# Matching law: understanding behaviour in non laboratory settings

The matching law was first introduced by Richard J. Herrnstein (1961). The matching law is a predictor of activities that an individual would undertake when they are concurrently available to an individual. The law does not predict that actual activities will occur rather it predicts that the rate of response that one assigns to a particular activity will match the percentage of reinforces that the individual obtains from participating in that activity. (Lieberman, 1993; Herrnstein, Rachlin, Laibson, 2000)

A particular activity that occurs is strengthened or weakened by the response. In other words the rate of an activity occurring is strengthened or weakened by the rate of the reinforcement.

Many laboratory experiments have been set up to demonstrate the effectiveness of isolating the value that is obtained from a particular activity amongst concurrent activities. Controlling the rate of reinforcement which can be in the form of water for thirsty rats or pigeons or food for hungry rats or pigeons also highlights the value of a particular activity. The frequency of the particular activity is measured in laboratories by having ‘ clearly dicriminable choices’ (Herrnstein, 2000) these choices are the particular activities that are concurrently available during the particular time period (rats pressing one of two levers or pigeons pecking one of two discs). The laboratory experiments predict the relative rate of responding (pressing a lever, or pecking) match the relative rate of reinforcement (water or food for the hungry rats or pigeons). (Herrnstein, 2000)

Herrnstein (1961) conducted an experiment with pigeons and demonstrated that the relative frequency of responding on a given key closely matched the relative frequency of reinforcement on that key. He demonstrated this by using three Carneaux pigeons. Herrnstein modified the 1957 Ferster and Skinner pigeon box by adding two response keys (left key: red, right key: white). The pigeons were initially trained to peck the keys by operant conditioning whereby the pigeons were ‘ rewarded’ with food pellets when they had pecked the keys, thus reinforcing the pigeons’ behaviour of pecking the keys.

The actual experiment involved the pigeons being faced with ‘ choices’. The concurrent schedule set up in this experiment left the pigeons to respond either to the left or right key. The keys operated on different variable-interval (VI) schedules. This schedule is set up so that the first response (key pecking) resulted in reinforcement (food) this then starts a timer in which a response can be reinforced again after a period of time has elapsed but the time is not fixed it can range from 5 seconds to 60 seconds but maintains an average time, it is also important to note that the VI schedules are unpredictable. The value of the mean interval on each key in Herrnstein (1961) experiment ranged from 1. 5 to 9 minutes. The rate of response did not change the maximum rate of reward. It was found that the relative frequency of responding on a particular key closely matched the relative reinforcement of a key.

The matching law can be outlined in the following equation: Ra/Rb = ra/rb

Ra/Rb are the rates of responses on the keys (a and b) by the subjects per (time), and ra/rb is the rate of reinforcement of keys (a and b) per (time).

Thus the pigeons pecked as many times as the reinforcement was delivered. (Herrnstein, 1961; Lieberman, 1993, Malot, Malot, Trojan, 2000)

Jacquet (1972) explored ‘ Schedule-induced licking during multiple schedules’, Jacquet experimented on rats devised an experiment which consisted of two-component multiple schedules for food reinforcement. The rats were taught prior to the experiment how to ‘ bar press’. The first component of the multiple schedules was a VI 1-min VI 3-min schedule. The components were recorded separately, the intervals were random but were restricted to a mean of 60 for the VI 1-min and 180 for the VI 3-min being played for 20 schedules on a tape. The tape was stopped until the bar was pressed again, during this component the rats were free to lick a tube in which they could get water (this did not affect the schedules) Component two changed in blocks of 27 sessions.

The second component in the first, third and fifth compromised of VI 3-min but only resulted in one pellet the second, session of the second component compromised of delivering three pellets. During stage 4 the schedule was VI 1-min and during stage six the schedule was extinction. Water intake altered according to the rate of reinforcement and was highest in the second component (stage four) in the VI 1-min schedule where the magnitude of reinforcement had increased. Both aspects of the study bar pressing and licking, showed interactions between the two components of the multiple schedules. The lick rate and reinforcement rate during the VI 1-min schedule were three quarters of the rate in the VI 30min schedules. When the magnitude of reinforcement increased from one pellet to three pellets the lick rate decreased. The VI 3-min one pellet condition induced more licks to pellets than the VI 3-min three pellet schedules. The relative frequency of licks in the constant component matched the frequency of reinforcement.

Bar pressing in rats demonstrated matching between relative rates of bar pressing and relative rates of reinforcement similar to pigeon pecking studies. The induced licking resulted in a closer match due to the initiation of licking due to delivery of food pellets, when the component two was changed to VI extinction licking ceased. (Jacquet, 1972)

The reinforcement value of water was highlighted in Cohens' (1975) study, where it was found that the matching law was a predictor of the relationship between frequency of food and the relative reinforcement of water. The rate of drinking thus was indirectly induced by the frequency of food reinforcements.

