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I-Shou university had make a big leap forward, was ranked 371st in the world of 6000 universities in terms of its Web site presence, according to the latest Webometrics Rankings of World Universities released in July, 2009. A great progress was make in compared to last year’s ranking of 529th place. This shown I-Shou University is growing steady with improvement on every areas. According to the data released by Ranking Web of world’s universities website. http://www.webometrics.info

According to the data released by the Ranking Web of World’s universities, there were 25 universities from Taiwan that entered the top 500. I-Shou University, dazzling new star from the southern part of Taiwan, was ranked 371st globally, 41st in Asia, 11th in Taiwan, 2nd place among private universities from Taiwan. The quantities of academic research had surpassed many well known national universities in Taiwan.

The Webometrics Ranking of World Universities is an initiative of the Cybermetrics Lab under the Spain-based National Research Council to improve the presence of academic and research institutions on the Internet.

The ranking is updated twice a year, in January and July, based on a combined indicator that measures through existing search engines the size (volume of content) of a Web
As the coming of globalization era, internet is universally recognized as the one of the most relevant tools for media communication. The standards and criterions of the academic and research institutions on the Web under the Spain-based National Research Council has became meaningful and internationally well known.

I-Shou University has made continuously progress in the short 19 years of its history. The various aspects of campus developments had grow rapidly and became the most scaled private universities on the southern part of Taiwan. The progress result of I-Shou University is obvious to all. In order to catch up with the current trend, I-Shou University vigorously carry out the strategy to be international and established the international college. The industry and university collaboration program also had outstanding result that make the I-Shou University internationally well known.
The numbers of National Science Council’s college students’ research projects passed by the students of I-Shou University made I-Shou top one among other private Universities

The students of I-Shou University, under the guidance of teachers, enthusiastic and vigorously participated in the National Science Council’s college students’ research projects, and had outstanding results.

The number of student research projects passed had reached 64 applications this year. This made I-Shou University become the top one among other private universities and surpassed many famous universities in Taiwan. This also shown the teachers of I-Shou university are ambitious in foster students. Students who have the potential research abilities, were inspired and encouraged to use what they had learned from school and devoted themselves into working toward their research gold.

Students of I-Shou University vigorously apply the National Science Council’s college students’ research projects. The outstanding result of 64 projects passed that made I-Shou University become the top among private universities in Taiwan.

Department of Biomedical Engineering had excellent results with 9 projects passes. Department of medical nutrition had 8 projects, department of materials science and engineering, department of biological science and technology and department of information engineering each had 7 projects. Department of electrical engineering had 6 projects.

Among the 7 projects that passed the accounting of higher education system nationally, 4 projects were from the I-Shou University, department of accounting. The passing percentage rate was exceptional high of 60 percentage nationally.
Students and teachers from I-Shou University, department of mechanical automation engineering had join forces and created 「The hydrogen gas motive power Motorcycle」.

The progresses of human technology bring economic growth. However, the results form economic growth of mass productions, consumption, and emission of waste gas also make the recovery of nature environment much harder. The diminishing of natural resources and environmental pollution could bring critical danger to the development of human generation such as global greenhouse effect and the used up of oil resources.

The students and teachers from the department of mechanical automation engineering of I-Shou university worked together and created 「The hydrogen gas motive power motorcycle」. The motorcycle is through the electrolysis system supply the hydrogen gas into four stroke motorcycle engine and makes the hydrogen gas blend in with gasoline into burning. This is wishing to lower the emission of wasted gas and decrease the air pollution created by it for environmental purpose.

Professor Chu Li-min from the department of mechanical automation engineering of I-Shou university indicated that most of the hydrogen researches focus mostly on the researches and development of fuel cell, solar energy and storage of hydrogen, less on the application of hydrogen gas used in the internal combustion engine.

The research teams from I-Shou university mainly use the electrolysis method to get the hydrogen gas, which has less volume, fast formation and can be used immediately without the need for steel cylinder in storage. This device uses hydrogen gas in coordination with the fuel gas of motorcycle to ignite the engine. This is to increase the speed of engine burning effectively and proceed to the decrease the usage of fuel gas and emission of waste gas.
It is worth mentioned that the device can decrease the emission of waste gas, such as carbon dioxide decreased 14%, hydrocarbon 32%. The device will not affect the speed or motive power of motorcycles. It can be easily install in either old or new motorcycles with a reasonable price about $3000 NT dollars. It is both economical and convenient.
Students and teachers from I-Shou University, department of biomedical engineering had developed a device to measure the hardness of arteries in prevention of chronic diseases.

