韓國感性科學會誌
Korean Journal of The Science of Emotion & Sensibility
1998. Vol.1, No.1, 123-133

A physiological approach to the effect of emotion on time series judgmental forecasting EEG and GSR

Joa Sang Lim*, Min Cheol Whang, Hung Kook. Park, Hyun Sook Lee

요 약 시계열 예측은 효과적인 기업 경영에 반드시 필요한 활동이지만, 이와 관련 인간의 인지 처리 과정에 대한 연구는 아직까지 미비하다. 본 연구는 인간 감성이 시계열 예측에 미치는 영향을 탐색하였다. 본 실험에서는 반복을 통한 2 (감성) x 2 (횟수) 팩토리얼 설계를 채택하였다. 감성은 청각, 시각, 후각자극을 통해 환경을 조성하고 준비된 시나리오를 연상케하여 유발시켰다. 12명의 대학, 대학원생이 실험에 참여하였으며, 감성의 영향을 탐색하기 위해 뇌파(EEG)와 피부저항(GSR)이 후두엽 (Oz)과 전두엽 (Fz)에서 측정되었다. 그 결과, 인간의 감성은 예측에 유의적인 영향을 보였다. 즉, 피험자가 부정적인 감성을 갖을 때 긍정적인 감성에 비해 예측의 정확성이 높은 경향이 있었다. 그 이유는 부정적 감성일 경우 전두엽에서 베타가 많이 출현하였고, 이는 시계열 예측의 정확도를 향상시키는 역할을 하였다.

1. Introduction

Despite a number of sound statistical tools and theories, managers often rely on their 'gut feeling' and thus, most firms appear to take judgmental approaches to sales forecasting (Dalrymple, 1987). Forecasting is a complicated task and the exercise of judgment in forecasting would require much cognitive efforts. Thus, it is quite likely that forecasters may simplify the task to an extent that they can easily manage (Payne, 1976). Such simplification of the task may lead to many judgmental biases (Hogarth & Makridakis, 1981). Psychologists and DSS (Decision Support System) practitioners have argued that some level of guidance is essential in tasks where people rely on their judgment to make managerial decisions. Guidance at a forecasting task may include (1) the provision of accurate statistical forecasts and causal information, (2) the graphical presentation of time series, (3) feedback of past forecasting errors, (4) some warnings of likely judgmental biases (Lim, 1994). A number of recent studies, however, indicate that one's emotion may play a key role at every phase of decision making in the way (s)he utilizes decision aids (Luce et al., 1997) and selects decision strategies for the task (Isen & Means, 1983). This suggests that emotion is a factor that may influence the accuracy of decision outcomes (Stone & Kadous, 1997) and thus, should not be missed out in relevant research. Despite its importance in the context of decision making, however, little evidence appears to exist as to the effect of emotion on judgmental forecasting.

The main aim of this study is to explore the

* 상명대학교 정보통신학과
서울시 종로구 홍지동 7번지 (110-743)
7, Hongji-Dong, Chongro-Ku, Seoul, Korea, 110-743
Tel: +82-2-287-5311
Fax: +82-2-396-6165
Email: jslim@pine.sangmyung.ac.kr

effect of emotion on the accuracy of time series judgmental forecast and its cognitive processes. As a way of tapping into the cognitive process in relation to emotion, this study makes use of some physiological measures to be obtained during the task of judgmental forecasting. Physiological measures may provide some insights into the mind-body relationship and may shed some lights on related cognitive processes. This study would be valuable to the practitioners of decision support systems to incorporate the 'emotion' factor into the design of more effective systems of aiding forecasters and decision makers. We raise research questions to be examined in this study as follows:

- Does the state of one's emotion influence the accuracy of judgmental forecasting?
- Do physiological measures (EEG and GSR) explain the reason and provide insights into the effect of emotion on forecasting accuracy?
- In what way is the emotion associated with brain waves?

