Neural Marketing:
Artificial Intelligence Neural Networks
In Measuring Consumer Expectations

by Bruce Grey Tedesco

SUMMARY

Developments in a variety of disciplines have provided the necessary components to assemble a system of artificial intelligence available for use in formulating marketing strategy. Based on artificial intelligence neural networks, the concept of neural marketing is presented. A flexible new technique, neural marketing has abilities to measure and interpret expectations.

Neural networks understand data and, in a process that mirrors human trial and error learning, neural nets find the relationships of cause and effect that are present in that data. This ability to learn is complicated with a facility to generalize that acquired knowledge and apply it to new experiences.

Market researchers will find neural networks of value for any situation requiring forecasting and prediction. Neural marketing takes the next step by uniting all data sources, marketing practitioners, and a new strategic intelligence.

In this paper there is a review of neural network theory, a presentation of the concept of neural marketing, and general examples of the benefit neural marketing provides for measuring expectations.

1. NEURAL MARKETING: CONCEPTS

Neural Marketing is a concept. It is the result of a natural evolution of the maturity of the science aspect of marketing. By fully embracing neural marketing, a firm gains an asset capable of distilling information and formulating decisions. Useful to the line executive and the staff analyst, neural marketing brings life to all data related to the products and services that consumers expect.

Artificial intelligence *neural networks* provide the foundation of a neural marketing system. Generally, artificial intelligence is applied in one of two forms. One is the expert system and the other is neural networks. Section 2 provides a brief explanation of the theory and structure of neural networks.

The theory and research of neural networks has been in hardware implementations and engineering/scientific applications. This paper is a hybrid of this author's theory and experimentation aimed at incorporating neural networks in the marketing of consumer goods and services.

Neural networks learn. They are taught to see the cause and effect relationships that exist in a data set. Further, neural nets can be guided to learn how various data bases interrelate in the context of a consumer marketplace. Once they have acquired all this comprehension, neural networks can be relied upon to generalize and apply that wisdom to new situations. The combination of neural networks and an experienced teacher/strategist catapults marketing decision making to a heretofore unattainable height.

Expert systems are known to marketers and are even sometimes confused as being synonymous with artificial intelligence. In their recent book, The Marketing Revolution, Clancy and Shulman provide an optimistic view of the growth of the importance of artificial intelligence in the corporate marketing function. Their justification and predictions are on point; however, they refer to expert systems as the vehicle that will harness computing technology for marketing information. Problems abound with expert systems. Expert systems make choices based on rules supplied by human "experts". And, while they can be thorough, fast, accurate, and efficient - - - expert systems do not *learn*!

Throughout this paper and underlining the notion of neural marketing, is the understanding that neural networks are the concepts of artificial intelligence that have the greatest benefit to marketing professionals.

Artificial intelligence has come to encapsulate a wide range of images, applications, mind sets and emotions. Any number of authors have argued the very existence of artificial intelligence across the continuum of reality to folly. At this point let us agree there is some foundation to the concept and move on to the application at hand.

Business people find intelligence attractive. Conceptually it portends creativity and resourcefulness. To harness an intelligence concentrated within an analytic and strategic system is the realization of what was quite a far fetched notion in recent years.

Even the broadest definitions of intelligence help in molding the idea of what we should expect from a neural network. Psychologists study the intelligence of individuals. The characteristics of behavior that portray intelligence follow:

Psychologist's view of intelligence

- Ability to learn and generalize
- Ability to discern essential from non-essential details
- The composition of Wechsler's scales directly reflects David Wechsler's (1944) definition of intelligence as "the aggregate or global capacity of the individual to act purposefully; to think rationally and to deal effectively with his environment"
- Evaluation of past experience, application of judgment to practical situations
- Freedom from distractibility
- Ability to synthesize parts into wholes

McClelland defines intelligence as having insights [Allman, 1989]. And Albert Einstein is quoted saying, "Imagination is more important than knowledge". It is each and every one of these traits that are possible in the entity of a working neural network.

