41	30.72	694.37	26.67	111.70	128.87	70.43	0.96	4.65	92.83	775.32	8.88	0.61
18.75	0.88	487.49	11.46	83.06	177.42	57.64	1.43	114.72	69.10	582.41	15.80	0.76
21.09	48.64	110.30	2.16	44.66	48.35	34.94	18.05	8.65	48.55	11.73	2.89	15.81
23.44	8.78	67.83	1.30	4.13	44.08	60.91	0.55	25.32	30.85	90.87	11.22	8.91
25.78	10.32	133.74	1.09	40.78	40.72	126.46	28.79	15.71	30.62	32.02	0.02	2.75
28.12	15.44	99.49	1.31	14.56	2.00	41.11	27.98	16.61	18.53	34.19	2.37	0.61
30.47	6.94	44.95	2.25	17.45	4.24	12.76	1.53	31.65	10.40	21.78	0.04	3.33
32.81	6.04	13.72	8.83	30.49	5.42	68.53	12.15	28.94	8.23	66.86	1.56	1.25
35.16	18.46	30.04	5.98	5.94	5.75	39.19	3.25	4.97	9.60	8.23	1.49	0.10
37.50	7.48	61.49	2.97	7.08	17.61	8.47	5.81	1.60	3.74	13.73	0.64	0.54
39.84	5.74	20.42	4.64	1.41	12.56	6.88	6.17	25.17	4.64	9.42	0.56	0.98
42.19	2.76	37.38	1.33	0.44	6.43	27.11	0.24	20.89	3.50	21.35	2.83	0.32
44.53	0.10	7.99	1.70	10.97	10.84	32.43	0.99	13.50	4.84	6.55	3.47	2.24
46.88	7.00	14.80	6.14	4.14	1.59	8.37	5.00	3.95	3.72	6.45	1.94	2.91
49.22	9.75	32.30	2.95	4.91	5.93	12.98	8.34	4.55	1.69	7.89	0.60	2.20

51.56	1.43	8.46	1.13	3.77	14.20	22.97	2.00	6.06	1.37	3.34	0.68	0.82
53.91	0.45	5.44	3.95	0.85	1.12	6.54	3.19	10.83	2.62	12.54	0.60	1.67
56.25	1.34	34.55	4.22	2.22	2.31	9.47	3.99	2.00	3.31	1.95	0.78	1.70
58.59	1.59	27.64	2.44	0.47	3.80	6.65	0.19	0.45	0.43	12.74	1.88	1.12
60.94	5.24	6.64	4.41	2.00	2.43	4.93	1.92	1.01	0.56	2.72	1.37	0.83
4.69	52.02	539.08	1.61	155.08	167.07	602.13	137.69	1140.19	39.13	423.54		667.68
7.03	104.56	201.54	7.74	48.16	39.71	1110.07	392.36	570.16	0.74	308.28		502.57
9.38	2.80	254.75	20.03	5.43	74.82	2142.68	10.72	1119.00	11.11	366.39		149.99
11.72	4.66	75.31	15.29	0.76	10.06	1137.24	34.33	719.71	10.25	264.12		115.36
14.06	19.52	27.55	12.10	9.06	52.29	339.91	62.13	57.26	6.95	5.50		102.61
16.41	31.69	276.63	12.00	6.17	59.52	21.39	73.49	1509.84	5.81	336.95		2.78
18.75	4.94	505.53	6.09	4.68	21.63	65.16	60.06	297.19	7.82	90.06		32.35
21.09	6.10	223.51	9.72	4.98	5.07	21.91	45.84	45.17	4.91	64.08		21.91
23.44	0.93	33.92	1.16	2.22	13.21	25.53	30.10	41.47	9.88	192.05		1.24
25.78	22.35	41.65	10.82	15.93	2.47	31.32	17.77	138.33	6.08	82.03		20.93
28.12	4.70	115.43	14.07	1.32	2.93	117.17	2.41	118.18	6.86	54.60		1.72
30.47	13.72	3.31	6.08	11.89	8.65	84.63	15.33	33.59	8.88	28.80		4.47
32.81	8.72	132.36	0.37	17.20	2.49	27.94	24.14	46.40	0.73	37.34		5.92
35.16	5.65	22.71	13.09	2.00	0.97	48.78	2.00	18.83	2.53	79.64		1.92
37.50	0.29	22.87	12.43	6.19	2.16	54.14	26.59	78.92	1.60	74.45		1.03
39.84	0.40	29.37	1.01	4.95	2.40	36.47	24.76	26.21	0.22	55.72		0.96
42.19	0.87	9.15	0.07	2.00	2.19	23.74	1.49	0.51	1.00	41.46		3.93
44.53	0.46	35.87	0.90	1.87	0.84	23.28	0.88	2.21	3.08	13.69		1.44
46.88	1.47	55.36	0.06	1.66	0.34	21.31	2.00	6.65	0.17	13.23		1.66
49.22	3.41	32.56	3.27	0.74	3.24	11.95	0.41	0.99	0.58	31.50		0.26
51.56	2.00	32.34	8.25	0.40	6.16	7.45	0.60	4.18	2.13	14.91		1.80
53.91	0.32	28.16	5.54	1.12	2.99	15.05	0.72	4.62	3.01	12.62		1.45
56.25	2.69	32.71	4.25	0.12	3.00	29.93	0.11	0.26	2.00	8.34		0.90
58.59	1.82	23.89	1.60	0.04	2.00	21.22	0.88	3.51	0.27	10.21		0.25
60.94	0.66	4.71	0.42	0.07	0.82	12.36	1.87	7.13	0.20	20.55		2.26

AMPLITUDE SQUARED AT EACH FREQUENCY

Frequency/Phase (cycles/min)	Bird A1		Bird A2		Bird A4	
	CS	ITI	CS	ITI	CS	ITI
Session #1						
4.69	69.42	54.23	79.49	4252.65	224.34	19.81
7.03	33.29	292.12	786.00	931.56	92.78	37.76
9.38	10.63	154.42	2037.42	477.79	169.23	41.72
11.72	19.95	213.60	941.91	250.97	257.50	12.75
14.06	11.29	40.14	96.38	123.34	171.01	18.01
16.41	6.59	32.65	193.38	39.47	119.74	24.01
18.75	3.28	66.18	460.86	29.53	14.15	21.01
21.09	2.68	16.36	277.10	22.51	12.04	15.77
23.44	9.81	28.52	17.57	16.07	21.38	13.93
25.78	6.83	8.52	83.85	33.24	0.65	34.37
28.12	4.84	7.81	52.59	27.10	15.79	31.97
30.47	11.88	6.94	4.11	9.77	20.37	1.98