2. Literature Review and hypotheses

Emotion is so commonplace that we hold in our mind and experience every day anger, sadness, fear, happiness, and etc. (Ortony & Turner, 1990). Thus, emotion has been of much interest to the schools of personality and psychology that extensively investigated its effect on social behavior (Isen, 1990). Not only does emotion play a critical role in social context, it also influences the process of individual decision making (Lazarus, 1990; Isen, 1990) as "psychological phenomena that encompass cognitions" (Cacioppo et al., 1993). Empirical evidence appears to exist that emotion may influence the way people process information and make decisions. Goldberg and Gorn (1987) found that commercials performed better with happy programs than with sad programs. However, when viewers were willing to like watching the negative programs, advertisements embedded in negative-emotion programs performed as well as the ones embedded in positive-emotion programs (Murry et al., 1992). A number of studies also suggest the effect of emotion on decision making styles which would certainly affect decision outcomes. Schwarz (1990) reported that people tended to be intuitive in happy mood, whereas more analytical judgment was evident when people were in sad mood. Indeed, increasing task-related negative affect appeared to lead people to use scanning strategies, which increased choice accuracy in easy tasks but impaired it in hard tasks (Stone & Kadous, 1997). More directly addressing the role of emotion in the selection of decision strategies, Isen (1983) argued that when induced to happy mood, people tended to simplify the problem space (Payne, 1976) and employ shortcuts in their decision making (i.e., Elimination-By-Aspects). To summarize, emotion plays a critical role in decision making and many of judgmental biases appear to be related to the cognitive efforts of people to maintain their mood/ emotion positive. That is, in positive emotion, people tend to be intuitive and protect their positive emotion. On the other hand, people in negative emotion appear to be analytical and avoid their negative emotion to turn it into positive one. Although this tendency may influence decision accuracy, there has been very limited evidence that addresses this issue. We put forward a null hypothesis as follows:

H_1 There is no difference in forecasting accuracy between the good emotion and the bad emotion groups.

The effect of emotion on EEG has been investigated by a number of researchers. A persistent finding appears to be hemispheric asymmetry in EEG between good and bad emotion. That is, the left hemisphere of the brain was activated (increased beta) with good emotion, whereas the right hemisphere, with bad emotion (Heller, 1986; Davidson, 1990; Ray & Cole, 1985). Similarily, Sutton and Davidson (1997) showed that subjects with greater relative left activation appeared to adjust their behavior in response to positive stimulus (e.g., incentives), whereas those with greater right activation were more capable of guiding their behavior in response to negative stimulus (e.g., threats and novel stimuli). There exists a line of research that the locus of this asymmetry may be found in the frontal lobes (Davidson, 1982; Cohn, 1946; Shpiberg, 1947; Faure, 1950). Since there has been little research in the context of decision making and judgmental forecasting, a null hypothesis is formulated as follows:

H_2 There is no difference in alpha and beta in EEG between the good emotion and the bad emotion groups.

It is generally accepted that alpha and beta activities are associated with cognitive tasks. Yet the empirical evidence regarding the exact nature of the relationship appears to be confounding. A view that receives a wide acceptance is a phenomenon of alpha desynchronization and beta synchronization (Fernandez et al., 1995). That is, alpha activity appeared to be more evident in a general relaxed mental state and decrease with mental efforts (Andreassi, 1989). Then beta rhythms appear to be augmented as alpha activity is desynchronized (i.e., alpha blocking). Since alpha power appeared to be inversly related to mental effort (e.g., Butler & Glass, 1976; Donchin, Kutas, & McCarthy, 1977; Glass, 1964) and indicative of transient paucity of mental activity (Adrian & Mathews, 1934; Lindsley, 1952), it may be deduced that good performance is possibly associated with higher levels of alpha blocking. Along with alpha blocking, changes in the beta band can be found with cognitive efforts (Gevins et al., 1979; Tucker et al., 1985; John et al., 1989; Ray & Cole, 1985).

While this notion of inverse relationship between alpha and beta rhythms, there has been some empirical evidence that alpha activity is not necessarily blocked during mental tasks. Darrow (1947) argued that alpha is associated with the 'automation' or 'habituation' of learned behaviors. Accordingly, alpha activity may increase during the performance of some mental tasks. Indeed, there exists a line of research that upholds the possible contribution of alpha activity to good performance in mental tasks (Jausovec, 1996). As discussed earlier, this is contrasting to the view that the reduction of alpha power is associated with good performance (Earle, 1988). This may be due to the capability of good performers not to use many brain areas not required for the problem at hand (Jausovec, 1996). This study shall investigate the changes in alpha and beta activity during mental tasks, in particular in frontal areas that are known to be associated with mental tasks (Petsche et al., 1986). A nulll hypothesis is set up as follows:

H_3 There is no relationship between forecasting accuracy and alpha and beta in EEG.

