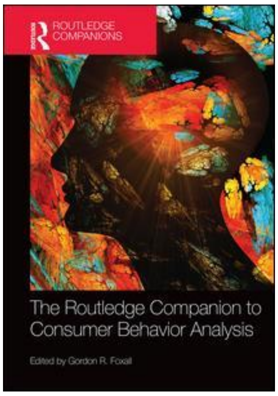


# The Routledge Companion to Consumer Behavior Analysis

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## Experimental analyses of choice and matching

Publication details
https://test.routledgehandbooks.com/doi/10.4324/9781315850696.ch6
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**Published online on: 08 Sep 2015**

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# Experimental analyses of choice and matching

## From the animal laboratory to the marketplace

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> Even after we've studied behavior in the laboratory, we can't expect to be able to interpret every instance of behavior outside the laboratory. There are limits to what we can know. . . . In our study of learning, it's important to recognize what remains out of our reach.
>
> *(Catania, 1998, pp. 6–7)*

### Introduction

Marketing needs to have a theoretical and/or empirical foundation to account for the situational influence of the marketing mix on consumer choice. The matching law (Herrnstein, 1961, 1970), or the quantitative law of effect, is a mainstream behavior analysis of choice behavior and has been studied for several decades. The matching law's research history, indeed the history of the whole of behavior analysis, has mainly been conducted in a systematic experimental framework where knowledge is built by constantly putting more factors under experimental control. Most of the research has been done on animal behavior in the behavioral laboratory. The few experimental studies that have been conducted on human behavior have mostly been done in a rather closed setting. This casts doubt on the generalization of the matching law to the more complicated real behavior of humans.

Consumer behavior analysis explores the generalization of the matching law on human behavior in the most open, real setting. This important work has differed in important ways from most other research on the matching equations. The experimental method has not been applied to much extent and the behavior under study is mostly maintained on concurrent ratio schedules (that is pricing, instead of concurrent interval schedules).

The subject matter of consumer behavior analysis is first and foremost the exploration of the possibility of using the concepts and methods of behavior analysis applied in research, on a more simple level, for the study of consumer choice behavior in real settings. As such, it studies the impact of more known important variables on consumer choice in real-life situations. Some of these variables have already been identified from research on matching at a simpler level. To deal with the influences of the marketing mix on consumer choice, behavior analysis needs to find the sole effects of the most important variables to determine its importance in accounting for complex consumer behavior. The experimental method, where the effect of each independent variable is found to keep the others constant, is a necessary step in exploring the ability of behavior analysis to describe, predict and control consumer choice in open settings. This entails behavior analytical evaluations (see, e.g., Johnston & Pennypecker, 1993) and comparisons of the legitimacy of different outcomes from consumer choice and matching analysis of sales data obtained with in-store and/or online consumer experiments.

## Behavioral and experimental economics

> We descendants of Bentham can agree about the primacy of pains and pleasures; we can agree even that, as Hirshleifer recently said, there is only one social science. But now, to pursue that social science, and to use it to design social institutions, we need to reconcile the divergent answers provided by empirical approaches, such as that of behavioral psychology, with the formal structures of economic theory.
>
> *(Herrnstein, 1997, p. 264)*

Behavioral economics is a broad term; it can be classified, as was done for psychology in general, as cognitive and behavioral. This classification can be built on the explanatory value in behavioral terms that is given to internal, non-observable variables (cognitive processes). The discussion will begin with the more mainstream behavioral economics, the interplay between cognitive psychology and economics. This is most famously known from the work of such scholars as Simon (e.g., 1955), Kahneman and Tversky (e.g., 1979), Thaler (e.g., anomalies articles in *Journal of Economic Perspectives*), and Rabin (e.g., 2002). This line of research, cognitive psychological experiments on choice and decision making, has bridged the gap between economics and psychology by pointing to the overestimation of human rationality and the relevance of experiments in economics. It has had a major impact on consumer behavior research (Simonson et al., 2001). The discussion will later be limited to research in the tradition of "behavior analytical" behavioral economics, mostly known from former students of B. F. Skinner at Harvard University; such as Herrnstein (e.g., 1997), Rachlin (e.g., 1982), and Baum (e.g., 1979). From these and other behavioral scientists at the Harvard Pigeon lab, and afterwards, came matching analysis with rigorous animal experimental research, and mathematical treatment of behavior. This has stimulated Foxall at Cardiff University, his students and collaborators (the Consumer Behavior Analysis Research Group) to explore to what extent these behavior principles and this methodology are applicable and useful in the realm of consumer behavior. Furthermore, this research has also been connected to, supported and challenged the basic disciplines: behavior analysis and economics (e.g., Foxall, 2001; Oliveira-Castro et al., 2006).

## Matching analysis

> Skinner discovered response rate, stimulus control, and schedules. He and his students saw the possibility of a real (natural) science of behavior and set about establishing that science based on those concepts. Herrnstein discovered relative response rate, the matching law, and the psychophysics of choice. He and his students saw that the science could be quantitative and set about making it so.
>
> *(Baum, 2002, p. 355)*

Principles and techniques developed in basic behavior analysis have been transferred from the animal laboratories to the analysis of patterns of consumer choice in open real settings (cf. Foxall, 2007). This has mostly been done within the framework of the matching law, and has dominated research choice in behavior analysis for decades. Theoretically, the matching law has been presented in many forms and played a major part in the mathematical enhancement of behavior analysis, where different parameters have been experimented with and put together. It has been important in the cooperation, or friction, between economics and behavior analysis. It is one of the most successful behavioral laws, discovered with experimentation, in terms of reliability and generalization (Herrnstein, 1997), and has recently been tested in consumer choice research (see literature below).