The structure of Taiwan society is moving toward aging population. As the elderly population increased, the various kind of chronic diseases also increase as well. Therefore, the problems of arteriosclerosis have gradually become the center of attention for the people in Taiwan. Nevertheless, at the present time, clinically on how to examine or evaluate the hardening of the arteries, still has no accepted opinions. The opinions on how to measure arteriosclerosis are widely divided. Because of this, the department of biomedical engineering from I-Shou University made the device that can measure the absolute value of the hardening arteries. They developed a system that use the technique of tiny vibration, without invasion of body to measure the hardening of arteries. This outstanding result had won themselves the excellent prize award on the third 「 National college students Biomedical Engineering originality design competition 」.

Biomedical engineering graduate student Jang wei-jing and four other undergraduate students Chen Jiu-n- Jian, Jian min- Yi, Wang Zeng- Chi, Lin Liang -Yu, under the guidance of professor Wang Jia-Jung, designed and developed the device that measures the absolute value of the hardening arteries. The using of tiny vibration technique to measure the hardness of arteries is definitely practical for use. If this device earn the support from industry for production, undoubtedly it can bring more benefit to people.
Professor Wang Jia-Jung indicated, this device apply different frequency on the arteries and through the relations between contact, displacement volume and frequency to calculate the elasticity resistance of the arteries. The device can measure the absolute value of hardening arteries in a short time and not the relative value. Moreover, the complete wave pattern of hardening during the cardiac cycle period can be seen. If the device from this project becomes a product, users can monitor and have a better understanding of the level of arteries hardness. Way of effectively safeguard health is through 「Better prevention than treatment」.
Color-Based Image Salient Region Segmentation Using Novel Region Merging Strategy

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Abstract

This paper proposes a novel unsupervised algorithm for the segmentation of salient regions in color images. There are three phases in this algorithm. In the first phase, we use nonparametric density estimation to extract candidates of dominant colors in an image, which are then used for the quantization of the image. The label map of the quantized image forms initial regions of segmentation. In the second phase, we define salient region with two properties; i.e., conspicuous; compact and complete. According to the definition, two new parameters are proposed. One is called “Importance index”, which is used to measure the importance of a region, and the other is called “Merging likelihood”, which is utilized to measure the suitability of region merging. Initial regions are merged based on the two new parameters. In the third phase, a similarity check is performed to further merge the surviving regions. Experimental results show that the proposed method achieves excellent segmentation performance for most of our test images. In addition, the computation is very efficient.

Index Terms—Dominant color, importance index, merging likelihood, nonparametric density estimation, salient region
1. Introduction

Image segmentation partitions an image into non-overlapping regions, which ideally should be meaningful for a certain purpose. Thus, image segmentation plays an important role in many multimedia applications. Generally, color and texture are the most important and widely used low-level attributes for content-based visual information retrieval. Therefore, the use of low-level visual features to retrieve relevant information from image and video databases has received much attention in recent years. For last two decades, many content-based image retrieval systems have been established [1, 2]. According to the observation from extensive experiments, we found that low-level features based natural images matching using overall image similarities is often too crude such that too many unrelated images are retrieved, and consequently their performances are unsatisfactory.

A trade off solution to narrow down the gap between low-level features and high-level human perception is to use spatial local features instead of global features of images. Therefore, developing a suitable image segmentation technique, which effectively partitions image into salient regions, is an important issue.

Because there is no formal definition for image segmentation, it is very difficult to propose a semantic index to measure a given segmentation quality. Therefore, the goal of image segmentation is very application oriented. Automatic segmentation in still image has been investigated for many years. The existing segmentation techniques can be mainly divided into the following approaches: 1) Histogram-based methods [3, 4], 2) region-based methods [5-8], 3) boundary-based method [9-11], 4) hybrid-based method [12-20], and 5) graph-based method [21, 22].