3. Methods

3.1. Subjects

Twelve under- and postgraduate students were used as a surrogate of managers. Most students were from the School of Information Technology and Telecommnuications at SangMyung University located in Seoul, South Korea. They took part in the experiment as part of their course. Participants were provided with a 3000-Won worth phone card. It was also announced that those who rank high in terms of forecast accuracy would be granted extra monetary incentives.

3.2. Research Design

The research was conducted as a 2 (emotion) x 2 (trials) factorial design. The first factor, emotion, was expressed either (1) good or (2) bad. This factor represented an experimental condition in which some stimuli were provided for the subjects to feel bad or good over the task of judgmental forecasting. The second factor, trials, accounted for the rounds of time series which were given for the subjects to forecast.

3.3. Independent variables

This study involved three independent variables to be controlled as follows:

- **Emotion**
  It was manipulated by (1) scenario recalls and (2) auditory, visual and olfactory stimulus. The scenarios were given in handouts and worded for the subjects to feel either good or bad, depending on the conditions to which they were assigned. Subjects were asked to maintain their emotion by recalling the scenarios throughout the experiment. Each condition was reinforced by providing some appropriate environmental stimulus. That is, along with scenario recalls, the good emotion was conditioned with music, ordor, and office surroundings in the way that the subjects feel good. On the other hand, the environmental stimulus of the bad emotion was arranged in the opposite way that could lead the subjects to uncomfortable and unhappy feeling.
- **Number of trials**
  Subjects were provided with a set of eight time series. The number of trials represents the rounds of time series they performed.

3.4. Dependent variables

Three dependent variables were measured as follows:

- **Forecasting accuracy**
  MAPE (Mean Absolute Percentage Error) was adopted because of its academic popularity (Carbone & Amstrong, 1982) and robustness (Armstrong & Collopy, 1992). It measured the extent of deviation of subjects' forecasts from the actual values (optimal criterion).
- **Physiological measures**
  EEG (ElectroEncephaloGram) was measured based on the 10-20 systems (Jasper, 1958) at two positions: (1) occipital and (2) frontal sites of the brain (Oz, Fz). This was due to the fact that the experimental task required the subjects to process visual time series information (i.e., occipital) in need of much cognitive efforts (i.e., frontal, Petsche, 1992: Inouye et al., 1933). GSR (Galvanic Skin Resistence) was measured by the first peak after stimulus.
- **Subjective measures**
  Subjects were asked to report their feeling on a 10-point scale. It should be noted that it was a subjective indicator of their emotion how good and bad emotion they experienced in relation to the experimental condition of emotion. Thus, there may be some deviation in the subjective ratings among the subjects in the same condition.

3.5. Tasks

Used in this experiment were ten time series, taken from M-Competition (Makridakis et al., 1982). This set of time series were successfully used in a series of earlier experiments (Lim & O'Connor, 1996). Subjects were asked to suppose themselves as managers and to project eight-period ahead forecasts from the given time series. The time series were drawn and printed out on a piece of paper using spreadsheet software. The reason why printouts (not computer screen) were opted for was due to possible electromagnetic interference with EEG and GSR recording. This resulted in a total of 64 forecasts produced by each subject (eight time series x eight-period ahead forecasts). The task was worded as sales of ice cream that students would be interested in. The experimental task lasted for about 40 minutes to complete.

3.6. Procedure

Subjects were randomly assigned to the emotion condition and asked to sign up the experiment individually according to the time schedule. Due to the difficulty of setting up the condition alternatively between 'good' and 'bad' emotion, each condition was experimented on the same day. That is, a day was reserved for the group of subjects who belonged to the good emotion condition. The other condition (bad) was administered on the following day. On entering the experimental room, subjects were seated and briefed about the types of incentives and the tasks that they were required to perform. Then, in order to measure EEG and GSR, physiological gadgets were attached on the subjects (brain, fingers, ankles, etc.). They were ushered into the experimental room, organized in advance for them to feel good and bad. They were asked to sit and relax for 1 minute with their eyes closed. Then, subjects were asked to open their eyes and look at the time series for 1 minute. With physiological recording paused, subjects were asked to project 8-period ahead forecasts for the given time series. The above task of judgmental forecasting was repeated for 8 different times series. After the 8 repetitions, a set of questions was given for the subjects to indicate their feelings and attitudes. This experiment was performed in one sitting.