This demonstrated that the matching law could be used in order to highlight similarities between animals. The rats and pigeons behaviour choices can be summed by the matching law. These studies support Herrnsteins matching law.

Schmitt, (1974) however demonstrated in his study on human participants that the effect of the rate of reinforcement and the magnitude of the reinforcer on VI schedule choices does not describe human behaviour effectively in laboratory settings. Two experiments were conducted in Schmitts' study, in experiment one the five human subjects responded using a button on a box which could switch between schedules, the button reinforcer was ' counter points' which could be exchanged for money. The four concurrent VI schedules in experiment one resulted in the relative response not matching the relative rate of reinforcement. This discrepancy also existed for the time spent responding to particular schedules and the relative rates of reinforcement. Furthermore the second experiment which looked at the magnitude of the reinforcement being varied, found discrepancies between the varied magnitude of the reinforcement and the relative responses. This suggests that the Matching law in laboratory setting can’t be generalised to human subjects.

One of the foundations of the matching law is the reinforcement. This is one of the prime and necessary components, Miller (1976) in his study ‘ matching-based hedonic scaling in the pigeon’ looked at this key component used in the matching law. The main reinforce for the birds used in Herrnsteins experiments was bird seeds although just as humans have preferences for different foods, birds have different preferences for seeds. It is also important to note that the same reinforcement (the same type of birdseed) was used for both schedules in Herrnsteins experiments.

Miller compared different birdseeds as reincorcers he puts pigeons through three conditions. He ran an experiment where one condition involved a concurrent schedule where wheat was the reinforcer for one key and buckwheat was the reinforcer for the other key. He allowed the pigeons to get used to the schedule and to produce a steady rate of response then he changed the schedule by changing one of the reinforcers for one of the keys. In the second condition he swapped the wheat for hemp. Once the pigeons again got used to the schedule arrangement and produced a steady rate of responding Miller found that he could on the basis of these two different conditions he could predict the preference of which reinforcer the pigeons would prefer in condition three by them pecking a particular key when he reintroduced wheat and kept hemp. This demonstrated that the matching law can highlight the elements that exist in choice. It can further predict choice, the implications of being able to predict what the pigeons would choose suggest that further predictions could be made using the matching law. (Miller, 1976)

Another factor that is to be considered is the actual schedule involved in the experiments. The VI schedule produces a reinforcer on an interval basis. Although a Variable ratio (VR) schedule requires a set number of responses in order for reinforcement to occur and the set number of responses varies across the reinforcement schedule. (Lieberman, 1993 Hernstein, Heyman, 1979) If the concurrent schedules in a study were both VR one being VR 2 and one VR 8 it is optimal to go for the VR 2 because it leads to more reinforcement as it has a higher reinforcement rate.

Hernstein and Heyman (1979) developed a study to look at what occurs when in a concurrent schedule on key operates on a VI schedule and the other on a VR schedule. Intuitively time spent on the VR key results in more reinforcement and more likely reinforcement from the VI key although time spent on the VI key is less likely to result in reinforcement in the VR key. Four pigeons on the concurrent VI and VR schedules were found to peck more on the VR than the VI which is not optimal thus not resulting to maximising reinforcement. The pigeons lost reinforcements at a rate of 60 per hour and ‘ matched’ rather than maximised their reinforcements with their responses.

This sets a strong case to suggest that animals prefer to match rather than maximise and optimise their responses with reinforcements. Although these experiments lack ecological validity in that they are laboratory experiments and the results may not lead to successfully generalising the results in natural setting.

‘ Choice in free-ranging wild pigeons’ was studied by Baum (1974). 20 pigeons lived in a house and had free access in and out of the house. The pigeons were trained to operate buttons (keys) by pecking, which subsequently allowed them access to food. The pigeons learned to peck the VI middle key on a box when it was illuminated. The middle key operated on a VI 30-seconds food reinforcement schedule. The Pigeons once they produced stable results were put into a concurrent condition in which two buttons operated at different VI schedules. Only one bird at a time had access to the buttons although the group as a whole was taken into consideration when taking results. The results demonstrated that the pigeon’s pecks on the buttons closely matched the relative reinforcement of food. (Pierce and Cheney, 2004) This suggests that Herrnsteins 1961 theory of the matching law may have applications to the behaviour of animals outside of laboratory settings, choice may be predicted in natural environments.