32.81	1.43	1.29	44.54	7.98	25.35	8.58
35.16	0.99	3.45	50.04	3.88	33.73	5.98
37.50	4.03	11.30	4.20	0.99	13.73	10.33
39.84	2.00	2.55	40.74	5.44	5.44	9.39
42.19	0.39	0.74	39.96	10.52	0.83	3.84
44.53	4.10	0.38	3.49	6.76	5.92	1.92
46.88	0.96	0.77	15.53	8.40	0.92	0.17
49.22	0.56	0.65	20.39	4.50	4.54	0.81
51.56	1.01	0.85	2.21	2.20	1.33	0.38
53.91	0.26	2.00	16.71	2.00	1.87	2.20
56.25	0.98	0.27	39.18	0.88	1.59	0.39
58.59	0.36	0.25	9.60	0.84	8.52	1.77
60.94	2.40	0.17	11.33	0.06	2.36	0.37
4.69	623.55	792.01	158.20	61.39	47.36	124.48
7.03	634.10	577.73	113.18	61.49	26.51	66.90
9.38	433.49	665.89	98.87	62.01	165.79	69.89
11.72	67.62	507.48	5.93	81.11	367.75	3.97
14.06	94.64	62.76	98.34	29.94	178.02	40.63
16.41	17.05	27.89	36.30	30.33	45.00	4.51
18.75	14.43	42.91	6.91	35.13	29.12	88.71
21.09	26.32	10.24	26.81	5.00	30.34	58.84
23.44	11.47	6.66	57.82	19.15	104.14	31.82
25.78	13.79	0.54	7.25	3.36	20.67	15.68
28.12	8.57	25.94	22.76	9.15	15.79	1.40
30.47	9.48	40.18	4.03	6.41	35.20	15.39
32.81	8.07	7.86	5.40	0.26	20.78	31.60
35.16	6.64	1.14	13.05	1.64	7.42	4.15
37.50	7.18	0.20	3.35	1.12	2.22	13.68
39.84	4.15	0.80	3.34	3.23	10.71	9.80
42.19	1.55	1.77	7.81	0.45	2.42	12.39
44.53	0.18	0.04	5.83	4.29	11.78	15.93
46.88	0.33	1.06	1.07	4.70	6.25	9.00
49.22	0.58	3.21	2.33	4.25	6.90	7.51
51.56	0.20	2.24	2.26	3.07	7.07	7.68
53.91	0.27	0.05	3.64	1.93	0.71	0.18
56.25	1.49	0.93	1.00	0.24	0.19	3.34
58.59	1.40	3.03	2.58	1.90	0.89	1.73
60.94	1.26	4.02	4.12	4.48	1.00	0.00
4.69	221.39	11.61	12.53	291.75	39.11	7.18
7.03	47.18	49.44	27.52	249.99	190.98	1.52
9.38	37.89	32.94	33.05	313.14	293.55	35.49
11.72	66.37	15.51	38.96	368.16	186.33	126.57
14.06	10.58	3.50	166.98	385.91	31.00	252.14
16.41	7.62	4.00	122.21	78.05	3.96	132.23
18.75	19.97	23.80	33.35	10.02	18.60	4.53
21.09	7.93	22.42	4.36	0.78	32.83	0.22
23.44	7.50	2.27	39.85	52.56	42.64	0.46
25.78	14.75	1.51	19.14	67.11	6.10	4.35
28.12	6.65	2.00	2.67	66.53	10.62	16.03
30.47	0.58	0.42	13.16	43.88	88.18	18.01
32.81	1.55	1.23	27.61	13.59	88.68	12.35
35.16	1.73	1.44	9.84	2.86	1.98	20.42
37.50	1.12	2.00	5.06	2.00	13.60	19.81
39.84	6.99	3.57	13.20	0.62	2.20	3.99
42.19	9.86	0.90	1.10	5.21	19.56	11.52
44.53	3.35	4.32	7.56	5.04	18.66	3.10
46.88	1.70	1.20	20.38	0.35	8.30	2.00
49.22	1.34	0.15	12.80	1.17	0.88	1.64

51.56	0.07	0.56	0.60	2.98	4.64	3.22
53.91	1.86	1.79	1.12	0.53	3.06	0.41
56.25	3.43	2.74	0.67	1.01	3.04	5.40
58.59	1.72	1.08	1.08	0.89	10.64	4.86
60.94	1.29	0.52	1.74	1.66	7.50	1.54
4.69	82.87	22.08	125.98	216.46	174.80	10.03
7.03	1.75	36.58	116.49	120.68	106.97	14.46
9.38	15.77	244.19	102.90	106.39	14.85	1.51
11.72	0.62	166.85	54.32	223.48	231.83	1.72
14.06	1.74	27.89	49.52	0.86	328.07	20.91
16.41	11.81	12.70	123.89	168.98	106.59	215.62
18.75	31.94	0.58	259.56	129.72	30.34	121.12
21.09	33.73	8.00	112.39	5.65	174.71	0.86
23.44	32.93	0.17	29.19	14.49	105.19	6.42
25.78	18.85	4.33	143.56	50.50	26.78	2.74
28.12	5.84	0.66	60.54	15.33	18.68	0.42
30.47	9.67	1.71	3.25	15.24	8.07	6.22
32.81	4.42	2.51	3.75	24.83	23.31	3.48
35.16	1.63	4.91	14.66	13.68	30.36	3.78
37.50	3.24	4.70	4.99	15.61	9.04	4.31
39.84	13.41	4.05	19.93	23.49	10.08	21.66
42.19	2.34	0.04	5.64	10.01	11.55	12.42
44.53	3.37	4.27	25.99	0.39	6.71	8.13
46.88	3.03	2.88	17.94	3.70	14.60	12.06
49.22	0.03	6.77	9.57	4.09	14.53	11.39
51.56	2.46	3.41	13.58	2.41	3.15	8.54
53.91	0.32	0.17	4.27	4.18	8.42	2.70
56.25	2.76	0.07	4.93	7.06	8.06	0.81
58.59	1.50	1.16	9.22	8.05	1.53	1.41
60.94	0.21	0.58	3.00	1.20	0.49	0.37
4.69	879.23	12.07	16.92	4.49	44.26	129.36
7.03	693.42	25.88	16.05	80.21	5.87	47.83
9.38	39.50	151.05	29.30	99.78	95.39	102.90
11.72	623.67	85.91	118.17	22.23	183.74	40.80
14.06	40.40	7.48	69.60	7.31	82.79	60.62
16.41	83.24	43.08	15.40	12.59	21.99	62.58
18.75	87.56	57.96	52.25	43.15	23.26	7.10
21.09	5.88	28.94	6.93	10.96	19.86	44.42