3.7. Analysis Methodology

Prior to any analysis, Cook's distance was run to remove any outliers contained in MAPE data. EEG and GSR data were also visually scanned for artefacts. Then, initial 15 and 30 second segments were taken from EEG and GSR at two stages of (1) emotion induction and (2) time series tasks. FFT analyses were performed to obtain alpha and beta rhythms with which beta/ alpah ratios were also computed for statistical analyses. The number of trials was halved into two divisions of early and later trials and 2 (emotion) x 2 (trials) ANOVAs were computed. Along with ANOVAs, correlation analyses were also performed to test the effect of emotion on the subjective ratings of emotion obtained from questionnaires.

4. Results

4.1. Manipulation Checks

Subjects were asked to indicate their feelings on a 10-point scale after the experiment - the smaller the number of a scale, the more positive. These subjective ratings on emotion were significantly different between the good and the bad emotion groups. The good emotion group tended to report positively (4.15), whereas the bad emotion group, more negatively (7.47) (t $(700.5)=-45.21$, $p<.005$). The 95% confidence level also indicated these differentiating subjective ratings of their emotion between the two groups. That is, 95% of the subjects in the bad emotion group appeared to fall in the range of between 7.38 and 7.55, whereas those in the good emotion in the range of 4.03 and 4.27. In the light of the neutral state of their emotion being 5 out of a 10-point scale, the overall ratings were a little skewed toward the negative assessment of their subjective emotion.

4.2. The Effect of Emotion on Accuracy: H_1

The first hypothesis was concerned if there was some effect of emotion on the accuracy of judgmental forecasting. It was found that the bad emotion group (MAPE= 23.49) achieved a higher accuracy than the good emotion counterpart (MAPE=27.43). However, the results of ANOVA did not bear out such an effect. In the light of the fact that emotion was also reported subjectively by the subjects, correlation analysis was performed to test the hypothesis. We found a statistically significant correlation between accuracy (MAPE) and emotion ($r=-.123$, $p<.005$). The negative correlation suggests that the more negative emotion the subjects reported, the higher their forecasting accuracy was. This contrasting result between ANOVA and correlation may be due to the fact that the emotion effect was not homogenous among the subjects in the group. It should be noted that the factor of emotion was controlled by some stimulus given to the subjects according to the experimental condition they were assigned to. And the subjects may have responded somewhat differently among the subjects in the group to the questions as to their feelings over the experiment. This difference was, however, very slight in that the manipulation of the emotion factor was successful that as reported earlier, the good emotion group appeared to report more positive feelings than the bad one. In addition, learning effect was found on forecasting accuracy. Judgmental forecasts of early trials (MAPE=26.21) was less accurate than those of the later trials (24.71) ($F=5.360$, $df= 1$, $p<.05$). But, there was no interaction effect of emotion and trials.

4.3. The Effect of Emotion on EEG: H_2

The second hypothesis tested if there was some effect of emotion on EEG over the task of judgmental forecasting. Measured were alpha and beta rhythms in the region of occipital and frontal lobes over two experimental stages (1) emotion induction and (2) time series task. Over the stage of emotion induction, there was a tendency that the good emotion group produced more of EEG, except for frontal beta (see Table 1). That is, the good emotion group produced occipital alpha, occipital beta and frontal alpha more than the bad one ($p<0.005$). On the other hand, frontal beta was higher in the bad emotion group than the good emotion one ($p<0.005$). This tendency was also manifest during the stage of time series task. The good emotion was characterized by the increment of both alpha and beta at the occipital region in this study. Given that emotion may consist of both valence and arousal (Stein et al., 1990), this study dealt with the emotion at a higher level of arousal in that GSR was maintained at a high level during the task. Normalized variations from the emotion induction to the time series stage was computed to test any changes in EEG. Both alpha and beta activities were found to increase as cognitive efforts were required more. This finding did not vary between emotion conditions. The ratios of beta to alpha power were higher in the bad emotion group than the good one, which suggests the overwhelming effect of beta over alpha activity. Given that forecasting accuracy tended to be higher in the bad emotion than the good emotion group, beta frequency may be associated with forecasting accuracy.