## Schedules

To comprehend matching analysis it is necessary to introduce the topic of schedules. A reinforcement schedule (Ferster & Skinner, 1957) produces behavioral patterns because it is the rule that controls under what conditions reinforcement is delivered. Schedules have been investigated for more than five decades. They determine steady state behavioral patterns and resistance to extinction. In experimental analysis of nonhuman behavior, schedules induce remarkably lawful behavior but their effects on human behavior are more controversial and complex (e.g., Lowe, 1979; Pierce & Epling, 1999).

Continuous reinforcement is the simplest schedule; it requires that every response be reinforced. Intermittent reinforcement, when behavior is reinforced occasionally, is most often the rule in a real environment. This intermittent type can be classified as either ratio schedule or interval schedule. Ratio schedule is response based, meaning that reinforcement follows a number of behaviors or responses. Interval schedule, in contrast, delivers reinforcement only after a particular behavior is performed – when some time has passed since the last reinforcement. Both of these types of schedules are further classified as either fixed or variable. Fixed schedule reinforces after a fixed number of responses or length of time. Variable schedule, however, has changeable reinforcement. It delivers reinforcers after various response requirements or time, and is generally dependent on some average delivery system in the long run.

## Relative response rate

The single operant analysis, where behavior is analyzed based on one response class on a single schedule of reinforcement, is important for the discovery of basic laws, principles and applications. It is, though, more natural to study behavior as a choice among alternatives. De Villiers and Herrnstein's (1976, p. 1131) view "that choice is merely behavior in the context of other behavior" is appropriate for consumer marketing, when studying brand substitutability. This is because reinforcement on one schedule can affect the response on another schedule, and vice versa. The concept of relative reinforcement is important in consumer behavior analysis, as different brands compete for consumer choice. It is called "concurrent schedules" when two or more simple schedules are simultaneously available (e.g., concurrent VI VI). These schedules are used in experimental matching analysis, on animals, using a changeover delay (COD); a procedure that penalizes rapid switching by delaying reinforcement for a brief period after each change of a key (Herrnstein, 1961). The COD is necessary to prevent accidental switching, arising from too little latency between changing a key and acquiring a reinforcer, leading to reinforcement of rapid switching behavior that prevents any meaningful choice analysis. The duration of the COD can have an effect on the slope of the relative response function. Research has, however, shown that different delays generally don't have much systematic effect (Davison & McCarthy, 1988). In laboratory experiments on human behavior, factors such as the distance between keys have been used to avoid subjects pressing both keys at the same time (Herrnstein, 1997). Such a procedure is not necessary in the consumer setting as rapid switching or choosing two brands (reinforcers) at approximately the same time is not a problem, but is seen as normal (matching data is found to be dividing behavior with other behavior, not time).

Choice behavior has mainly been studied on concurrent interval schedules (mostly variable), where the schedule on one key is supposed to be independent of the other schedule (e.g., Herrnstein, 1961; Pierce & Epling, 1983). Concurrent variable schedules induce an allocation of behavior between the alternative schedules. This does not, however, happen on concurrent fixed schedules, which make subjects show exclusive choice of the leaner (better) schedule – when in a steady state (Herrnstein, 1997, chapter 4; Pierce & Epling, 1999). According to Herrnstein (1997, chapter 4) concurrent VR VR schedules, or something akin to them, are frequently seen in real environments, including consumer situations (e.g., Foxall et al., 2004).

## The strict matching law

The matching law was discovered by Herrnstein (1961, 1970) and was initially developed by him and his students at Harvard, but is now studied nearly worldwide (see Baum, 2002; Logue, 2002). It is a molar law[1] which states that relative response rate (behavior) matches its relative reinforcement (utility: see Herrnstein, 1997), on concurrent interval schedules of reinforcement,[2] in equilibrium (see, e.g., Davison & McCarthy, 1988; Herrnstein, 1997). For example, if 80% of all of the reinforcement in an experimental chamber comes concurrently from one of two possible response sources, then it will be chosen in that exact proportion. The simplest form of the strict matching law for two response possibilities is shown algebraically in Equation 1:

$$\frac{B_a}{B_a + B_b} = \frac{R_a}{R_a + R_b}, \qquad (1)$$

where the $B$ term stands for behavior frequency, or specific choice, and $R$ means corresponding reinforcers (e.g., per unit time). The reinforcement alternates between $R_a$ which is contingent on behavior $a$ and $R_b$ is reinforcement derived from behavior $b$, which can also be defined as all other behavior than $a$. As long as the behavioral possibilities under study are symmetrical (e.g., pecking discs or two identical lanes to drive on) and the reinforcement is indifferent between the behavioral choices other than reinforcer frequency or any other measurable parameter (e.g., reinforcer amount), then Equation 1 is appropriate. The matching law should therefore, theoretically, be appropriate for accounting for consumer choices between different brands.