23.44	27.08	11.55	8.37	8.82	163.23	56.59
25.78	65.80	6.76	8.20	0.81	103.97	12.91
28.12	33.04	6.86	13.01	0.01	21.76	15.08
30.47	8.13	5.13	30.93	3.71	3.02	14.03
32.81	79.17	6.16	33.86	2.25	8.80	25.44
35.16	32.26	3.52	14.84	7.60	6.64	30.89
37.50	4.42	8.05	1.99	9.79	3.32	24.19
39.84	29.29	2.67	2.14	2.36	5.13	4.98
42.19	27.72	8.31	2.00	0.09	4.64	5.17
44.53	5.51	3.31	0.94	1.34	0.50	12.97
46.88	14.17	2.23	1.20	0.06	33.22	3.54
49.22	29.06	0.77	0.65	0.65	55.65	0.41
51.56	6.69	1.01	0.91	0.46	14.63	0.02
53.91	1.00	0.33	1.46	0.63	0.56	0.06
56.25	4.42	0.76	0.35	2.48	3.24	0.36
58.59	1.25	2.83	0.98	5.52	2.66	0.39
60.94	0.11	0.80	2.52	5.43	2.74	3.86
4.69	1391.67	38.48	0.68	7.91	749.76	135.25
7.03	537.27	39.94	0.68	38.32	593.94	425.08
9.38	261.60	32.28	0.62	83.70	244.15	524.97
11.72	515.86	24.91	4.19	258.29	44.57	207.53
14.06	47.42	52.83	1.42	169.76	81.29	63.18
16.41	539.50	0.94	5.90	16.03	132.56	450.12
18.75	211.10	18.35	1.65	46.67	109.97	492.60
21.09	7.51	19.26	0.31	54.94	22.89	81.83
23.44	34.10	21.54	1.08	18.37	96.42	30.22
25.78	88.83	7.53	1.35	8.77	8.38	6.78
28.12	32.91	4.13	0.46	27.05	6.77	10.21
30.47	8.58	5.16	3.60	29.13	3.17	12.30
32.81	11.10	1.59	0.07	13.69	7.90	2.00
35.16	10.19	0.58	5.53	11.85	6.30	3.82
37.50	0.93	0.36	0.56	8.20	1.51	6.02
39.84	27.82	0.75	0.08	1.25	7.03	0.18
42.19	21.35	3.06	0.59	4.23	10.17	5.21
44.53	0.48	1.64	0.86	5.40	1.11	16.68
46.88	3.06	0.20	0.32	0.46	10.93	4.88
49.22	2.50	0.27	0.04	0.70	20.30	0.02
51.56	1.32	0.63	0.10	4.56	14.52	0.02
53.91	5.43	0.95	0.33	3.25	4.63	2.21
56.25	5.66	0.54	0.52	3.25	0.35	10.08
58.59	0.43	0.24	4.00	0.87	1.06	2.18
60.94	5.74	0.30	3.84	0.40	1.20	0.00
4.69	93.62	113.10	172.00	89.84	58.63	2.15
7.03	415.92	81.71	269.08	100.73	48.83	8.65

9.38	249.04	23.42	179.47	71.80	3.88	62.63
11.72	192.20	21.01	84.13	159.99	52.75	159.18
14.06	106.36	66.04	146.39	56.97	114.09	128.51
16.41	43.69	43.40	123.92	82.92	392.64	239.18
18.75	18.60	12.84	61.87	14.32	359.39	50.31
21.09	17.39	4.58	69.13	22.09	230.07	132.60
23.44	4.68	2.61	101.60	95.04	51.46	54.55
25.78	1.75	3.05	58.43	42.99	31.33	2.88
28.12	2.00	2.39	29.17	8.58	30.15	52.86
30.47	16.84	2.14	30.61	8.85	19.71	84.40
32.81	11.16	0.67	15.82	8.48	10.78	2.59
35.16	6.76	2.15	1.26	10.54	20.95	12.86
37.50	13.78	0.16	5.44	17.72	53.22	21.08
39.84	9.72	2.86	3.90	3.53	19.14	29.31
42.19	6.55	2.78	0.09	1.87	4.50	29.86
44.53	14.49	3.87	4.27	2.00	41.57	13.72
46.88	13.67	2.53	6.35	3.96	13.76	11.20
49.22	1.31	0.43	2.34	6.17	4.21	5.91
51.56	6.46	3.50	2.63	1.96	8.54	3.71
53.91	7.81	9.96	7.21	0.62	15.42	2.14
56.25	0.46	8.02	1.68	0.47	19.92	2.00
58.59	3.12	4.21	5.66	1.99	0.16	1.17
60.94	2.25	1.58	14.68	0.11	2.36	1.40
4.69	35.16	7.97	0.22	356.77	47.63	67.61
7.03	18.77	6.62	2.93	81.19	45.46	136.57
9.38	5.31	7.93	4.85	126.36	16.86	162.96
11.72	9.42	29.16	1.29	65.64	112.42	97.58
14.06	7.71	47.11	0.21	65.28	55.14	179.72
16.41	28.87	32.46	0.26	85.11	51.62	141.25
18.75	11.87	9.99	3.75	37.52	25.68	108.17
21.09	15.45	3.57	3.16	28.35	5.41	97.61
23.44	23.80	0.37	0.35	17.01	2.21	9.47
25.78	7.48	1.62	1.16	6.46	35.72	23.79
28.12	1.24	5.74	2.32	9.25	87.21	29.99
30.47	8.89	5.53	0.46	13.46	6.37	7.83
32.81	22.23	9.25	0.23	0.17	24.32	19.14
35.16	14.56	7.90	0.07	7.33	7.46	38.59
37.50	4.64	10.44	0.24	2.63	1.66	28.01
39.84	4.71	5.57	1.36	3.25	1.52	55.15
42.19	6.19	0.63	0.86	0.54	9.72	40.64
44.53	3.56	1.31	0.71	3.26	21.14	8.36
46.88	0.94	4.13	1.35	2.30	10.76	1.95
49.22	0.46	2.18	2.20	0.13	3.79	9.01
51.56	1.27	1.81	1.37	2.21	15.86	12.87
53.91	2.65	3.21	0.19	2.39	4.04	4.70
56.25	1.60	2.28	0.11	3.48	0.56	1.80
58.59	0.60	3.07	0.63	4.10	2.15	10.34
60.94	1.80	0.53	0.67	5.55	0.25	12.24
4.69	8.78	17.10	118.41	1395.12	22.87	108.75
7.03	10.59	35.12	77.63	830.45	8.16	61.18
9.38	2.00	9.42	62.06	558.49	67.76	103.77
11.72	10.71	8.54	72.47	374.54	141.80	167.02
14.06	18.30	67.74	99.47	297.06	119.98	46.20