Understanding marketing information is a natural extension of the power of a neural network. The nature of market data is one of subtle connections and fuzzy relationships between cause and effect of consumer behavior. Neural networks offer definite advantages which meld well in this environment. Specifically, characteristics of a neural net include self-organization, fault tolerance, adaptive learning, and most importantly the ability to deal effectively with the contradictions, errors, and inexactitudes of real world knowledge.

Prediction, forecasting, estimation, and classification are the tasks faced by the observer of the marketplace. Traditional statistical methods and human experience are limited in these tasks by design and time. Neural nets have the promise to excel beyond any current systems.

2. NEURAL NETWORKS: THEORY

Using computer systems to replicate the learning and recall methods of the human brain has been a goal of researchers in a variety of disciplines for half a century. Neural network computing is the closest approximation of brain function to evolve to a stage where practical application is attainable.

The brain and nervous system provide the structural model for a neural network. A neural net consists of a number of processing elements known as neurons, each of which can have multiple inputs and only one output. Single outputs do branch out and become input to many other neurons, thus affording the many incoming signals each neuron receives. In a typical neural network, neurons receive most of their inputs from other neurons; the rest are from the outside world -- -- -- data describing events.

Within the organized shape of a neural network the neurons are arranged most often in layers. These layers each have a different function. A common approach is to see a neural net with three layers: one for input, a hidden layer, and an output layer. The input layer contains the individual neural neuron that each depicts a variable affecting some behavior. These neurons are also known as features. In the hidden layer (or layers) some number of neurons reside and become the bridge of knowledge from the input level to the output level. Residing in the output level are neurons functioning as representations of the result being investigated.

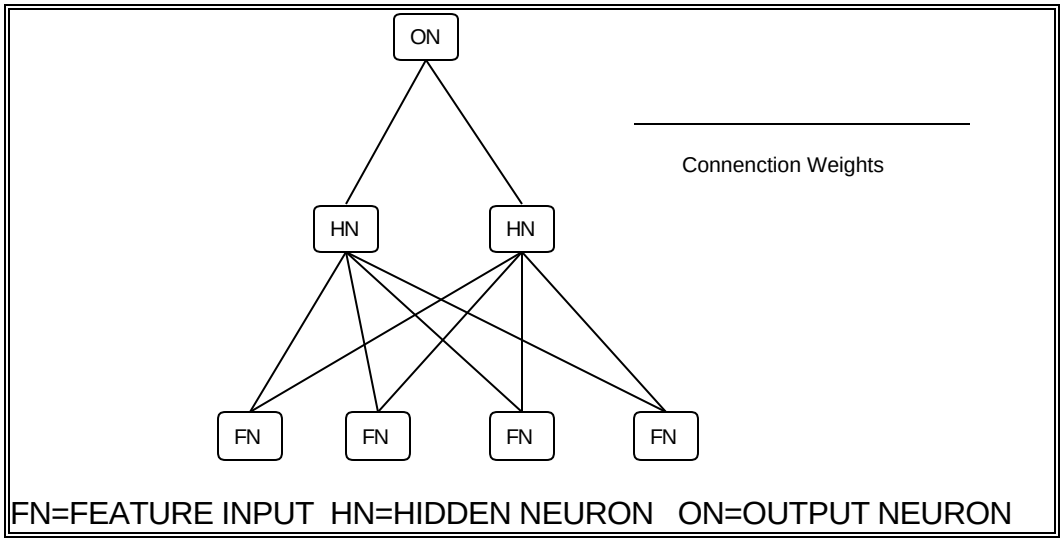
From a functional view, a neuron fires, i.e. sends a signal to another neuron, when the sum of its inputs exceeds a set threshold. The interconnections among neurons are quite complex. A weighted value is associated with each input. It is the combination of a) this weight, b) the input value, and c) the firing threshold, determined by constructs such as differential calculus, that decides if a neuron will fire. Weight values are typically modified either by an outside expert teacher or by the neural net itself. Modification of weights is responsible for the ability of neural networks to exhibit learning and memory.

A variety of options for determining initial weights, adjusting weight values during learning, and controlling the competition among hidden neurons has been well researched. For a neural network to effectively learn a set of marketing data its critical to apply the proper options. This task requires a person experienced with marketing information and a complete knowledge of the mathematics of neural network theory.