The matching law is empirically well established from laboratory experiments (de Villiers, 1977; Herrnstein, 1997). Although the matching law has this empirical foundation, it can be viewed either as an empirical generalization or as a theoretical (tautological) system of equations used to define how environmental consequences control behavior (see, e.g., Killeen, 1972; Rachlin, 1971).[3] It is a simple molar law, which is one of its strengths, but it has univocal explanatory ability and generality. It deals with overall relative frequencies of choice behavior, which has been very useful and significant in behavior analysis because it has forced researchers to take into account the competition of different reinforcers. Herrnstein and colleagues (Herrnstein & Prelec, 1991; Herrnstein & Vaughan, 1980) also developed a theory at the molecular level that they called melioration, to account for how matching occurs in the long run.

## Melioration

Melioration predicts that the consumer will always show behavior which has a higher local reinforcement value each time, but will not take the long-run consequences into account (as rational choice theory predicts). It is supposed to predict exactly when the consumer is going to shift from one activity to another.

Unlike melioration that states which behavior is the most likely on each occasion, the matching law predicts the behavioral allocation to different possibilities in the long run, when behavior is steady. It is possible to define behavior in many measurable ways, as for example time spent, frequency of response, magnitude chosen, or money spent on different brands.

In the analysis that follows the concept of melioration, as Vaughan and Herrnstein (1997) defined it, will be used, but the effects of punishment will be added because this is necessary when dealing with consumer behavior. A defining character of consumer behavior like any other economic activity is the reciprocal transfer of rights. It simultaneously presents intended reinforcers and possible punishers (see Alhadeff, 1982; Foxall, 1998). Purchase responses can be reinforced by the acquisition of the commodities, and other benefits, but factors like price and effort can, and will in most cases, make the demand lower than it would otherwise be. The operation of melioration leads to matching in the long run. The reinforcement magnitude will be equal between the brands because of diminishing returns in reinforcement value. If reinforcement (minus punishment) for buying and consuming tomatoes is higher than reinforcement (minus punishment) for buying and consuming chocolate, then melioration predicts that tomatoes will be bought next time and as a consequence the reinforcement value for buying and consuming them will decrease. In most instances this will result in average reinforcement for the different products to be equal in the long run (matching), when everything else is unchanged. Melioration is the behavioral dynamic which is supposed to lie behind matching. The operation of melioration (with punishment) is shown in Equation 2:

$$d\frac{C_a}{C_a + C_b} / dt = f_x(V_a - V_b), \qquad (2)$$

where $V_a$ and $V_b$ are functions of reinforcement and punishment per unit time that the consumer spends on a particular brand, which here are two. The terms $C_a$ and $C_b$ represent money spent on *a* and *b*, which here can mean tomatoes and chocolate, with a fixed income ($C_a + C_b = 1$). It is assumed that the function $f_x$ is differentiable, strictly monotonically increasing, and $f_x(0) = 0$ (the analysis is built on Vaughan, 1985, with added punishment effects on choice behavior). Equation 2 shows that if reinforcement minus punishment for brand *a* is more than for brand *b* then relatively more money will subsequently be spent on brand *a*. The process that the equation describes comes into equilibrium when:

$$V_a = V_b \qquad (3)$$

For consumer behavior the assumption is that the value ($V_i$) for a particular circumstance is a strictly monotonically increasing function of reinforcement minus punishment in that situation: $V_i = g(R_i - P_i/T_i)$, where $R_i$ represents reinforcement (for example, the magnitude of reinforcers) in situation *I*, $P_i$ represents punishment (for example, price), and $T_i$ stands for unit of time. By defining melioration with punishment in this way the molar law will be able to account both for the effects of reinforcement and punishment on behavior in the form of the positive and negative law of effect.

## The positive and negative law of effect

As there is general agreement in the behavioral and social sciences that behavior is influenced by its benefits and costs,[4] it is important to add punishment to Equation 1. De Villiers (1980) presented Equation 4 to account for how reinforcement and punishment work simultaneously on behavior. From the theoretical point of view of Herrnstein's (1970) matching law:

$$\frac{B_1}{B_2} = \frac{(R_1 - P_1)}{(R_2 - P_2)} . \quad (4)$$

De Villiers' (1980) equation states that punishers ($P$) directly decrease the strength of reinforced behavior and shows exactly how reinforcement and punishment jointly control behavior.

The above equations of the strict matching law (1 and 4) describe choice behavior only accurately in symmetrical choice situations. Although it is possible to add parameters to the equations to account for a different quality of reinforcers (Miller, 1976) or other parameters such as reinforcer amount or delay (Herrnstein, 1997), most researchers today choose to use the generalized matching equation when studying matching.

## The generalized matching equation

The generalized matching equation (Baum, 1974a, 1979; Lander & Irwin, 1968) was developed so that data that did not conform to strict matching could be portrayed in the same terms as strict matching data. It "is a generalization of the strict matching law in the sense that the strict matching law is a special case of the generalized law" (Davison & McCarthy, 1988, p. 48). It is considered an improvement from the stricter version (McDowell, 2005) and measures how well the strict matching law can account for choice behavior (see Equation 5):

$$\frac{B_a}{B_b} = c\left(\frac{R_a}{R_b}\right)^a . \quad (5)$$

Here the terms $B_a$, $B_b$, $R_a$, and $R_b$ represent behavior and reinforcers as in the equations above. The parameters $c$ and $a$ are free and found by getting a straight line through data of relative response (choice behavior) and relative reinforcers transformed logarithmically (Equation 6):

$$\log\frac{B_a}{B_b} = a\log\frac{R_a}{R_b} + \log c . \quad (6)$$

The parameter $a$ accounts for the sensitivity of preference to changes in the independent variable and $c$ is inherently biased. When both $a$ and $c$ are equal to 1 then the data shows strict matching. Then Equation 6 is equivalent to Equation 1, the strict matching law (for a discussion of the generalized matching equation and its parameters see Baum, 1979; Lowe & Horne, 1985).