16.41	13.77	58.56	84.22	154.30	107.73	37.57
18.75	10.39	27.93	60.28	91.88	25.34	90.52
21.09	6.31	12.69	35.08	59.80	34.91	99.80
23.44	0.56	16.06	11.05	45.11	137.60	55.30
25.78	0.10	60.23	14.36	14.44	147.02	37.60
28.12	0.61	18.37	11.48	8.41	65.03	52.59
30.47	1.71	0.69	17.13	3.64	20.99	43.55
32.81	8.17	6.10	24.28	1.19	4.42	29.32
35.16	8.87	3.18	20.32	5.05	18.10	7.62
37.50	4.76	0.17	10.90	2.00	0.56	32.97
39.84	4.23	0.17	7.63	0.96	6.32	35.57
42.19	2.49	0.67	6.37	7.90	4.53	3.14
44.53	2.39	1.01	0.10	0.44	4.18	2.26
46.88	6.40	1.14	5.99	1.84	5.31	0.12
49.22	2.54	0.60	12.04	1.43	3.17	0.75
51.56	0.75	3.02	16.58	2.00	1.43	2.88
53.91	0.94	0.75	13.64	1.28	2.84	10.49
56.25	1.03	0.19	10.35	3.55	4.85	4.11
58.59	2.23	0.08	5.21	6.35	5.12	1.51
60.94	1.35	0.12	0.83	2.50	0.90	2.36
4.69	151.58	81.82	315.32	70.50	4.37	16.70
7.03	37.81	15.72	170.88	477.82	57.57	29.85
9.38	16.41	22.63	67.43	306.45	87.22	56.25
11.72	5.93	24.16	7.35	23.90	102.76	27.43
14.06	7.51	38.86	7.45	7.34	14.19	90.15
16.41	14.87	31.90	35.96	22.70	13.95	174.63
18.75	7.53	14.95	53.99	20.61	73.90	211.94
21.09	12.86	5.00	45.08	25.61	4.25	100.27
23.44	7.32	0.25	30.09	18.47	7.55	30.86

	25.78	0.95	0.58	14.54	2.61	54.22	1.28
	28.12	0.47	0.51	4.10	2.82	16.82	45.17
	30.47	0.75	1.05	4.05	0.26	1.73	20.84
	32.81	3.14	0.67	8.24	2.00	11.07	17.10
	35.16	3.32	3.07	11.05	2.57	19.84	30.58
	37.50	2.63	0.82	11.68	2.95	59.83	23.20
	39.84	1.67	0.53	11.24	5.54	62.66	5.37
	42.19	0.08	0.16	7.64	1.55	4.42	7.75
	44.53	0.07	0.33	5.38	0.14	3.64	1.20
	46.88	0.82	0.12	4.83	0.13	6.78	10.88
	49.22	4.23	0.03	5.80	1.63	4.82	17.34
	51.56	3.04	0.64	4.49	2.93	9.70	8.98
	53.91	4.16	2.00	2.48	2.20	7.57	3.81
	56.25	1.93	1.50	1.91	0.81	1.88	0.99
	58.59	0.34	0.68	2.35	0.42	0.94	1.26
	60.94	0.24	1.17	2.47	0.63	1.11	0.32
Session #2	4.69	695.38	12.74	0.57	1804.60	1233.91	27.21
	7.03	600.81	1.60	0.72	1482.54	569.92	68.44
	9.38	450.25	20.77	0.20	1447.11	107.81	197.00
	11.72	295.18	7.20	0.10	684.13	0.44	291.67
	14.06	192.06	0.24	1.41	43.25	31.20	139.36
	16.41	77.77	0.86	3.05	22.17	63.61	14.25
	18.75	43.17	1.28	4.12	12.70	94.17	31.59
	21.09	56.11	1.56	2.89	5.65	86.79	15.65
	23.44	16.26	3.08	2.32	3.51	33.81	25.07
	25.78	19.18	0.45	0.79	9.10	4.53	15.32
	28.12	40.95	0.22	0.49	17.05	5.16	11.77
	30.47	31.53	0.09	1.12	7.36	17.12	11.66
	32.81	10.97	1.37	0.32	9.90	7.79	26.19
	35.16	11.20	0.11	2.00	8.34	2.00	16.60
	37.50	30.53	1.13	2.70	1.04	5.86	11.12
	39.84	6.21	1.68	0.21	1.04	70.18	3.30
	42.19	3.20	0.75	0.53	1.35	45.04	8.82
	44.53	5.29	0.99	0.49	1.25	6.67	10.15
	46.88	3.57	0.98	0.30	3.03	0.88	6.37
	49.22	2.88	1.55	2.70	5.70	5.08	0.58
	51.56	3.33	0.04	3.15	1.94	9.58	9.89
	53.91	5.89	0.95	1.54	0.61	26.30	4.84
	56.25	7.32	4.38	1.53	2.00	20.50	1.73
	58.59	11.36	0.86	1.61	2.38	0.93	1.58
	60.94	13.93	0.09	1.05	0.55	2.86	3.77
	4.69	1.47	1344.32	80.39	125.13	76.65	269.06
	7.03	11.29	743.87	67.04	18.51	340.05	468.48
	9.38	3.34	360.87	60.61	14.47	119.42	1141.06
	11.72	0.69	115.38	59.25	21.50	31.38	1035.72
	14.06	2.58	69.87	51.63	11.69	211.78	357.76
	16.41	6.00	35.31	37.55	16.76	99.00	101.04
	18.75	5.74	0.15	38.96	0.44	1.06	31.68
	21.09	0.27	1.06	24.28	5.49	44.22	70.34
	23.44	0.98	0.38	16.10	26.76	24.71	12.26
	25.78	1.38	2.81	23.49	3.44	4.81	18.49
	28.12	1.28	5.30	15.79	0.48	8.40	28.05
	30.47	1.77	3.74	8.00	5.24	7.63	1.22
	32.81	0.07	3.83	3.29	14.06	5.03	5.05
	35.16	0.54	1.87	1.81	6.44	6.75	0.29
	37.50	5.56	2.97	1.95	22.05	3.61	3.20
	39.84	1.45	5.63	1.27	9.03	15.42	7.93
	42.19	0.44	5.02	5.06	0.04	7.10	10.27
	44.53	1.54	2.96	5.21	1.14	9.51	2.63
	46.88	0.21	5.57	1.54	0.69	25.04	0.51
	49.22	0.37	3.41	2.22	0.83	29.47	1.89
	51.56	1.16	2.73	4.05	1.22	4.08	1.18
	53.91	0.13	7.10	4.34	3.27	1.14	0.41
	56.25	0.02	3.35	2.46	4.70	2.22	0.62
	58.59	0.05	1.40	1.31	1.72	2.29	1.26
	60.94	0.97	2.00	0.63	0.96	10.48	0.06
	4.69	0.21	435.53	1.30	1540.55	55.88	151.34