Learning takes place as the neural net reviews data containing information about the cause and effect of a given situation. Connections between neurons simulate the brain activity with the synapse sending signals through axons. Memory is represented by the value of the weights and learning is accomplished by comparing the net's calculated outcome to the known result presented by the data.

The following display is a picture of the structure of a simple neural network:

Simple Neural Network Structure



Neural networks have been used in a wide variety of scientific and engineering applications since the early eighty's. With theory dating back to 1943 and research and development beginning in 1956, neural networks of today represent a strong link in the evolution of machine intelligence.

Popularity has grown for neural nets as personal access to more powerful computers has become widespread. Able to learn relationships and patterns among events, neural networks are being constructed ever more frequently. Creating advances in speech recognition, image processing and robotics - - among others - - has helped to solidify neural network use as a proven technique.

Types of neural networks are typically grouped by application. In the scientific community where today's working systems were developed, those applications include prediction, data association, data filtering, optimization, classification, and data conceptualization. Specific network types have been created for these tasks. Each network type has an indigenous topology of neuron and layer placement. Unique algorithms required for changing connection weights, determining neuron firing thresholds, and preprocessing input data complete the self definition of each type of neural network. Volumes exist detailing the theory and scientific application of the many networks available. It is, of course, beyond the scope of this paper to examine the specifics of neural network design; therefor the interested reader is encouraged to consider independent study of some of the networks listed below.

Neural Networks of value for marketing data

- Learning Vector Quantization
- Self-Organizing Map
- Backpropagation
- Boltzmann Pattern Completion
- Adaptive Resonance Theory I
- Hopfield Network

3. PRACTICAL EXAMPLES FOR INTERPRETING EXPECTATIONS

The far reaching power of neural marketing will become commonplace in as aspects of consumer marketing . Certainly measuring consumer expectations is an integral part of any firm's strategy for success. Neural marketing provides a new and intriguing possibility. We now turn to two case examples meant to demonstrate this use of neural marketing.

The case examples are based on actual models and neural networks constructed by the author. The networks were trained using a combination of data related to consumer expectations. For the purpose of this paper please be advised the case examples reflect a synthesis of real experience and, due to the confidential and proprietary nature of their use, these examples are presented to illustrate neural marketing's effectiveness without comprising the client's position.

Retail Expectations

In this case neural marketing is used to evaluate consumer expectations and simulate a response to those expectations by adjusting components of the marketing mix. A retail chain selling recorded music, compact disks and cassette tapes, primarily, has approximately 100 stores in the northeast and central United States. Data available for each store included:

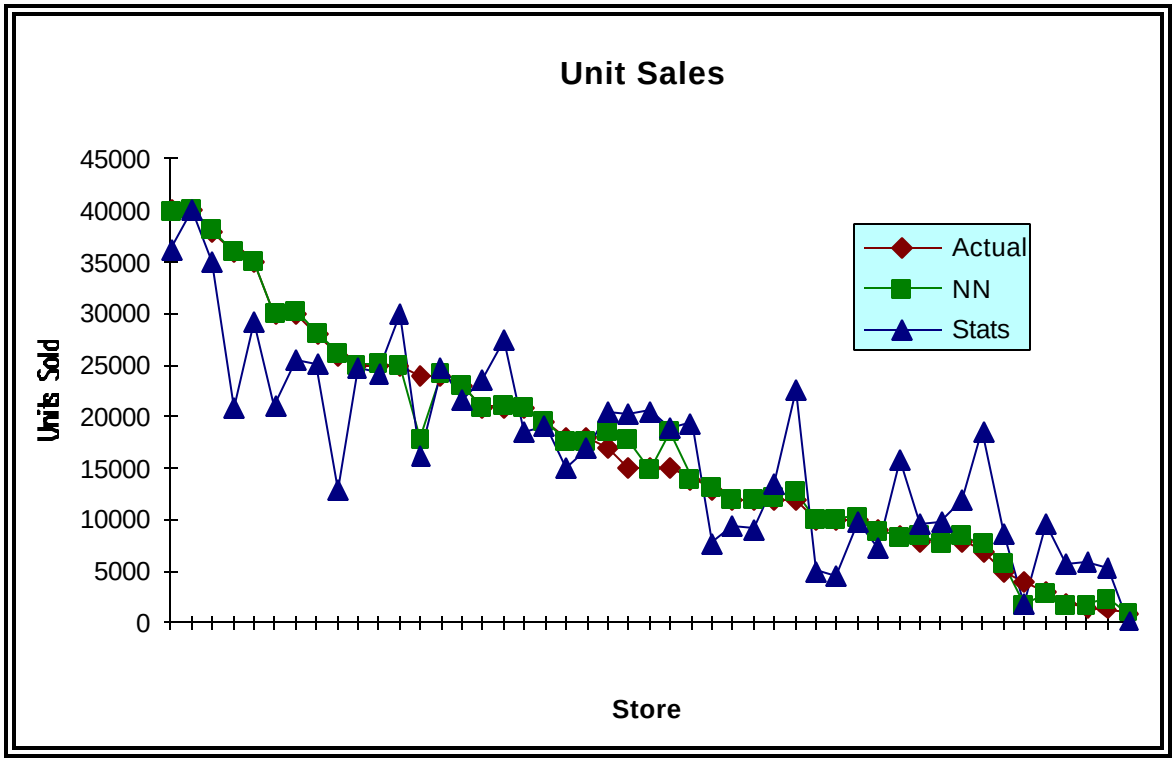
- selling square feet
- inventory
- unit sales volume
- sales personnel information
- competition factor
- local advertising expenditures
- promotions

Additionally, survey research was conducted at each store among customers who had just made a purchase. Ratings were obtained from each customer to measure their perceptions. The attributes measured fell into the general categories of price, service, and production selection. Lastly, included in the neural network was some general socioeconomic data which served to define characteristics of the general trade area for each store e.g. gender, age, income, housing, employment, etc.

The ability to test the knowledge of this network was enhanced by a bit of luck. All of the data used in the learning process had previously been analyzed by a third party. This well respected independent firm used traditional statistical techniques to form a forecasting model for unit sales by store. Once the model was developed, it was tested by applying the results to a sample of forty seven stores where unit sales were known. The results obtained were acceptable by usual standards.

The true unit sales volume for each store was plotted with the predicted volume from the neural network and the statistical model. As this chart shows, the accuracy of the neural network is astounding.

Sales Volume Estimates



Clearly neural networks have an ability to understand relationships in a data set which are not measurable in common statistical repertoire.

This neural network creates a model of purchase dynamics. It has reduced the survey questions to three indicators of consumer expectations for each store. These expectations are shown to be a direct influence on the sales volume of a store. Further, the demographics and other variables for each store can be treated as static information.

Now comfortable with the knowledge obtained by the neural network, the marketing practitioners approach the topic of what action to take in response to the consumers expectations. In this case example management felt they had a fair degree of control over the aspects of expectations - - price, service and selection. Various scenarios of expectation levels were created within the parameters of afffordability and anticipated profits. This neural marketing system produced an actionable strategy anticipating the expectations of the market in the context of each shopping experience.

One interesting by product of this case was the trained neural network is able to serve well as a site selection model. If there are a number of alternative locations being considered for a new store, then present to the network the all of the demographic and socioeconomic data along

with anticipated estimates of levels of price, selection, and service to meet expectations. The neural network will provide a forecast of unit sales under each alternative considered. This information is analyzed with the other criteria to choose the most favorable new site.

Economic Expectations

Isolating one aspect of neural marketing, it is clear that we have an excellent device for database mining. That aspect is the faculty of learning the meaning and value contained within the natural relationships present among all the quantitative representations of a large data set. In this example the database is a national probability sample of consumer attitudes, retail sales data, and an accepted measure of consumer confidence.

The economic indicators were measured by The Conference Board of New York. Leo J. Shapiro and Associates of Chicago, Illinois surveyed consumer attitudes monthly since 1985 using a household probability sample. Actual marketplace expenditures are tallied by the U.S. Department of Commerce in the publication Monthly Retail Trade.