Table 1: EEGs between Good and Bad Emotion Groups (15s segment, time series task)

		Frontal Lobe	Occipital Lobe
Good emotion	Alpha	0.00001506	0.01573396
	Beta	0.02295375	0.05817086
Bad emotion	Alpha	0.00001233	0.01284458
	Beta	0.02727146	0.04659708

4.4. Forecasting Accuracy and EEG: H_3

The first and second hypotheses revealed the effect of emotion on accuracy (H_1) and EEG (H_2). The last and third hypothesis was concerned with which part of EEG contributed most to the accuracy of judgmental forecasts. Interestingly enough, frontal beta was the one that accounted for accuracy as well as bad emotion. Correlation analyses were performed with the factors of accuracy, emotion (controlled emotion & subjective ratings) and EEG (alpha, beta). Frontal beta was found to be correlated with subjective ratings of emotion ($r=.349$, $p<.005$). Also, there was a positive relationship between frontal beta and forecasting accuracy ($r=-.080$, $p<.05$). This indicates that frontal beta was related to both emotion and accuracy. Shifting the analysis to GSR, there was also significant correlations between GSR and the subjective ratings of emotion ($r=.101$, $p<.005$). In addition, GSR was significantly correlated with forecasting accuracy ($r=-.115$, $p<.005$). Taken these correlation effects together, we can conclude that those who rated their feelings negatively tended to show a higher GSR than those who rated less negatively and GSR appeared to become higher as forecasting accuracy improved. This is consistent with the earlier finding that bad emotion contributed to accuracy.

5. Discussion

Although judgmental forecasting is a commonly accepted method in business practice, we do not know in details as to its cognitive processes and factors influencing the accuracy. This paper investigated the effect of emotion on judgmental forecasting by employing a physiological approach to tap into its cognitive processes and explore what brain waves contribute to good performance. It is important that emotion is the one that people always carry during their routine performance of tasks. Very scarce research on the effect of emotion on decision-making behavior and process has been made to directly address the effect of emotion on decision accuracy. The main findings of personality and psychology literature are that people when they are forced to feel sad tended to be more analytic than those in happy mood. This suggests that one's emotional state may influence forecasting accuracy. We found that people in bad emotion performed better than those in good emotion. Physiological data obtained in this study suggest that this may be due to some intervening effect of EEG. Forecasting accuracy appeared to be positively correlated with frontal beta which was manifest more in those in bad emotion.

Alpha (8-12 Hz) and beta (13-50 Hz) have been of interest to examine the relationship between EEG and the performance of cognitive tasks. It is now generally accepted that alpha and beta activities are associated with cognitive tasks (Ray & Cole, 1985). Yet the empirical evidence regarding the exact nature of the relationship appears to be confounding (Fernandez et al., 1995). Despite a number of studies regarding alpha and beta changes in relation to mental tasks, very limited studies directly investigated its effect on decision making and performance. Findings from attention studies offered little support for a consistent relationship between performance decrement and any EEG frequency (Butler & Glass, 1976; Donchin, Kutas, & McCarthy, 1977; Glass, 1964; Jausovec, 1996). There have been, however, a number of empirical studies to suggest that the power of frontal beta appear to be associated with decision performance. Main findings for the effect of emotion on EEG are asymmetrical hemispheric differences, more beta being present in the right temporal area during positively as opposed to negatively valenced emotional tasks (Ray & Cole, 1985). Recent electrophysiological evidence suggests that the locus of this asymmetry lies in the frontal lobes (Davidson, 1982). In addition to asymmetrical allegation of EEG to emotion, emotion may affect EEG in various ways such as (1) suppressed alpha, (2) increased frontal beta and (3) increased alpha and decreased beta (Mundy-Castle, 1957). To be consistent with the findings of the earlier studies, the power of frontal beta was found to be an indicator of negative emotion. Interestingly enough, frontal beta appered to contribute to an improvement of forecasting accuracy.

The results of this study should be generalized with caution. First, it should be noted that this study observed ipsilateral asymmetry in contrast to translateral asymmetry of the earlier studies (Davidson, 1982). As discussed earlier, however, the results of this study corroborated with those of earlier studies. In addition, individual differences in subject's EEG (Galbraith and Wong, 1993) were not considered in this study assuming that the normal EEG can be stable intraindividually (Gasser et al., 1985). This study may be valuable to forecasting practitioners and researchers in understanding the cognitive processes of time series judgmental forecasting by exploring its psychophysiological measures. For example, in a time series context, the results obtained in this study may provide a clue to the dampening behavior for the down-trended time series (O'Connor et al., 1995). This study also contributes to the academic field of forecasting and decision making in that the effect of emotion was studied with physiological measures of EEG and GSR. EEG may be used as a powerful and valuable instrument to gain insights into the way people rely on their judgment in forecasting and decision making. Given that very limited research has been made in this context of physiology and judgment, further research is required with a refined methodology.