	7.03	0.25	355.75	1.39	1411.54	52.22	15.04
	9.38	0.18	610.41	6.94	165.24	22.99	16.42
	11.72	0.10	229.81	4.96	270.30	15.75	32.76
	14.06	1.30	5.52	2.29	323.24	34.58	204.61
	16.41	0.81	33.95	2.66	57.16	35.28	140.58
	18.75	0.06	32.31	3.50	1.28	37.84	82.59
	21.09	0.11	0.71	3.55	18.83	13.73	67.27
	23.44	0.18	8.65	2.80	49.38	36.18	21.29
	25.78	0.21	23.43	0.32	22.08	31.08	1.36
	28.12	0.88	26.71	3.25	46.93	33.22	8.38
	30.47	0.98	7.88	5.96	21.54	16.16	20.34
	32.81	0.59	3.41	2.47	17.57	0.80	18.41
	35.16	0.20	4.72	0.35	0.99	6.80	39.34
	37.50	0.07	1.37	4.50	3.45	11.97	44.05
	39.84	0.11	2.67	2.80	6.94	9.27	5.76

42.19	0.47	5.83	1.13	5.40	5.71	0.49
44.53	0.27	4.74	0.99	0.36	5.70	16.13
46.88	0.03	1.36	0.68	4.04	2.26	15.61
49.22	0.08	1.80	2.47	3.86	1.57	0.47
51.56	0.08	0.37	2.25	1.39	1.02	0.81
53.91	0.05	1.44	0.30	1.62	4.04	3.06
56.25	0.05	2.00	1.10	1.50	4.60	0.48
58.59	0.10	2.27	2.28	1.38	1.72	2.32
60.94	0.26	1.35	2.26	1.36	3.31	1.43
4.69	44.63	2697.68	2.33	191.15	1.77	441.37
7.03	241.54	597.96	2.56	72.22	2.52	418.57
9.38	128.44	43.15	1.60	736.22	0.37	90.20
11.72	4.21	26.62	0.43	787.62	0.53	159.81
14.06	138.13	68.74	2.59	355.58	2.80	144.67
16.41	107.91	15.62	4.33	34.33	1.84	370.09
18.75	2.39	0.26	2.64	1.93	1.66	232.00
21.09	38.29	0.38	3.51	28.43	3.52	69.70
23.44	61.38	18.03	2.81	98.25	3.22	32.98
25.78	10.57	25.80	1.76	32.28	0.55	12.53
28.12	5.47	10.68	3.09	11.55	2.00	6.85
30.47	22.44	16.54	2.00	25.06	2.76	1.15
32.81	8.39	13.73	1.93	2.37	0.99	14.70
35.16	2.68	5.18	1.16	4.77	0.20	15.04
37.50	9.88	5.42	0.98	1.70	3.60	0.36
39.84	5.98	1.63	1.26	3.52	2.57	3.56
42.19	5.92	1.69	2.35	0.09	0.74	5.33
44.53	13.52	1.72	5.29	0.68	3.11	1.73
46.88	6.36	2.77	4.68	0.22	0.13	3.76
49.22	4.16	1.40	0.86	1.11	0.56	1.98
51.56	14.77	2.00	0.37	0.56	1.83	6.22
53.91	8.51	3.99	1.03	0.57	2.38	7.54
56.25	1.84	2.16	0.06	1.04	0.07	4.05
58.59	8.00	1.91	2.25	4.27	2.57	0.72
60.94	6.87	1.43	2.69	5.39	4.74	1.29
4.69	71.15	2788.60	1.87	1328.23	88.41	152.99
7.03	10.81	1133.54	4.44	443.09	1179.21	400.59
9.38	10.66	327.00	0.72	164.43	1849.07	481.33
11.72	4.62	68.15	1.46	394.79	1227.03	286.15
14.06	0.04	29.70	1.03	367.24	1186.47	199.94
16.41	2.48	22.78	4.42	182.61	715.23	108.98
18.75	0.33	14.85	1.14	15.35	174.14	16.49
21.09	2.40	10.85	1.48	49.96	235.44	0.09
23.44	0.84	13.86	3.63	81.86	203.38	7.22
25.78	0.46	8.53	0.39	80.71	65.68	30.32
28.12	2.48	3.53	3.31	17.18	64.81	27.21
30.47	4.90	3.22	4.17	7.35	63.57	0.77
32.81	0.41	3.68	0.94	3.71	32.45	12.19
35.16	2.89	1.87	0.68	8.43	54.18	3.73
37.50	2.44	1.84	1.95	5.64	97.00	0.50
39.84	0.13	2.60	2.70	0.98	69.96	3.44
42.19	0.91	0.95	0.89	12.70	37.30	5.94
44.53	2.36	0.29	0.65	10.66	43.58	3.76
46.88	0.93	1.41	3.01	3.25	16.83	2.94
49.22	0.17	3.02	2.77	6.14	12.90	1.31
51.56	1.49	2.00	1.16	2.00	46.45	0.46
53.91	1.90	1.65	0.06	0.50	44.73	3.85
56.25	0.65	0.50	0.38	1.17	19.68	4.20
58.59	0.16	0.12	0.29	0.61	15.48	2.00
60.94	0.42	0.89	0.30	1.58	12.15	0.62
4.69	8.96	931.13	3.84	3.33	1.43	226.08
7.03	16.97	202.47	3.31	33.67	4.44	204.89
9.38	7.34	34.66	3.78	113.39	2.93	203.56
11.72	1.48	14.41	4.35	39.84	1.96	134.71
14.06	7.55	14.14	3.25	35.23	15.50	54.60
16.41	7.00	17.27	5.94	76.56	9.61	59.34
18.75	1.34	13.52	4.78	72.42	0.31	24.74
21.09	9.31	11.09	7.06	78.40	4.33	39.19
23.44	6.40	3.89	6.96	39.56	11.60	22.15
25.78	1.78	3.88	8.90	33.33	0.63	4.90
28.12	10.82	2.59	5.41	27.89	5.95	5.11
30.47	10.91	0.08	1.03	25.43	9.12	5.90
32.81	2.33	5.30	1.19	14.60	2.56	31.03
35.16	4.31	2.37	1.87	6.20	1.96	19.99
37.50	6.04	0.12	3.35	0.80	10.07	0.93
39.84	2.24	0.28	1.11	0.04	2.73	17.57
42.19	1.60	0.79	4.14	0.80	0.81	23.99
44.53	4.29	0.79	6.94	4.38	5.68	19.05
46.88	1.39	0.69	4.91	7.43	3.91	21.07
49.22	0.51	0.56	0.48	3.20	0.36	3.35
51.56	1.12	1.77	3.69	1.04	5.27	5.90
53.91	0.06	2.32	4.31	3.17	3.48	7.87
56.25	0.76	0.48	1.07	3.91	0.11	15.31