## Different dimensions of matching analysis

Matching analysis can take different forms. Choice can show perfect matching, overmatching, undermatching, antimatching, and bias. The slope $a$ gives a measurement of how much choice behavior changes when the reinforcement ratio is altered. The parameter $b$ represents the intercept or bias, a constant preference for one alternative over another for all points of the independent variable (Davison & McCarthy, 1988).

It is called overmatching (Baum, 1979) if the value of *a* (the slope) is higher than 1 because choices favor the richer reinforcement schedule. This means that the subject chooses this particular possibility ($B_a$) more often than the proportional reinforcement dimension for the option is [log($R_a/R_b$)]. In the laboratory this is considered to be a problem of design if the reinforcers are supposed to be equivalent, indicating that one of the alternatives is qualitatively different, or that switching is being penalized too severely. However, if relative choice behavior is allocated less to the target behavior ($B_a$) than anticipated from the basis of relative reinforcement, it is called undermatching (Baum, 1974a). This can indicate that either switching between alternatives is accidentally reinforced or that subjects discriminate poorly between the alternatives (Herrnstein, 1997).

In the case of bias there is a systematic preference for an alternative not explainable from the viewpoint of the strict matching law (from the perspective of one dimension of objective reinforce elements, e.g., relative rates of reinforcement alone). Bias indicates differences between response requirements (e.g., different shelf placements for different brands) or reinforcer parameters (e.g., different brand qualities or delivery time). This is represented by the intercept in Baum's generalized matching equation (see Equations 5 and 6). In terms of antimatching, when an increase of choices of one alternative increases the selection of a second option, the reinforcers (products or brands) are gross complements instead of substitutes (e.g., red wine and a steak). This makes the slope parameter *a* less than 0 (Foxall, 2007). In all, the generalized matching equation (sensitivity to reinforcer dimensions, reinforcer parameters, and response requirements), accounting for consumer behavior, should be under the influence of all traditional independent variables known in microeconomic analysis (see Lea, 1978, for a discussion of the analogy between reinforcement analysis and demand analysis).

## The concatenated generalized matching equation

It is possible to use many independent variables for the generalized matching equation. These can, for example, be variables that research has shown affect behavior such as rate, amount, immediacy, and quality of the reinforcers or response effort (for a review see Fisher & Mazur, 1997). To account for this within the framework of the generalized matching equation it is possible to use the concatenated generalized matching equation (Equation 7):

$$\log\frac{B_a}{B_b} = a_r \log\left(\frac{R_a}{R_b}\right) + a_m \log\left(\frac{M_a}{M_b}\right) + a_q \log\left(\frac{Q_a}{Q_b}\right) + a_d \log\left(\frac{D_b}{D_a}\right) + \log c\,, \tag{7}$$

where *R*, *M*, *Q*, and *D* represent reinforcer frequency, amount, quality, and delay, respectively. If it is possible to assume that the effects of the independent variables do not interact, then the concatenated generalized matching law can be relevant and useful when researching the effects of two or more independent variables (Landon et al., 2003).

Critchfield et al. (2003) used the generalized matching equation to test the prediction of Equation 5 on human behavior and compared it to another equation which is in the tradition of two-factor theories of punishment. Their results showed clearly that punishment directly reduces reinforced behavior in the data for six of seven subjects in their research:

$$\log\frac{B_1}{B_2} = a\log\left(\frac{R_1 - P_1}{R_2 - P_2}\right) + \log c\,. \tag{8}$$

These results are consistent with other research (de Villiers, 1980; Farley, 1980) on nonhuman behavior, which has pointed to the superiority of a direct-suppression punishment model. This increases faith in the generalization of experimental results that have tested the effects of punishment on nonhuman behavior.

## Experimental research on the matching law

Research on the matching law has mostly been done with animals as subjects but some has been done on human behavior. Research on human behavior from the framework of the matching law has been increasing. This is how the science of behavior analysis works. It starts on a simple level of analysis, such as experiments on animal behavior, and then moves on to generalization and studies on a more complicated stage. It is possible to classify matching research as that performed on animal/human behavior, and in open–closed settings.