Because of perception subjectivity, a good all-purpose algorithm for image segmentation does not exist. The main purpose of this paper is not to precisely segment every single object in an image but to find the salient regions that are relatively meaningful to human perception. In the new approach, we develop a fast dominant color extraction scheme based on non-parametric density estimation. The new scheme automatically determines the number of dominant colors. We also give a definition of region salience and accordingly develop a novel merge strategy, which takes into account not only the homogeneity but also the geometric properties of regions. Experimental results show that the proposed method has very promising performance.

In Section 2, we briefly describe the image segmentation problems. The details of the proposed method are given in Section 3. In Section 4, we show and discuss the experimental results. Brief conclusions are given in Section 5.

2. Problem formulation

For salient region image segmentation, the salience is a macro property of an image. In other words, a salient region can be easily identified when we see an image. As shown in Fig. 7.1(a), we can easily see a dog sitting on the grass. Therefore, the dog and the grass are salient regions, although the dog and the grass
themselves are not homogeneous in color or texture. Unlike the object segmentation, salient region segmentation is not necessary to extract each object in an image accurately but viewing the whole objects as a salient region, as shown in Fig. 7.4 in which the herd of elephants is a salient region. As not requiring a priori domain knowledge about object, salient region segmentation is more feasible for applications such as region based image/video retrieval than is the object segmentation.

In this paper, we propose a new region merging strategy based on the image salience and a new merging rule. We first calculate the “Importance index” of each region and then merge those regions with lower value of “Importance index” into one of its neighboring region according to the new merging rule. As a result, the final segmented regions satisfy the image salience. The proposed algorithm is illustrated in Fig. 1, which is divided into three phases. In the following sections, we will describe each phase of the new algorithm in detail.

### 3. Dominant color extraction, image quantization and region merging

For a true color digital image, there are a huge number of colors in color space no matter what the chosen color space is. The representative colors (or dominant colors) of an image are critical for natural image segmentation. Therefore, an efficient and effective scheme to extract the representative colors is necessary.

In our work, we develop a new dominant color extraction scheme based on nonparametric density estimation [23-25]. Given an n-dimensional dataset \( \{ x_i \in R^n ; i = 1 \ldots N \} \), the nonparametric density \( f(x) \) is obtained by convolving the dataset with a unimodal density kernel \( K_\sigma(x) \),

\[
f(x) = \frac{1}{N} \sum_{i=1}^{N} K_\sigma(x-x_i) \tag{1}\]

where \( \sigma \) is the bandwidth for the kernel. In our work, we selected a Gaussian kernel as

\[
K_\sigma(x) = \left( \frac{1}{2\pi\sigma^2} \right)^{n/2} e^{-\frac{\|x\|^2}{2\sigma^2}} \tag{2}\]

To estimate the density for the entire feature space, the computational complexity of Eq. (1) is \( S \times N \), where \( S \) is the size of the feature space and \( N \) is the number of all data points. When both \( S \) and \( N \) are large, the computation cost is huge. Let us give a simple example: Considering a CIF format color image in RGB color space, the computational complexity is \( 256^3 \times 352 \times 288 \), which is prohibitively huge.

Because not all colors in the color space will appear in an image, we make a simple modification to reduce the computational complexity. Let \( I \) denote a color image, and then we reformulate Eqs.(1),(2) into Eqs(3),(4), respectively, as follows:

\[
f(i_{x,y}) = \frac{1}{WH} \sum_{j=1}^{W} \sum_{k=1}^{H} K_\sigma(i_{x,y}-i_{j,k}) \tag{3}\]

\[
K_\sigma(i_{x,y}) = \left( \frac{1}{2\pi\sigma^2} \right)^{n/2} e^{-\frac{\|i_{x,y}\|^2}{2\sigma^2}} \tag{4}\]
where \( i_{x,y} \in I \) is the color of a pixel at position \((x,y)\) and \( i = (i_r, i_g, i_b) \) is a 3D color vector. Moreover, the \( W \) and \( H \) are the width and height of the image, respectively. Eq.(3) estimates the nonparametric density of a given color on image plane. For an image, the computational complexity of Eq.(3) is \( N^2 \), where \( N = (W \times H) \) is the size of the image. Because \( S = 256 \) is much greater than \( N \), the computational complexity of Eq.(3) is much less than Eq.(1). Therefore, Eq.(3) is a better solution.