58.59	1.25	0.28	0.23	1.40	3.06	15.05
60.94	0.31	0.55	1.75	1.33	4.19	13.06
4.69	13.21	90.14	39.96	639.43	57.52	230.97
7.03	23.57	134.73	48.37	667.98	68.79	154.49
9.38	14.15	101.39	38.43	432.23	54.70	54.06
11.72	11.71	33.18	52.36	38.90	54.06	173.17
14.06	26.66	15.70	38.97	48.10	68.86	51.13
16.41	12.55	19.50	33.50	193.14	54.35	98.21
18.75	6.37	2.37	36.54	257.69	48.67	64.55
21.09	17.08	4.53	16.90	323.12	58.41	24.46
23.44	23.13	3.31	34.92	6.10	36.14	6.02
25.78	8.79	5.50	13.73	55.18	25.49	2.92
28.12	8.72	2.79	16.19	117.33	40.31	14.87
30.47	10.19	5.41	27.28	139.73	30.40	56.18
32.81	5.23	1.76	12.77	80.11	18.96	61.19
35.16	10.10	0.00	6.55	14.19	25.37	43.03
37.50	9.94	0.44	6.25	8.39	13.44	9.41
39.84	4.37	0.76	4.05	4.67	5.19	0.88
42.19	4.80	0.13	5.97	2.19	11.36	7.07
44.53	7.47	0.04	2.31	1.00	13.32	10.35
46.88	3.43	0.07	1.47	7.75	3.65	1.39
49.22	1.27	0.60	1.04	8.47	5.57	4.65
51.56	2.90	1.02	2.23	5.17	5.37	4.92
53.91	1.40	0.47	4.72	2.40	2.72	1.34
56.25	0.47	0.14	0.51	1.52	2.19	0.08
58.59	1.17	0.56	4.12	3.47	4.12	0.36
60.94	1.21	1.68	3.51	4.50	2.33	4.34
4.69	2.25	4.85	2292.56	0.40	62.32	15.03
7.03	2.76	0.37	1442.75	57.68	360.18	3.59
9.38	2.60	21.80	808.62	39.26	193.65	48.52
11.72	0.76	40.06	272.78	247.30	19.84	133.49
14.06	2.28	35.23	62.91	176.41	236.60	192.39
16.41	2.00	6.76	6.67	213.64	185.16	131.41
18.75	0.92	1.08	9.27	81.29	6.43	34.43
21.09	1.52	6.19	23.40	14.05	134.85	136.89
23.44	0.76	8.39	15.64	5.33	161.53	34.99
25.78	0.42	15.37	6.87	80.72	8.10	19.17
28.12	0.66	9.40	3.72	178.93	58.79	36.94
30.47	0.65	0.62	2.28	89.34	99.73	12.33
32.81	0.06	2.79	3.84	37.29	15.95	21.41
35.16	0.35	0.40	6.38	19.84	12.16	20.05
37.50	0.87	0.99	2.98	2.38	37.17	0.38
39.84	0.55	3.29	0.99	2.67	5.58	4.17
42.19	0.71	3.75	4.87	14.00	5.39	11.79
44.53	1.76	0.21	4.78	25.04	13.39	0.73
46.88	1.29	2.00	0.20	9.97	5.26	7.01
49.22	0.77	1.75	1.51	5.29	0.52	2.18
51.56	1.04	0.50	1.33	1.10	2.86	1.46
53.91	0.11	0.15	0.92	1.14	2.85	3.07
56.25	0.29	0.05	1.09	1.71	0.02	0.61
58.59	0.78	0.31	0.99	1.60	1.75	1.54
60.94	0.62	1.09	0.86	0.41	1.60	2.92
4.69	1.85	3382.19	9.68	30.35	14.25	987.59
7.03	6.46	1251.89	31.90	9.21	56.92	586.46
9.38	1.58	97.05	10.19	25.14	56.43	201.51
11.72	0.21	34.54	10.42	66.94	26.19	69.92
14.06	4.56	44.33	19.41	100.54	67.13	38.54
16.41	4.03	7.51	8.45	25.95	75.69	54.35
18.75	0.01	0.26	3.09	340.41	10.25	35.12
21.09	2.66	3.99	15.35	418.60	18.27	21.76
23.44	2.36	7.79	19.21	305.63	48.99	2.21
25.78	0.57	5.33	3.58	74.25	12.67	21.71
28.12	1.90	12.55	11.92	17.15	4.91	24.98
30.47	2.72	4.06	15.24	4.96	44.20	2.62
32.81	0.49	0.17	4.80	1.40	31.92	12.39
35.16	0.92	1.16	12.61	5.67	5.91	2.26
37.50	3.96	4.75	12.57	18.26	7.70	11.96
39.84	1.21	5.01	0.90	55.35	6.07	3.24
42.19	0.20	1.65	5.20	72.23	8.38	5.68
44.53	1.28	1.62	7.06	26.66	28.16	0.18
46.88	0.22	3.65	3.07	4.22	21.77	1.14
49.22	0.35	0.99	1.89	1.66	3.94	1.52
51.56	0.81	0.53	1.53	1.91	8.13	1.27
53.91	0.40	0.30	0.79	3.61	7.75	2.86
56.25	0.18	0.33	1.10	0.91	1.05	0.67
58.59	0.52	1.61	2.75	0.12	4.37	1.72
60.94	0.94	3.22	6.08	0.51	9.63	0.85
4.69	3.99	43.30	1.48	209.18	92.54	3.91
7.03	29.51	22.09	5.38	88.73	127.64	16.90
9.38	15.89	23.06	3.75	194.61	90.38	73.20
11.72	3.09	4.22	2.79	52.73	74.43	64.54
14.06	22.83	5.91	4.76	164.52	76.63	28.09

	16.41	19.27	0.29	2.00	125.21	71.57	37.18
	18.75	0.92	5.60	0.60	56.51	54.12	153.52
	21.09	12.98	10.39	2.47	225.28	59.03	112.35
	23.44	19.96	2.32	3.82	301.71	62.43	5.53
	25.78	2.93	1.62	3.44	150.72	39.12	11.20
	28.12	6.88	1.36	4.28	40.84	12.26	32.01
	30.47	13.73	2.31	3.84	29.91	20.60	146.92
	32.81	3.55	3.12	0.98	4.25	26.04	173.29
	35.16	0.47	0.87	0.83	5.14	2.69	128.62
	37.50	3.39	4.47	2.19	8.93	7.55	2.81
	39.84	2.37	3.44	2.00	11.28	8.49	39.15
	42.19	0.25	2.56	0.61	1.95	0.74	1.71
	44.53	2.00	0.97	0.50	17.42	5.45	9.41
	46.88	1.76	1.06	0.52	29.31	4.48	0.49
	49.22	0.81	0.15	0.96	31.50	0.50	5.65