## Open–closed settings

In accordance with the summative Behavioral Perspective Model (BPM, Foxall, 1998) of consumer choice and the matching law (more reinforcers in the denominator, *ceteris paribus*, mean less behavioral control from each, and vice versa), we propose a continuum of closed–open behavior settings where the researcher has a different degree of control over the environment. A closed setting can be characterized as a situation where only few reinforcers are available and one has a great effect on behavior. The researcher has control over deprivation and controls the delivery of the reinforcers to behaviors, which are clearly defined, and there are no effective alternative operant consequences (Schwartz & Lacey, 1988). Experimentation on animal behavior in the laboratory can be examples of the most closed settings related to the matching law. Thereafter, on the continuum come experiments on human behavior in the behavioral laboratory, studies on human activity in closed natural settings, and then studies on animal and human behavior in open natural environments. One of the most open settings where the matching law has been used, i.e. on human behavior, is the supermarket (e.g., see Foxall et al., 2004). If analyzed according to the above classification of Schwartz and Lacey (1988), the supermarket has near uncountable numbers of reinforcers, where many can have a strong impact on behavior, and the researcher has no control over deprivation or satiation. The consumer can choose whatever he likes and can afford, he can come hungry, or full, and freely wander around, and walk out when he wants (see Foxall, 1998, for a discussion).

In what follows we will go over research on the matching law from research done in open-closed settings, and looking at animal–human behavior. The discussion will go from closed to open settings; when the setting becomes more open, it is of more interest to the topic of consumer research. For this reason the research carried out in the most closed setting, in which animals were subjects, is not presented here in full detail. This will only be mentioned in terms of experiments conducted to compare the prediction of matching and maximization accounts of choice behavior.

## Research on the matching law with animal behavior in open settings

Baum (1974b) published an important quasi-experiment where he studied a flock of free wild pigeons that lived in the attic of his house. Pigeons had access to grain through an experimental apparatus with different concurrent variable-interval schedules. The results showed that the pigeons' choices conformed to the matching law. This experiment showed that matching for animals was not a creation of the laboratory procedure. This is because the pigeons were wild and the apparatus recorded the combined responses of many pigeons. Therefore, the animals could choose from a wide range of different reinforcers, and Baum had no control over deprivation (see also a similar experiment in Graft et al., 1977). Related to this kind of open environment research are studies on the matching law, and the equivalent optimal foraging model of ideal free distribution, done on group choice (for a discussion see Kraft & Baum, 2001). This kind of research has, though, also been done on animal and human behavior in closed settings.

## Research on human behavior in closed settings

The matching law has generally been used to predict human behavior with good results. The amount of research on human behavior is thought small compared with research done on animal behavior. It is possible to roughly classify the research done on human behavior from three types of closed settings: experimental setting (e.g., Bradshaw & Szabadi, 1988; Critchfield et al., 2003; Goltz 1999; Hantula & Crowell, 1994; Horne & Lowe, 1993; Lowe & Horne, 1985; Schroeder & Holland, 1969); hospitals and mental institutions (e.g., Martens & Houk, 1989; Oliver et al., 1999); and schools and universities (e.g., Beardsley & McDowell, 1992; Conger & Killeen, 1974; Martens et al., 1992; Mace et al., 1994). In addition to this research it is worth mentioning a study by McDowell (1982/1988) that has similarities to the studies taking place at the hospitals and mental institutions. McDowell reappraised data originally published by himself and Carr (1980). He evaluated the relation between a boy's serious scratching, taking place at his home, and his parents' reprimands that occurred contiguously with the self-injury. Results showed that the matching equation closely predicted the proportion of time the boy spent engaging in self-injury. This correlation was useful for McDowell to experimentally test the hypotheses that the reprimands served as positive social reinforcement for scratching. The functional analysis supported the hypothesis, and behavior modification was used to eliminate the problem behavior.

Overall, the matching law accounted well for the data in the above research (except for a considerable undermatching and bias in the study by Mace et al., and the two studies published by Horne and Lowe). Mace and colleagues pointed to the importance of adjunct procedures (e.g., COD and timers) in matching research. In the studies by Horne and Lowe, some subjects' behavioral data showed approximate matching – but others departed greatly from the prediction of the matching law. Regardless of this, the experiments by Horne and Lowe indicated the importance of matching research by pointing to the possibility that choice behavior is both influenced by the current reinforcement contingencies and the subject's verbal rules. This is an idea that has stimulated other researchers in the field (e.g., Foxall, 1998; see the utilitarian–informational bifurcation in the BPM).

## Research on human behavior in open settings

Bold steps have been taken in the direction of studying the predictability of the matching law on human behavior in open natural settings. As stated before, open setting is here defined as any environment which has numerous available reinforcers, where many can have an effect on behavior (inversion of Schwartz & Lacey's, 1988, definition of a closed setting). The open systems can be contrasted with the closed controlled environments of the laboratory, clinical settings, and schools. The matching studies, in open settings, have been undertaken in two different areas of research: sports competitions and consumer marketing. Both types of research have a similar bearing for the external validity of the matching law, and seemingly uniform development, strengths, and weaknesses. It is, however, interesting that the two research streams have not, to date, made any reference to each other.

## Research on behavior in sports

In the area of sports behavior Vollmer and Bourret (2000) published an important study for the enhancement of the external validity of matching research. They showed that the relative frequency of two- and three-point shots in a college basketball division matched the relative frequency of the proportional reinforcement rate (scores) produced by each type of shot. The researchers had no control over the behavior but used a version of the concatenated matching equation (9) to describe the allocation of two- and three-point shots:

$$\frac{B_1}{B_1 + B_2} = \frac{R_1(1.5A)}{R_1(1.5A) + R_2(A)}\,. \tag{9}$$

As three-point shots give more scores than two point shots (3:2 → 1.5:1), the concatenated matching equation, applied in the study, used a reinforcement frequency parameter (*R*), in the form of points acquired, and a reinforcement amount constant (*A*), representing the difference in reinforcement between the two alternatives.