By applying a neural network to learn the relation ships existing within such data, an accurate portrait of national expectations can be developed. This picture of expectations is useful for broad planning in a number of situations. Notably, leisure time activities, travel plans, and major household purchases are trends which neural nets can forecast. A single application of this use is a dual forecasting of auto sales and the Consumer Confidence Index. This example has the secondary purpose to illustrate the power of neural networks in estimating two outcomes simultaneously.

In other neural marketing projects auto sales have emerged as a sound surrogate for expectations of economic trends and their impact on leisure time expenditures. A number of neural networks have learned to forecast attendance at films, resorts and theme parks. After reviewing all of the many input features, these networks show constantly that the consumer's expectations of national economic conditions is the most influential presence in the decision frame. Further exploration of these neural nets reveals that these expectations are manifested in actual auto purchases. Additionally a growing number of firms see the Consumer Confidence Index act as a precursor to spending patterns which are driven by expectations of national economic health.

It now follows that if a neural network can provide advance knowledge of these expectations, expressed as actual dollar volume, and the future Confidence Index, a firm will be able to employ appropriate measures to maximize purchase decisions at each level of economic condition. It is with this framework in mind that the current example is presented.

In order to react to changing expectations, a marketer will require a certain amount of time for product positioning . The neural network is therefore taught to learn how current responses to attitude questions and economic indices relate to auto purchases made and confidence expressed two months later

The detailed data presented to the net in the form of feature or input neurons were:

- Percent responses to 12 attitude questions
- Retail sales receipts for restaurants, book stores, and sporting goods
- Indices of present situation, and expectations

The twelve attitude questions are:

Attitude Questions Used in Neural Network

In your opinion, are things getting better or worse for the country as a whole?

Over all, are you pleased or displeased with the job George Bush has been doing as president of the United States?

Do you feel that now is a good time to go ahead and make some major purchases?

Has you family income increased or decreased since a year ago?

Taking account of your income, assets, property, value of your investments as well your debts and current expenses, are you in a better or worse financial position this year than last?

Looking ahead, do you expect to be in a better or worse financial position next year than you are right now?

Do you think that the amount of money your family saving will increase or decrease during the next 12 months?

Speaking for yourself, has it become easier or harder to get by and pay all the bills than was the case a year ago?

Looking ahead, do you think it's going to be easier or harder for your family to get by a year from now?

In the past month or so, have you had to cut your standard of living either because of inflation or because of decreased income?

Is your family cutting back on driving to deal with the cost of gasoline?

Looking ahead to the coming year do you feel that you might buy a house?

Rather than create a model with seventeen feature inputs, the attitude questions were reduced to a total of five neurons which contain all of the original relationships. Reducing the data in this manner was accomplished by running a type of neural network known as a self organizing map.

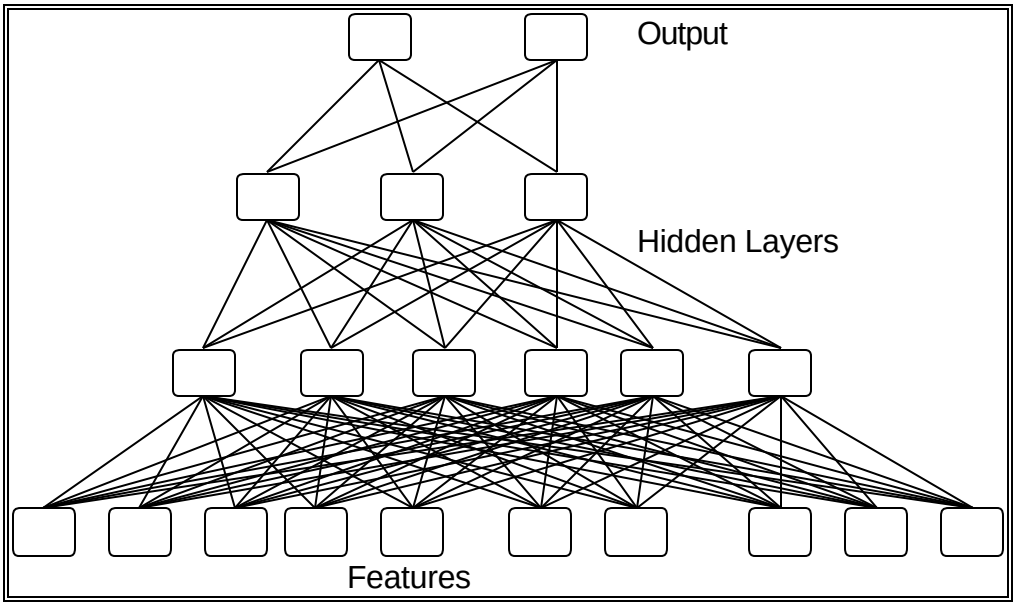
The result of this preprocessing is a new set of neurons that are able to learn in the contact of a new network.