	51.56	1.33	0.56	2.00	17.86	5.01	4.67
	53.91	1.55	0.30	2.00	4.83	3.06	0.31
	56.25	0.86	0.59	0.86	0.21	1.10	1.03
	58.59	1.43	2.19	1.57	2.59	3.01	1.65
	60.94	1.04	2.00	1.87	1.76	4.23	0.22
Session #3	4.69	11.74	1323.30	49.28	209.55		
	7.03	7.28	2.47	223.90	417.88		
	9.38	3.84	46.21	107.21	207.45		
	11.72	4.75	39.47	1.23	983.35		
	14.06	6.68	55.42	104.00	1141.30		
	16.41	2.98	12.97	101.89	121.70		
	18.75	0.73	5.53	2.47	227.23		
	21.09	3.09	4.59	61.47	331.40		
	23.44	2.19	1.99	66.46	87.56		
	25.78	0.56	0.83	2.00	1.90		
	28.12	3.92	0.19	54.57	59.22		
	30.47	2.77	1.15	54.73	18.49		
	32.81	1.64	0.43	3.74	2.00		
	35.16	0.85	1.03	10.58	2.66		
	37.50	0.97	4.19	32.09	0.20		
	39.84	1.59	0.99	14.96	1.28		
	42.19	1.92	0.94	7.88	1.04		
	44.53	0.02	0.04	34.45	0.45		
	46.88	1.41	1.19	14.23	0.37		
	49.22	1.57	0.45	2.14	0.03		
	51.56	3.07	0.11	16.04	0.42		
	53.91	0.69	0.11	11.42	0.29		
	56.25	0.05	0.02	0.40	0.40		
	58.59	0.30	0.10	9.75	1.92		
	60.94	0.04	0.31	18.49	6.05		
	4.69	2.20	23.73	872.20	23.05		
	7.03	18.46	4.41	5332.00	175.34		
	9.38	6.26	1.93	2372.65	33.80		
	11.72	2.69	0.84	133.97	31.22		
	14.06	23.44	2.00	2326.85	97.69		
	16.41	21.42	0.47	1318.44	27.10		
	18.75	0.55	0.05	1.48	152.14		
	21.09	11.43	0.76	496.79	127.93		
	23.44	17.17	1.11	367.96	40.05		
	25.78	2.00	1.59	16.20	149.83		
	28.12	2.21	1.88	66.57	65.58		
	30.47	6.29	0.67	127.07	306.53		
	32.81	2.33	0.80	32.49	507.64		
	35.16	1.27	0.84	6.16	364.30		
	37.50	12.78	0.50	56.39	38.72		
	39.84	4.50	0.72	23.88	48.30		
	42.19	0.60	0.76	2.40	15.38		
	44.53	5.90	0.41	26.81	44.38		
	46.88	3.73	0.51	24.45	97.64		
	49.22	0.47	0.25	0.76	20.49		
	51.56	3.49	0.10	17.16	2.68		
	53.91	2.87	0.16	39.03	3.22		
	56.25	0.14	0.15	11.46	4.44		
	58.59	0.46	0.01	8.60	6.35		
	60.94	0.32	0.06	23.79	2.23		
	4.69	2058.35	172.33	601.20	92.24		
	7.03	1398.37	19.54	4086.91	45.85		
	9.38	570.15	31.89	3264.46	59.82		
	11.72	373.01	26.27	238.00	25.60		
	14.06	154.22	4.27	814.78	16.32		
	16.41	6.92	1.87	1533.56	70.39		
	18.75	6.96	1.00	339.58	50.37		
	21.09	72.92	1.29	58.96	24.18		
	23.44	67.26	0.45	298.91	42.18		
	25.78	14.51	0.21	204.07	145.83		
	28.12	39.52	0.68	205.52	128.42		
	30.47	29.78	1.11	116.65	43.56		

32.81	2.33	0.74	15.30	43.63
35.16	14.47	0.53	90.07	119.52
37.50	30.63	0.50	107.40	65.06
39.84	8.53	0.31	9.15	34.29
42.19	5.56	0.59	31.57	206.79
44.53	22.16	0.79	60.68	144.66
46.88	14.26	0.54	6.57	34.50
49.22	4.68	0.78	21.62	15.44
51.56	9.75	0.26	68.97	3.45
53.91	10.22	0.05	27.39	9.16
56.25	2.38	0.53	3.13	6.41
58.59	4.01	0.24	33.44	0.38
60.94	7.38	0.26	26.90	0.55
4.69	30.57	292.49	732.04	295.59
7.03	202.95	39.95	5386.26	126.29
9.38	293.00	0.42	3616.54	6.22
11.72	50.48	10.99	79.76	28.71
14.06	18.48	16.44	1288.27	10.78
16.41	64.34	9.92	1682.98	7.19
18.75	21.78	8.12	260.40	5.98
21.09	3.16	2.31	97.27	1.51
23.44	14.87	0.21	252.11	0.91
25.78	1.49	1.65	105.57	5.56
28.12	3.08	0.16	90.37	7.35
30.47	12.03	1.27	41.19	26.31
32.81	4.02	4.34	4.42	164.90
35.16	1.46	5.46	46.00	619.10
37.50	9.40	2.52	53.86	328.70
39.84	2.80	1.97	3.90	48.45
42.19	1.02	0.74	20.46	2.14
44.53	9.81	1.41	49.02	0.76
46.88	4.94	0.55	7.37	0.73
49.22	1.06	0.52	8.77	0.70
51.56	4.99	0.28	33.98	1.14
53.91	3.81	0.86	16.34	2.64
56.25	0.01	0.45	6.65	0.57
58.59	1.65	1.14	24.69	0.47
60.94	2.36	0.70	28.13	0.89
4.69	342.09	11.74	1421.75	15.43
7.03	520.88	88.66	6248.09	23.86
9.38	438.52	54.15	4652.70	9.96
11.72	171.62	21.75	379.79	12.41
14.06	155.76	27.76	878.70	11.65
16.41	191.28	35.88	1419.54	19.27
18.75	75.67	12.22	242.15	0.40
21.09	59.14	0.27	140.15	6.75
23.44	95.59	2.54	149.92	3.62
25.78	23.47	3.66	3.73	5.14
28.12	2.72	11.21	146.25	5.98
30.47	24.16	3.80	202.22	20.14
32.81	6.33	2.54	37.61	122.23
35.16	8.27	4.53	21.36	598.63
37.50	39.83	1.80	121.83	342.03
39.84	18.31	0.51	41.88	39.60
42.19	6.47	0.84	12.82	0.44
44.53	18.63	2.51	111.38	2.27