Reed et al. (2006) followed up on the sports study using the generalized matching equation to describe play-calling data from the American National Football League. The results showed that the matching equation accounted for most of the variance in play calling, although some undermatching and bias was identified. Possibly one of the most interesting contributions of this study to the external validity of the matching law was that the researchers were able to show that estimated matching parameters varied in accordance with important sports conditions such as team success.

Although the sport matching studies are important explorations of the relevance of the matching law in real open environments, they have some limitations that can be classified either as problems of reinforcement schedules, or lack of environmental control. The problem of reinforcement schedules is that these sport matching analyses differ from other matching studies in a way that both basketball shooting (see discussion in Vollmer & Bourret, 2000) and passing and rushing are best described as being maintained on ratio schedules, but, as previously mentioned, nearly all matching research has been performed on behavior maintained on interval schedules. The reason for the traditional restriction to the interval schedules, most often concurrent VI VI schedules, is that it provides a pure independent variable and behavioral allocation, whereas ratio schedules produce interdependent "independent" variables and monotinical choice patterns, not very suitable for the analysis of choice behavior (see, e.g., Pierce & Epling, 1999). As the matching law predicts exclusive choice allocation to the leaner, or better, schedule on concurrent ratio schedules (Foxall & Schrezenmaier, 2003; Herrnstein & Loveland, 1975), there is a serious misunderstanding in stating that the matching law predicts behavioral allocation in the sports research. This holds as long as there is an agreement that the behavior is on ratio schedules, or more accurately, to what extent it is best characterized by ratio schedules. Scoring (reinforcement) is most likely affected not only by frequency of shooting, but also by time, as both two- and three-point shots should be more effective if they are performed unexpectedly, something that should be a function of time (see the tennis riddle in Herrnstein, 1990; and discussion of this point in Vollmer & Bourret, 2000). The sport matching results contradict anticipated choice data from concurrent ratio schedules in being well accounted for by the generalized matching equation (as it should be on interval schedules), as the behavioral allocation quite fairly corresponded to the relative reinforcement produced. However, the meaning and importance of this relationship are questionable because ratio schedules compel matching, as more behavior allocation must mean more reinforcement (at least in most instances). This means that the supposed dependent variable drives, at least in part, the independent variable.

The other problem mentioned in the sports studies, lack of environmental control, is attached to the schedules' problem of interdependency. As these studies have no experimental control, the correlational research is not equipped to deal with the problem of functionality: which variable is controlling which? The problem of reciprocal control is not restricted to studies on behavior maintained on ratio schedules, but it certainly does not make things easier, especially where there is no experimental control. In previously mentioned research by Martens and Houk (1989), using VI VI schedules, they discuss the problem of interdependency in their correlational matching study on the compliance of an 18-year-old developmentally disabled girl, where it is hard to specify whether the teacher's attention ("reinforcement") is controlling the student's behavior or vice versa. This problem with experimental control is, however, more serious when there is little doubt that the "dependent" variable is a source of variation in reinforcement delivery, as is the case for concurrent ratio schedules.

Another publication in the series of sport matching research is a further analysis of the two- and three-point shot allocation, published by Romanowich et al. (2007). It attempts to deal with the lack of experimental control – but does not mention schedules of reinforcement. The research replicates and adds to the original study (Vollmer & Bourret, 2000) by analyzing National Basketball Association (NBA) data from 1991 to 2000. During this time, the distance of the three-point line was decreased in 1994, but was increased again in 1997. This gives data in line with a quasi-experimental ABA reversal design where the reinforcement rate should increase during the time period from 1994, when the three-point line distance was decreased (it should increase the frequency of scores from such shots), until it was increased again. The logic is, if the data conforms to the prediction of the matching law, that is if the proportion of three-point shots increases during the 1994–7 period, and then lowers again, it should show that matching provides a valid description of the behavior, and can be used to predict and control behavior. In fact, the results do support this claim. The difficulty is, however, that this does not support the matching law (on concurrent FR schedules) and it is methodologically flawed because if the rule change is successful in increasing the rate of three-point shots, that will automatically lead to an increase in the score. It is not surprising that more shots (behavior) will increase scoring (reinforcement), leading to a spurious approximation to matching. In fact, Vollmer et al. (St. Peter, Vollmer, Bourret, Borrero, Sloman, & Rapp, 2005) themselves warn against the danger of spurious matching. This could result either from the rate of the behavior under study (the problem behavior in the article) affecting the rate of reinforcement (attention), or if matching occurs by chance, where there is only correlation between the variables but no functional relation. It seems to me that these methodological problems are unfortunately present in the sports matching research. There is no question if there is a functional relationship between scoring and type of shot; however, this relationship is hidden, or overestimated, by the fact that shooting affects the rate of scoring. On top of this, the lack of control over variables, both internal and external, limits the valuation of the matching analyses, and their applications, in the sports settings. This is acknowledged in Vollmer and Bourret (2000) and dealt with cleverly but in a rather methodologically limited way in Romanowich et al. (2007). The next research steps must aim for further experimental control, which amounts to acquiring the autonomous variables controlled by the researcher as well as control of external variables.