Although \( N^2 \) is much less than \((S \times N)\), \( N^2 \) is still a large number for computation. To address this problem, we decompose the 3D color space into three 1D feature spaces. We estimate the densities on three 1D color channel instead of one 3D color space. Therefore, we reduce the size of feature space from \( 256 \times 256 \times 256 \) to \( 256 + 256 + 256 \), which is about 0.0046% of the original size.

Because the luminance and chrominance are mixed together in RGB color space, we adopt YUV color space to take advantage of decorrelating the luminance and chrominance. To further speed up the density estimation, the convolution of Gaussian kernel does not directly apply to the source image plane but to the histogram of each channel. Let \( h(r) \) denote the histogram of an image for one of the three color channels, where \( r \in \{Y,U,V\} \). We then reformulate Eqs.(1),(2) into Eqs.(5),(6), respectively, as follows:
where $r_k$ is the kth level of that channel and $M$ is the total number of levels of it. Although the computational complexity of the channel is $M^2$, the computational cost is very low in that $M$ is a small number, say 256. The density of each channel (Y, U, and V) is estimated by Eq.(5), which tremendously decreases the required processing and achieves equivalent results.

After nonparametric estimation, the density distribution for each channel is obtained. Using the gradient ascent scheme, we can easily find the local maxima. We select the local maxima of each channel and combine them to form the candidates of dominant colors. Fig. 2 illustrates the dominant color extraction scheme.

Once the candidates of dominant colors are available, each pixel in image will be replaced by the nearest candidate by looking up the Nearest-color mapping table, as shown in Fig. 3. Consequently, a quantized color image is obtained and a label map is created as well. We

\begin{equation}
 f(r_k) = \frac{1}{M} \sum_{i=1}^{M} h(r_i) K_\sigma (r_k - r_i) \tag{5}
\end{equation}

\begin{equation}
 K_\sigma (r_k) = \left( \frac{1}{2\pi\sigma^2} \right)^{\frac{1}{2}} e^{-\|r_k - r_i\|^2/2\sigma^2} \tag{6}
\end{equation}

(a) Original densities

(b) Nonparametric densities

![Fig. 2 An example of the dominant color extraction](image-url)
simply eliminate those candidates with lower pixel count, and keep the rest as dominant colors.

We apply the region-growing algorithm on the label map of the quantized image to obtain initial regions. Some of them may be very small and less important. In the following, we will define the salience of image region, calculate the region importance accordingly and then develop a new merging strategy to form the salient regions.

3.1 Region merging strategy

For salient region image segmentation, the salience is a macroscopic property of an image. In other words, the salient region can be easily identified when we see an image. In our definition, they should have two properties as follows:

- **Salient regions should be conspicuous**

  In general, when we look at an image, the larger regions may contain more complete information for human’s perception than that of small regions; therefore, they will capture our attention with most probability. For instance, looking at Fig. 7.1(a) we may readily find a dog, and the grass as its background. However, we may not pay much attention to the eyes of the dog, or how many flowers there are in the background, because they are not with complete information. For Fig. 7.3(a), we may perceive that there exist an elephant, the grass, and the sky, but not the tusks. Thus, we can conclude that a salient region with conspicuous should be big enough.

- **Salient regions should be compact and complete**

  When an image is processed by quantization and region growing, the obtained regions are dissimilar to each of their adjacent regions from the viewpoint of homogeneity, regardless of the sizes of them. A large region may contain many small regions or holes inside it. Holes inside a region violate the region completeness and should be combined to form a more complete and meaningful region. On the other hand, there may
have some small regions with same color label but distributed unconnected in the entire image, shown as Fig. 4. Although, the total size of these regions is big enough, they are not compact. Thus, they are not salient regions.

Generally, after the region growing, the initial regions themselves are homogeneous, but they are dissimilar to each of their adjacent regions. Thus, the homogeneity driven approaches cannot achieve the requirement of salient region. We need new rules to check each region and merge the unsatisfactory ones.

In our work, two new parameters are proposed. One is called “Importance index”, which is used to measure the importance of a region, and the other is called “Merging likelihood”, which is utilized to measure the suitability of region merging. Whether a region should be merged mainly depends on its “Importance index”, and where it should be merged into depends on the “Merging likelihood” between the region and each of its adjacent regions. In the following, we will define the “Importance index” and the “Merging likelihood”.