46.88	11.00	0.85	67.93	1.32
49.22	0.71	0.96	0.60	0.15
51.56	8.47	1.28	57.59	1.48
53.91	6.12	0.19	64.61	0.19
56.25	4.86	0.39	5.08	1.12
58.59	16.33	0.58	23.60	0.01
60.94	13.81	0.01	47.82	0.65
4.69	63.53	400.44	615.96	2378.28
7.03	0.80	42.24	393.11	2249.93
9.38	36.94	0.53	881.33	898.41
11.72	0.88	10.87	12.62	83.79
14.06	25.15	27.52	1115.64	8.99
16.41	13.94	7.39	489.98	44.17
18.75	7.03	2.67	33.74	162.11
21.09	15.37	3.40	325.97	185.48
23.44	5.12	0.78	428.10	97.08
25.78	2.22	3.27	36.55	49.76
28.12	4.04	21.81	163.23	39.95
30.47	2.89	22.21	341.55	40.75
32.81	2.96	3.53	44.15	53.68
35.16	5.73	0.15	60.15	63.26
37.50	1.26	1.34	163.42	92.67
39.84	1.25	0.31	44.75	59.06
42.19	2.32	2.36	8.84	4.72
44.53	2.23	2.33	80.15	5.58
46.88	2.00	0.71	52.23	2.84

49.22	0.67	0.92	1.54	2.41
51.56	0.52	1.18	49.31	7.03
53.91	0.67	1.35	52.24	3.19
56.25	0.15	1.32	2.82	1.87
58.59	0.74	0.30	26.64	1.70
60.94	1.32	0.02	47.38	1.86
4.69	19.92	17.51	2685.62	0.93
7.03	78.59	34.20	7344.77	49.69
9.38	37.94	7.17	1605.87	7.33
11.72	8.22	1.29	762.14	17.79
14.06	63.69	7.17	2268.96	11.90
16.41	39.44	2.24	669.59	6.85
18.75	2.34	4.32	78.73	0.64
21.09	26.65	2.69	289.29	1.77
23.44	19.21	0.58	551.59	3.82
25.78	1.41	0.92	125.85	4.20
28.12	18.92	0.32	66.42	5.03
30.47	14.53	1.30	221.45	16.98
32.81	1.68	0.98	31.28	147.60
35.16	10.33	0.03	33.05	487.05
37.50	10.91	0.02	101.18	364.15
39.84	6.62	0.03	29.87	20.53
42.19	5.08	0.21	19.97	34.62
44.53	6.19	0.11	101.34	5.88
46.88	6.82	0.04	41.05	0.03
49.22	3.39	0.02	6.35	1.97
51.56	4.58	0.13	57.75	2.00
53.91	4.85	0.05	38.28	0.90
56.25	0.86	0.31	1.85	0.64
58.59	0.60	0.14	37.60	1.85
60.94	1.09	0.07	43.34	0.60
4.69	3117.86	408.51	872.96	44.25
7.03	587.46	285.40	6586.70	39.15
9.38	260.31	22.54	3872.07	11.91
11.72	563.20	12.42	25.64	35.55
14.06	119.45	13.08	1836.48	14.62
16.41	44.03	10.79	1775.59	10.78
18.75	202.65	5.84	91.20	8.48
21.09	81.86	5.18	215.25	6.09
23.44	7.10	10.79	237.88	7.21
25.78	106.52	6.98	13.87	15.52
28.12	70.07	2.83	106.09	17.71
30.47	1.38	2.82	126.94	8.38
32.81	62.16	2.98	20.05	281.42
35.16	47.75	2.00	32.87	476.98
37.50	0.47	0.83	143.00	146.41
39.84	28.93	1.01	45.83	42.40
42.19	42.47	0.04	13.13	36.97
44.53	4.33	0.33	86.60	0.59
46.88	16.60	1.78	34.73	7.90
49.22	32.18	1.37	4.22	3.23
51.56	5.04	3.56	56.18	3.82
53.91	8.50	6.01	39.54	5.42
56.25	24.68	1.96	0.19	1.01
58.59	8.19	0.58	27.75	0.49
60.94	2.47	0.10	37.03	0.43
4.69	3.10	55.64	1052.99	53.65
7.03	45.75	19.15	6765.14	9.46
9.38	32.04	6.11	2832.87	77.71
11.72	1.73	7.89	131.93	23.30
14.06	45.91	19.35	2277.36	13.75
16.41	39.03	2.31	1421.17	1.02
18.75	2.41	1.16	2.33	12.18
21.09	18.65	2.31	252.29	11.45
23.44	32.94	5.23	200.25	4.67
25.78	1.03	0.79	11.61	0.27
28.12	15.10	0.56	23.81	7.61
30.47	34.18	1.22	66.41	12.99
32.81	10.39	4.37	7.93	2.94
35.16	4.85	2.67	23.74	250.93
37.50	16.25	0.77	83.84	510.23
39.84	5.89	3.20	20.28	150.68
42.19	0.58	1.94	4.10	8.91
44.53	7.95	0.02	34.32	4.14
46.88	3.16	1.74	18.37	4.20
49.22	1.91	1.23	0.98	2.61
51.56	6.16	0.10	37.19	1.21
53.91	4.53	0.17	32.71	0.28
56.25	0.39	0.21	1.34	0.82
58.59	3.31	0.92	15.18	0.78
60.94	2.00	0.35	23.16	0.08
4.69	8.80	83.76	3199.03	499.23

7.03	33.64	98.09	8474.01	274.36
9.38	18.89	93.68	1551.56	325.41
11.72	8.53	17.05	440.89	138.45
14.06	28.72	24.25	1509.82	130.28
16.41	13.18	20.05	1197.58	30.07
18.75	0.42	9.64	59.31	7.97
21.09	13.84	3.39	219.28	3.73
23.44	11.28	2.00	345.67	32.98
25.78	0.13	3.27	62.28	16.48
28.12	5.98	5.11	53.81	11.72
30.47	9.94	5.93	159.28	165.36
32.81	1.86	5.84	26.97	247.70
35.16	0.23	1.62	55.34	65.73
37.50	3.93	0.51	176.24	21.74
39.84	3.23	0.85	67.92	25.51
42.19	0.76	0.21	14.44	19.53
44.53	3.85	0.43	108.14	1.23
46.88	4.87	0.03	50.14	0.93
49.22	1.36	0.04	5.26	3.30
51.56	0.59	0.61	68.54	6.23
53.91	1.09	1.74	54.03	1.21
56.25	0.15	0.49	2.00	1.80
58.59	0.48	0.26	41.01	2.84
60.94	0.74	0.38	42.78	2.51