6. Reference

Andreassi, J. L., 1989, Psychophysiology : Human behavior and physiological response (2nd Ed.), Lawrence Erlbaum Associates Publishers, Hillsdale, NJ.

Armstrong, J. S. & Collopy, F., 1992, "Error Measures for Generalising about Forecasting Methods : Empirical Comparison," International Journal of Forecasting, 8 (1), 69-80.

Basar, E., 1988, "EEG Dynamics and Evoked Potentials in Sensory and Cognitive Processing by the Brain," Springer Series in Brain Dynamics, 1, 30-55.

Cacioppo, J. T., Klein, D. J., Berntson, G. G., & Hatfield, E., 1993, "The Psychophysiology of Emotion," Book Chapters.

Carbone, R. & Amstrong, J. S., 1982, "Evaluation of Extrapolative Forecasting Methods Results of a Survey of Academicians and Practitioners," Journal of Forecasting, 1 (2), 215-217.

Dalrymple, D. J., 1987, "Sales Forecasting Practices : Results from a United States Survey," International Journal of Forecasting, 3, 379 391.

Darrow, C. W., 1947 , "Psychological and psychophysiological significance of the electroencephalogram." Psychological Review, 54, 157-168.

Davidson, R. J., 1982, "Asymmetrical Brain Acitivity Discriminates Between Positive and Negative Affective Stimuli in Human Infants," Science, 218, 1235-1236.

Davidson, R. J. et al., 1990, "Approach Withdrawal and Cerebral Asymmetry:

Emotional Expression and Brain Physiology I," Journal of Personality and Social Psychology, 58 (2), 330-341.
Earle, J. B., 1988, "The Effects of Arithmetic Task Difficulty and Perofrmance Level on EEG Alpha Asymmetry," Neuropsychobiology, 20, 96-112.
Fernandez, T., Harmony, T., Rodriguez, M., Bernal, J., Silva, J., Reyes, A., Marosi, E., 1995, "EEG activation patterns during the performance of tasks involving different components of mental calculation," Electroencephalography and Clinical Neurophysiology, 94, 175-182.
Galbraith, G. C. & Wong, E. H., 1993, "Moment Analysis of EEG Amplitude Histograms and Spectral Analysis : Relative Classification of Several Behavioral Tasks," Perceptual and Motor Skills, 76, 859-866.
Gasser, T., Bacher, P. & Steinberg, H., 1985, "Test-Retest Reliability of Spectral Parameters of the EEG," ECN., 60, 312-219.
Hogarth, R. M. & Makridakis, S., 1981, "Forecasting and Planning: An Evaluation," Management Science, 27 (2), 115-137.
Heller, 1986, in Psychological and Biological Approaches to Emotion, 167-172.
Inouye et al., 1933, "Localization of Activated Areas and Directional EEG Patterns during Mental Arithmetic," ECN, 86, 224-230.
Isen, A. M. & Means, B., 1983, "The influence of Positive Affect of Decision-Making Strategy," Social Cognition, 2(1), 18-31.
Isen, A. M., 1990, "The Influence of Positive and Negative Affect on Cognitive Organization : Some Implications for Development", In Stein, N. L., Leventhal, B. & Trabasso, T. (Eds), Psychological and Biological Approaches to Emotion, Lawrence Erlbaum Associates Publishers, Hillsdale, NJ, pp 75-94.
Jasper, H., 1958, "The Ten Twenty Electrode System of the International Federation," Electroencephalography and clinical Neurophysiology, 10, 371-375.
Jausovec, N., 1996, "Differences in EEG Alpha Activity Related to Giftedness," Intelligence, 23, 159-173.
Juolasmaa, A., Toivakka, E., Outakoski, J., Sotaniemi, K., Tienari, P. & Hirvenoia, R., 1986, "Relationship of Quantitative EEG and Cognitive Test Performance in Patients with Cardiac Valvular Disease," Scandinavian Journal of Psychology, 27, 30-38.
Lazarus, R. S., 1990, "Constructs of the Mind in Adaptation," In Stein, N. L., Leventhal, B. & Trabasso, T. (Eds), Psychological and Biological Approaches to Emotion, Lawrence Erlbaum Associates Publishers, Hillsdale, NJ, pp 3-19.
Lim, J. S., 1993, "An Empirical Investigation of the Effectiveness of Time Series Judgmental Adjustment using Forecasting Support System," Ph.D Thesis, University of New South Wales.
Lim, J. S. & O'Connor, M., 1995, "Judgemental Adjustment of Initial Forecasts : Its Effectiveness and Biases," Journal of Behavioral Decision Making, 8, 149-168.
Luce, M. F. & Bettman, J. R. & Payne, J. W., 1997, Choice Process in Emotionally Difficult Decisions, Journal of Experimental Psychology: Learn, Memory, and Cognition, 23 (2), 384-405.
Makridakis, S., Anderson, A., Carbone, R., Fildes, R., Hibbon, M., Lewandowski, R., Newton, J., Parzen, E. & Winkler, R., 1982, "The Accuracy of Extrapolation (Time Series) Methods : Results of a Forecasting Competition," Journal of Forecasting, 1, 111-153.
Mundy-Castle, A. C., 1957, "The Electroencephalogram and Mental