With a set of data as diverse as this it is necessary to design a network that is somewhat more complex than most networks used within the neural marketing framework. The complexity first appears as the need for using the self organizing map for preprocessing. Many times marketing data can be learn and used without this step. Next, this neural net requires two hidden layers of neurons in order to properly complete the learning stage. As illustrated, there are seven neurons in the first hidden layer and three in the second hidden layer. A danger of using so many hidden neurons is the network will learn, but then not be able to generalize its knowledge. In other words, the neural net will be nothing more than one very sophisticated "look up table". Compensating for this tendency demands careful monitoring of the connection weights and learning rules.

Comprising the first case was input data from January 1985, and the Confidence Index and auto sales from March of 1985. Each subsequent case was organized in the same manner through the final example with input of data for June 1991 and output data for August of 1991.

The following illustration is a conceptualization of the connections and position of the various neurons and layers of this neural network:

Fully Connected Neural Network



Testing the accuracy of the network is extremely straight forward. Following the learning stage, the neural network estimated auto sales volume for September, October and November of

1991 and the Consumer Confidence Index for the same period. A comparison of the neural net forecast and recorded values revealed a highly acceptable rate of less than 2% error.

Neural Network Test Results

	Auto Sales[1]		Confidence Index	
	Actual	NN[2]	Actual	NN
September 1991	$27.3	$28.1	72.9	72.4
October 1991	$27.8	$27.5	59.4	60.1
November 1991	$24.9	$24.9	52.7	53.1

[1] Data in millions of dollars
[2] Neural Network Estimate

Conclusion

Auto sales have been shown to be a steady and reliable indicator of amalgamated consumer expectations regarding the general state of the US economy and particular expenditures in the areas of travel and leisure time activities. The ability to estimate sales two months in advance gives marketers an awareness of the degree and trend of expectations for this profitable segment of commerce.

Clearly further research is necessary to discover if the specifics of this example will be effective in Europe. It is the firm belief of the author that a similar system of neural marketing can be developed for any country and the benefits of its use are attainable.

4. NEURAL MARKETING: ACTION AND INTEGRATION

Neural Marketing is a new and important addition to the process of marketing decision making. This is not an analytic device such as any of the statistical routines (e.g. factor analysis, multidimensional scaling, clustering or regression). Instead, two equally essential components are required for true neural marketing: 1] the teacher/strategist and 2] a neural network software development system.

The neural nets do not teach themselves properly. The network must be taught. In neural marketing this role falls to the *teacher/strategist*. It is this central issue that has allowed the migration of neural networks to practical situations. A teacher/strategist is familiar with the mathematics of neural network theory and has a solid base of experience in the nuances of collecting and analyzing marketing information. In realistic applications an experienced teacher/strategist has a strong impact on the ability of a neural network to learn and respond to questions based on that learning. Under the tutelage of such a person, a neural network will come alive with insight , subtly, robustness and an intelligence that heralds this most powerful new addition to marketing strategy development.