## Research on consumer behavior

The insufficient amount of research on the matching law in real open settings is surprising for the reason that has been emphasized (e.g., Logue, 2002) and challenged (e.g., Fuqua, 1984) in the literature. The following text taken from Logue (2002) states the need for research testing the relevance of matching on human behavior in real settings:

> Unfortunately, research that speaks directly to the world outside the laboratory has been limited, with the exception of some clinical settings. There are many areas still ripe for investigation. For example, why not examine, within the quantitative framework of the matching law, the tendency to save or spend money given changes in overall level of income and expenses? Another example might be shoppers' trips to one of two aisles of a grocery store as a function of the frequency of free samples of food in those two aisles.
>
> *(p. 363)*

As Logue points out, consumers' settings are an interesting new area for the matching law to be used and tested. In fact, at the time of Logue's publication, this kind of research had already begun under the name of consumer behavior analysis, with similar promises and problems as the sports matching research.

## Previous matching research on consumer behavior

At a molar level of analysis the Behavioral Perspective Model comprehends consumer choices, as they are distributed over time, as a function of the rates of both utilitarian and informational reinforcement (Foxall, 1997) and punishment (Foxall, 1999), here put into an algebraic form in Equation 10:

$$\frac{B_1}{B_2} = \frac{(({}_uQR_1 + {}_iQR_1) - ({}_uQP_1 + {}_iQP_1))}{(({}_uQR_2 + {}_iQR_2) - ({}_uQP_2 + {}_iQP_2))}\,. \qquad (10)$$

This is the summative behavioral perspective model's matching equation where the difference from previously shown matching equations (e.g., Equation 9) is that the consequences of behavior are divided into utilitarian[5] (${}_uR$) and informational[6] (${}_iR$), for the two possibilities. Equation 10 is here shown to characterize the consumer behavior analytical standpoint; this equation has not been empirically quantified. It captures the complexity of consumer behavior as a subject matter for matching research.

## Correlational consumer behavior matching

If seen from the point of view of the generalized matching equation, the Consumer Behavior Analysis Research Group (Foxall & James, 2001, 2003; Foxall et al., 2004; Oliveira-Castro et al., 2005; Romero et al., 2006; see research review in Foxall et al., 2007) has studied three different forms of matching relationships in natural consumer settings, with ever-increasing scope. In this panel research households, or participants, have gone from just a few (e.g., Foxall & James, 2001) to thousands, with research taking place for a period of time that extends from several weeks to up to a year. Three different kinds of matching, and matching-related, analyses have been performed: amount matching (classical matching), cost matching (relative demand analysis), and probability matching (maximization analysis). The data analyses have all been done within the framework of the generalized matching equation where matching between different variables in the consumer environment (brand amount, brand price, and reciprocal brand price) and some dimension of consumer behavior have been tested. This research has been performed on the assumption that consumers' buying behavior conforms to concurrent quasi or analogical $FR^a$ or $VR^a$ (a = the number of brand possibilities) schedules. This means that the marketplace analogy to the response requirements in the laboratory, brand price, is known (fixed) on each and every shopping occasion (FR) for fast-moving consumer goods, but can change with time (VR). Consumer behavior is considered to be best represented by being maintained on a quasi schedule because the "independent" (e.g., reinforcement in terms of brand amount) and "dependent" (behavior in terms of spending) variables are reciprocal. For instance, the amount paid (the behavior) seriously affects the amount bought (the reinforcement) and vice versa. As previously mentioned for the sports matching research, this deviates from standard laboratory matching analysis, using variable-interval schedules, which should give a true independent variable because responses do not control this when reinforcers become available. The interval (time period programmed) controls this.

## Cost matching

In consumer behavior analysis, price is analyzed using behavioral economics methods of relative demand analysis similar to animal experimental studies done by Kagel et al. (1981). This method is unlike traditional economic demand analysis, as it takes into consideration competition among competing brands in the product category, and uses the x-axis to represent price instead of the y-axis (see a discussion of how psychological and economic demand curves are drawn in different ways in Lea et al., 1987). As for amount matching, cost matching is also studied using ratio analysis. In terms of matching this denotes the connection between relative reinforcers earned, in the form of the quantity of brands (dependent variable) earned, and proportion of punishment in the form of the cost (independent variable) of them:

$$\log \frac{M_1}{M_2} = a \log \frac{P_1}{P_2} + \log c \,. \qquad (11)$$

Here $P$ stands for average monetary price over the duration of the study. The dependent variable, the relative amount bought, is best represented as being maintained on concurrent ratio schedules, inverse to amount matching; as the price goes down, the amount bought should increase. This relationship is methodologically interesting, as it does not have the problem of interdependency between the independent–dependent variables denoted for sports matching and consumer amount matching analyses. The researcher can control prices (price = aversive stimuli = punishment) which are not a form of behavior (like the amount bought in amount matching), but true environmental stimuli. The results from previous cost matching analyses (e.g., Foxall et al., 2004) reflect this empirical foundation by showing mixed relative demand curves for purchasing data aggregated across purchasers and stores, where the regression lines show either neutral, downward-, or upward-sloping demand curves.