Activity," Electroencephalograph & clinical Neurophysiology, 9, 643-655.

Murry, Jr., J. P. & Dacin, P. A., 1996, "Cognitive Moderations of Negative-Emotion Effects: Implications for Understanding Context," Journal of Consumer Research, 22, 439-447.

O'Connor, M., Remus, B. & Griggs, K., 1995, "Going up - Going down: How Good Are People at Forecasting Trends and Changes in Trends", Working paper, The University of New South Wales, Australia.

Ortony, A. & Turner, T. J., 1990, "What's Basic About Basic Emotions?," Psychological Review, 97(3), 315-331.

Petsche, H. et al., 1992, "Thinking with Images or Thinking with Language: A Pilot EEG Probability Mapping Study," International Journal of Psychophysiology, 12, 31-39.

Ray, W. J. & Cole, H. W., 1985, "EEG Alpha Activity Reflects Attentional Demands, and Beta Activity Reflects Emotional and Cognitive Processes," Science, 228, 750-752.

Stein, N. L., Leventhal, B. & Trabasso, T., 1990, Psychological and Biological Approachs to Emotion, Lawrence Erlbaum Associates Publishers, Hillsdale, NJ.

Stone, D. N. & Kadous, K. 1997, "The Joint Effects of Task-Related Negative Affect and Task Difficulty in Multiattribute Choice," Organizational Behavior and Human Decision Processes, 70(2), 159-174.

Sutton, S.K. & Davidson, R. J., 1997, "Prefrontal Brain Asymmetry: A Biological Substate of the Behavioral Approach and Inhibition System," Psychological Science, 8 (3), 204-210.

Valentino, D. A., Arruda, J. E. & Gold, S. M., 1993, "Comparison of QEEG and Response Accuracy in Good vs Poorer Performers during a Vigilance Task," International Journal of Psychophysiology, 15, 123-133.

Vogel, W. Broverman, D. M. & Klaiber, E. L., 1968, "EEG and Mental Abilities," Electroencephalography & Clinical Neurophysiology, 24, 166-175.

Wegener, D. T., Petty, R. E. & Smith, S. M., 1995, "Positive Mood Can Increase or Decrease Message Scrutiny: The Hedonic Contingency View of Mood and Message Processing, Journal of Personality and Social Psychology, 69 (1), 5-15.

韓國感性科學會誌
Korean Journal of The Science of Emotion & Sensibility
1998, Vol.1, No.1, 123-133

A physiological approach to the effect of emotion on time series judgmental forecasting EEG and GSR

Joa Sang Lim, Min Cheol Whang, Hung Kook. Park, Hyun Sook Lee
(Sang Myung University)

Abstract Although judgmental time series forecasting is indispensable at most firms, little has been known as to its cognitive processes. In the light of the fact that emotion has been known to play an important role in cognitive activities, this study aimed to investigate the effect of emotion on judgmental forecasting. The research was conducted as a 2 (emotion) x 2 (trials) factorial design with repeated measures. Emotion was induced by scenario recall and auditory, visual and olfactory stimulus. Subjects were 12 under- and postgraduate students. Physiological measures of EEG and GSR were analyzed to explore the effect of emotion on judgmental forecasting. The results indicated that emotion tended to influence forecasting accuracy. People in bad emotion showed significantly higher accuracy than those in good emotion. This was due to the beta activity at frontal sites, observed more for those in bad emotion than those in good emotion, which in turn contributed much to accuracy improvement.