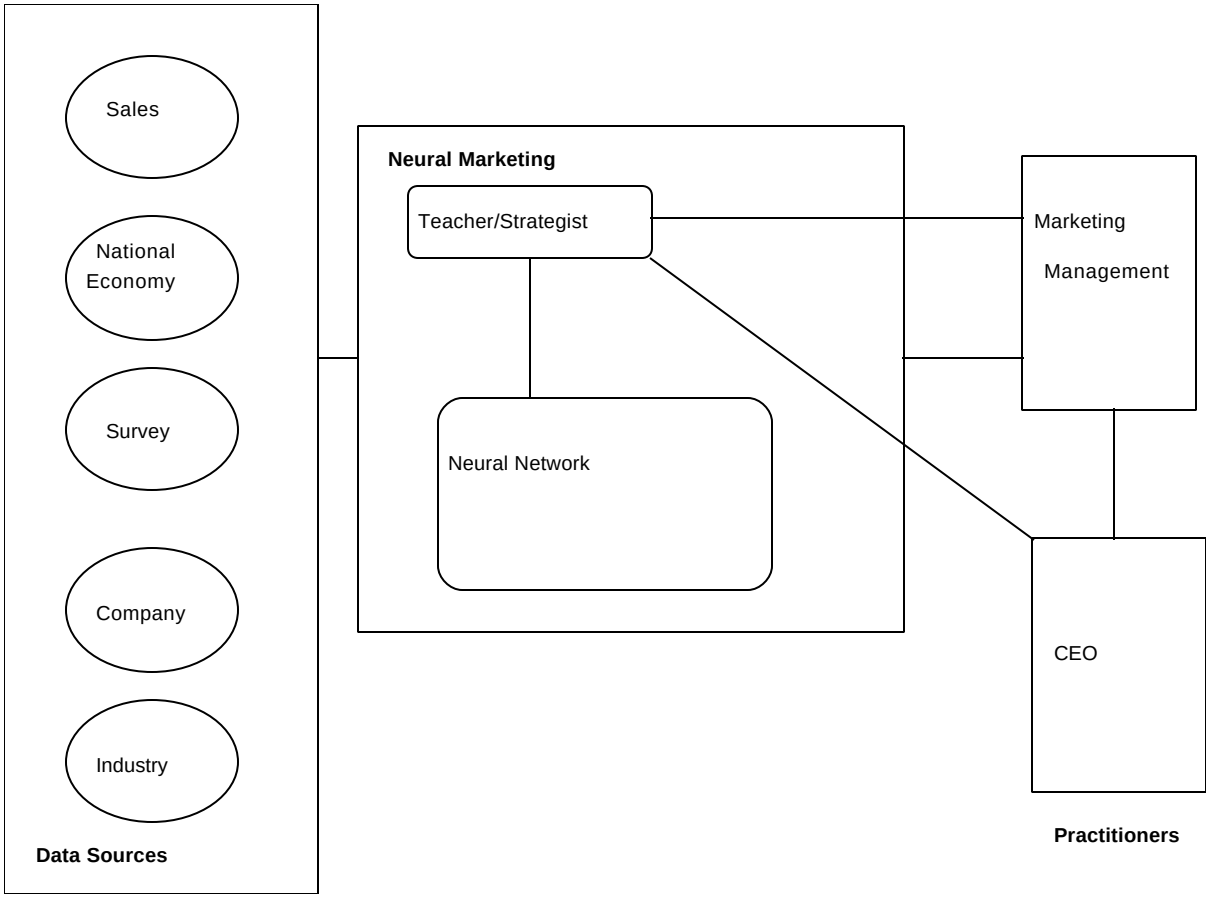
Neural networks are already being used by a number of global firms in a variety of applications including marketing. In most cases though, neural networks are employed for individual and separate projects. The concept of neural marketing progress to a different level. Neural marketing links data and decisions across the entire palate of marketing functionality. There is a tendency in even the most sophisticated organization to create research islands where information from various projects is treated singularly. Central to the idea of neural marketing is a facility that ponders all information that is collected for a marketplace.

In its completeness *neural marketing* will employ a number of neural nets each specializing in different functions. For example, the preprocessing tasks of data reduction, classification and pattern recognition are implemented by custom networks trained at a macro level. The neural nets used for the decision models forecasting and evaluation of strategy are a mixture of topologies using the results of the preprocessing networks.