## Experimental consumer behavior matching

> Marketing action consists mainly in altering the scope of consumer behavior settings and manipulating the system of rewards which maintain various patterns of consumer choice.
>
> *(Foxall, 1996, p. xii)*

Consumer behavior analysis has to date indicated the importance of using the matching law in consumer research and takes the important step of making a research program where the matching law is researched in open settings. Johnston and Pennypacker (1993) point out that "[d]oing science is not a matter of following specific rules like recipes in a cookbook. Cookbooks may work quite well when the recipe is well tested, but scientific discovery is more like creating the recipe in the first place" (p. 13). In accordance with this, the Consumer Behavior Analysis Research Group has created methodological recipes (see, e.g., Foxall & Schrezenmaier, 2003) which get increasingly more challenging and extensive. They show behavioral and consumer scientists how it is possible to interpret and perform consumer matching research, something that was previously only speculated about or hoped for (e.g., Logue, 2002; Vaughan & Herrnstein, 1997). This makes the methodological strengths and weaknesses of correlation research, of the particular matching equations used, clearer. But further methodological exploration is needed to assess the capability of the matching law, and the behavioral perspective model in consumer research. The power of further extensive experimental analysis has not yet been explored.

A behavior analysis begins with complex behavior and breaks it down into its components, and functional analysis holds the stimuli and responses of interest constant, while changing their relations (Catania, 1998). This is the ideal methodology that has mainly been used in research on the matching law. The aim of behavioral psychologists and analysts is to describe, predict, and control behavior. Foxall (1998) recognizes this: "given the radical behaviorist provenance of the BPM, the capacity of its analysis to lead to prediction must be demonstrated . . . and to comprehend the control of consumer behavior in its various environments" (pp. 56–7). Acknowledging this, we have a criterion to appraise different ways of doing behavioral science. When comparing different descriptions of behavior it is important to focus on the invented concepts and try to use those which make for economical and comprehensible descriptions of behavior (Baum, 2005). By focusing on control, the effectiveness of different methodologies is assessed by looking at the degree of control over the target behavior that can be produced by each approach (Johnston & Pennypacker, 1993). Foxall (1998, p. 338) asks the important question: "How far can the control of behavior be attributed to the environment when the setting is relatively open?" The sufficient condition for identifying functional relationships is the experimental manipulation of an independent variable (Johnston & Pennypacker, 1993). To answer Foxall's question it is thus necessary to manipulate the retail environment and see how it affects consumer behavior. By not being able to control, or hold constant, important variables of the concatenated generalized matching equation (e.g., reinforcement schedule, effort, and quality), it is hard to find the sole effects of marketing mix variables, like price, shelf placements, and in-store advertisements, on consumer choice. This is because all these variables intervene to produce the results in a purely statistical research.

Consumer behavior analysis, as a sub-discipline of behavioral economics and applied behavior analysis, has the agenda of fully exploring the usefulness of these parent disciplines in real marketing systems. In this respect consumer choice has been researched with panel data, in different forms and with ever-increasing scope in relation to the matching law, with experimental interventions in real market environments such as retailing (Curry et al., 2010) and simulated online consumer environments (Fagerstrøm et al., 2011). However, further examination of the experimental techniques, with their possible ability to control and surrender the situational influences of real marketing mix variables on consumer choice and matching, is necessary to strengthen the generalization of the matching law to the more complicated behavior of humans and consumption.

## Summary

The chapter has focused on the importance of consumer behavior analysis which has transferred concepts and data analyses, originally generated in the behavioral laboratory, to consumer choice research in the marketplace. Within the reviewed framework of matching research, this literature review has enforced this conduct by arguing also for the transfer of behavioral analytical research methods and relevant data analysis. How experimental control and relative choice analysis have the possibility to shed further light on methodological opportunities in this area of research, such as those of reinforcement schedules and a lack of environmental control, has been discussed. This was necessary to make possible a judgment of the validity and importance of consumer choice and matching research in terms of generating data which are possible to evaluate in terms of behavior analytical and marketing criteria. As both these fields are applied in orientation, by focusing on the effects of important marketing variables on consumer choice, important new data will hopefully emerge to enhance the ability of this kind of research to accurately and logically describe, predict, and control consumer behavior. This possibility has created the foundation for further research, which reveals the newly generated in-store and online consumer behavior experiments.

## Notes

1 Molar accounts of behavior are concerned with large-scale factors that regulate responding over a long period of time (Pierce & Epling, 1999, p. 395).
2 Overall response rate on different FI schedules typically does not fit the matching equation very well (de Villiers & Herrnstein, 1976).
3 Operant behavior (behavior that is under the control of its consequences) will, *ceteris paribus*, match its relative consequences. This is not an empirical question. However, the matching law and its derivatives can enhance empirical research aimed at discovering what enviornmental factors affect behavior in particular circumstances. Is it reinforcer frequency, latency, etc? It is also worth mentioning that although the matching law is logically true, it is not necessarily the best model to account for behaviour. That is an emprical problem.
4 For example, utility/price in economics, and reinforcement/punishment in psychology. These concepts are also used in fields like criminology, political science, and many other social sciences. This comes generally in the form of customer satisfaction/utility, price, and effort in marketing.
5 See Foxall (1998) and Wearden (1988). The shortest definition of utilitarian consequences, in consumer behavior analysis, is those mediated by the product.
6 See Foxall (1998) and Wearden (1988). The shortest definition of informational consequences, in consumer behavior analysis, is those mediated by other persons.

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