The application of the matching law to human beings in natural environments has been looked at by (Vollmer&Bourret, 2003) they highlight the value that exists in “ choice situations” when concurrent schedules of reinforcement are available within a subjects environment. They demonstrate this by giving the example of an individual wanting to contact a friend by telephone. They explain that the individual would more likely use a mobile number as opposed to a work number at a particular time of day because the relative reward (making contact with the friend via telephone) is more likely by choosing one method over the other. Vollmer and Bourret tested the matching law in a natural environment. They looked at a men’s and women’s basketball team and analysed their 3 and 2 point basketball shots. The 3 and two point shorts were the responses that were being evaluated they were the concurrent schedule whilst points were the reinforcer. Reinforcer magnitude was a factor too due to the fact that 3 point shots lead to a bigger reinforcer (3 points) compared to a small reinforcer of 2 points.

It was found that the relative rate of response (3 point and 2 point shots) matched the relative reinforcement (3 points or 2 points) for both the men’s and the women’s teams. A follow up study where Vollmer et al. (2003) looked at the NBA relative rates of 3 point and 2 point shots, had the opportunity to look at ‘ the relative response rates under different reinforcer rates for individual players’. The NBA moved its 3 point line, so Vollmer et al. Looked at the three year period of the NBA when before the line change, during the line change and when the line was moved back. It was hypothesised that there would be an increase in three point shots when the line was moved closer because the opportunity for reward (a 3 point shot) was higher. The findings found that the relative response rate matched the relative reinforcement rate. (Vollmer&Bourret, 2007) The study thus supports the matching law in a natural game play environment.

There are many sports that humans engage in, the previous study demonstrated how matching exists in basketball, Reed, Critchfield and Martens, (2006) conducted a study to show how the matching law can be applied to American football. The relative ratio of reinforcement was described as yards gained from the responses of passing versus rushing plays. The results demonstrated that the matching law accounted for much of the play in American football.

In another more ecologically valid setting, Skinner, Robinson, Johns & Logan (1996), conducted an experiment on college students in order to determine factors that influence their choice behaviour.

Subjects were asked to complete a 16 three-digit by two-digit (3×2) multiplication problem (condition 1), and another task that contained a similar (3×2) task with additional scattered six (1×1) equations (condition 2). The students rated the latter as an easier task. When the subjects were given the choice of choosing the next format the majority of students chose the condition 2 setup. A separate experiment was conducted in order to take out the (1×1) task to make in case the simple task confounded the results by adding a novelty feature to the choice. The altered experiment along with the previous experiment demonstrated that scattering easier problems amongst difficult problems has an effect on choice in that students tend to choose the tasks that have easier tasks interspersed in more difficult tasks and rate them as easier. The experiments demonstrated Herrnsteins' matching law by suggesting that completing the problem is a reinforcing event. (Skinner, Robinson, Johns & Logan, 1996)

The experiment has some limitation in that its subjects are undergraduate psychology students who wouldn't necessarily have an issue in choosing either of the conditions so their rating of either condition would need to be tested with a different sample group. The sample and research did not represent a typical classroom environment; a more useful sample would be from a more at risk group who do not necessarily feel comfortable with the tasks as the undergraduate students may have been.

One experiment that addressed these limitations was developed by Teeple and Skinner (2004). 32 students who had emotional and behavioural disorders (EBD) who were representative of 5 school year grades were given two tasks to complete with a time limit of 15 minutes each. A control task consisted of 15 paragraphs which subjects were instructed to rewrite adding in punctuation, and an experimental task which was interspersed with 8 additional very brief 1 sentence paragraphs every second paragraph (as opposed to the control task with multi-paragraphs). Subjects were asked to choose either the control task or experimental task after as a home work.

It was found that more students chose the experimental condition task as homework and rated both tasks similar in time and effort requirement. The study demonstrates that previous research with undergraduate students in task ranking may have not been accurate because more tasks should lead to more difficult task rather than easier and in this particular study it was found that the EBD students did not rate either of the tasks easier. Although their choice was still affected in that the interspersing of additional easier work encouraged the choice of that particular work amongst EBD students.

Similarly to the work of Miller (1976) whereby the value of reinforcement affects the matching law, this study highlights the importance of response variables in influence student’s choice. The study suggests that interspersing work with easier work helps encourage students in choosing that particular task with the reinforcer of discrete task complete (completion of paragraphs) as reinforcers.

In sum, Herrnsteins’ matching law sets the ground work for the explanation of choice behaviour in non-laboratory settings. The development of key laboratory questions built the rationale for non-laboratory setting experiments which had implication of supporting the findings of animal studies in laboratories such as support for pigeon choices. The matching law also gives an explanation for choices made in sports particularly basketball and American football. The implication further extend to classrooms where the importance of understanding what effects choice brings about positive results in helping students with EBD to work and choose work that they prefer. Herrnsteins matching law was developed in a laboratory setting and set the ground works for understanding motivations of choice in more ecologically valid natural experiments.