The abstraction and the term neural marketing were developed by the author and have been tested and refined over the last two years. There are certainly examples of artificial intelligence in general, and neural networks in particular as applied to a number of business problems. However, neural marketing is driven by the vision of interrelating all available data and creating a pool of information that has been intelligently defined.

Ultimately neural marketing will link between all sources of marketing data to the practitioners of marketing. This integration link is plotted below.

Corporate Neural Marketing System



Practitioners can expect an active Corporate Neural Marketing System to be a source of knowledge and guidance for all marketing needs. Some of the prosperous attempts at neural marketing are listed here.

Successful Neural Marketing Applications

- Purchase Intent
- Pricing Models
- Shopping Patterns
- Media Habits
- Brand Awareness

Of particular usefulness to the marketing professional is the range of utility available when combining results of a number of neural networks. The output from the hidden layer of a neural network is a flexible and useful data reduction technique if there were, say, four neurons in the hidden layer, it is assumed that the output of these four contains all of the information received from however many neurons are present in the input or "feature" layer. The advantage of data reduction is never more evident than in a case where the number of observations are limited and the number of features measured are numerous.

The power and promise of using neural nets is undeniable. There is however, one caution necessary to remember. A perceived weaknesses of neural networks is the lack of information pertaining to the relative influence on the learning process of a particular feature. Indeed a trained neural network will be remarkably accurate in forecasting future events but it is open to interpretation to determine each feature's importance.

This lack of a quantitative measure is another difference a neural network exhibits from general statistics. Statistics are designed to explain differences and similarities within data. Neural networks are meant to learn and apply knowledge.

There even exists a biological basis for this fact of a lack of quantitative property to measure relativity influences for the input features of a trained neural network. In the brain neurons are grouped in a topological field. Shape and proximity define the topology and influence the behavior of the neurons.

Neural networks are related only by the synaptic connections between individual neurons and thus are not topological ordered. As shown by Kosko [1992] this lack

of topological structure for neural network models is responsible for neural nets being abstractors and not descriptors.

While some may consider the non quantitative explanation of feature influence to be a problem in applying neural networks to practical problems, reality suggests a solution. Heuristics. A heuristic approach is both informative and enlightening. Consider a situation where neural marketing has been employed to implement a pricing model. A dozen features including price are identified to be the cause of a purchase decision. Following the learning phase, a trained neural network predicts purchase volume for a variety of new and different prices. Making radical changes to the other features will clearly indicate the influence each of these features contributes to the working model.

In the popular press are reports of "smart programs", "a marketing department in a box", and "the computer as a detective". The business community is prepared for a change. As market researchers, our heritage dictates that we experiment, lead, champion innovation, and search for new ways to use information. The race against expectations is our challenge and neural marketing is ready and available for use in measuring, understanding, and predicting expectations.

REFERENCES

Aleksander, Igor *Neural Computing Arghitectures: The Design of Brain-Like Machines*, in Cambridge, The MIT Press, 1989.

Allman, William F., *Apprentices of Wonder Inside the Neural Network Revolution*, in New York, Bantan Books, 1989.

Antognetti, Paolo and Milutinovic, Veljko *Neural Networks: Concepts, Applications, and Implementations Vol. 1-4*, in Englewood Cliffs, Prentice Hall, 1991.

Churbuck, David, "The Computer as Detective", Forbes, December 23, 1991, Vol. 148

Clancy, Kevin J., and Shulman, Robert S., *The Marketing Revolution*, Harper Business

Harston,Craig, Maren,Alianna and Pap,Robert *Handbook of Neural Computing Applications*,in London, Academic Press, Inc., 1990.

Kosko, Bart *Neural Networks and Fuzzy Systems*, in Englewood Cliffs, Prentice-Hall, Inc., 1992.

Mammone, Richard J. and Zeevi, Yehoshua *Neural Networks: Theory and Applications*, in London, Academic Press, Inc., 1991.

McClelland,James L., Rumelhart, David E. and The PDP Research Group *Parallel Distributed Processing: Explorations in the Microstructure of Cognition* , Vol. 1&2, in London, The MIT Press, 1986.

Schwartz, Evan, and Treece, James, "Smart Programs Go To Work", Business Week, March 2, 1992,