3.1.1. Importance index computation

“Importance index” is an indicator of importance for every single region in an image. Based on our definition of salience, the importance index should reflect the conspicuousness, compactness and completeness of a region. The first property can be easily examined by the ratio of the region size to the image size such that a bigger region will have a higher ratio. The second characteristic can be expressed as the ratio of the region size to the largest size of all regions that have the same color label as the region. Obviously, a unique region will have a higher value.

Finally, we define the importance index as the multiplication of these two ratios. The mathematical formulation of “Importance index” is expressed as,

\[
\text{Imp}(R_{ij}) = \left( \frac{N_{R_{ij}}}{\sum_{j=1}^{m} N_{R_{ij}}} \right) \times \left( \frac{N_{R_{ij}}}{\text{Max}(N_{R_{ij}})} \right)
\]  

(7)

\(R_{ij}\) : A region with color label \(i\), region index \(j\).

\(\text{Imp}(R_{ij})\) : Importance index of \(R_{ij}\).

\(N_{R_{ij}}\) : The number of pixels of \(R_{ij}\).

\(\text{Max}(N_{R_{ij}})\) : The number of pixels of the largest region with color label \(i\).

\(\sum_{j=1}^{m} N_{R_{ij}}\) : Total number of pixels of the image (image size.)

m : The number of the initial regions.

Fig. 4 An example of non-compact regions
than the merging threshold \( T_m \) then the region is called less important region, otherwise important region. Less important regions must be merged into one of their adjacent regions while the important regions are not necessary to be merged but a further check is proceeded to decide if they should be merged.

### 3.1.2. Merging likelihood computation

We take into account both homogeneity and geometric properties of regions to compute the “Merging likelihood” between regions. Three factors are considered to express the mathematical form of the merging likelihood.

- **Color distance between regions**
  
  The first factor is the color distance between regions. Since the human eye is more sensitive to luminance than chrominance, humans can easily tell the differences affected by the variation of illumination on an object. Nevertheless, for an image segmentation task, the variation of illumination may produce wrong segments. Hence, to reduce the influence of illumination we adopt a weighted Euclidean distance with a lower weighting for \( Y \) and a higher weighting for \( U, V \) channels. In our work, we define the weighted Euclidean color distance between two regions as follow:

\[
CD(R_i, R_j) = \sqrt{w_Y \left( y_i - y_j \right)^2 + w_U \left( u_i - u_j \right)^2 + w_V \left( v_i - v_j \right)^2}
\]

where the \( w_Y \), \( w_U \), and \( w_V \) are the weightings for \( Y \), \( U \) and \( V \) channels, respectively.

- **Boundary length between regions**
  
  The second factor is the boundary length between regions. We use an example to explain the principle. Fig. 5 shows an image with four regions, and \( a \) is a region to be merged. Because the longer the boundary length between two regions the stronger the connection between them. Therefore region \( a \) should be merged into region \( b \), which is consistent with our intuition.

- **Region sizes of neighboring regions**
  
  The third factor is the region sizes of neighboring regions. According to our extensive observation, for most images, the largest region in the image is the background. If we merge a region into its largest neighboring region, there is a higher probability that we will merge the region into the background. If we merge a region into its smallest neighboring region, the merging region may still be small and will have a lot more chances to be merged into a correct region. Therefore, the smallest neighboring region should have the highest priority to be the merging region, concerning the region sizes only.

To define the merging likelihood between regions, the following assumptions are given:

Fig. 5 An example of region merging concerning boundary length between regions
3.1.3. Similarity of important regions

After the merging process is complete, all the surviving regions are important. However, important regions may still be similar to their adjacent regions and should be further merged. The further checking criterion is to measure the color similarity with an adaptive threshold $T_s$. We define the adaptive threshold $T_s$ as in Eq. (10).

$$T_s = \text{Mean}_{dis} \times Ws,$$

where $\text{Mean}_{dis}$ is the average of the color distances between each of the surviving regions, $\text{Var}_{dis}$ is the variance of the color distances, and $C_i$ is a constant, which controls the output range of the exponential function.

$$W_s = \begin{cases} 0.7, & \text{if } W_{\text{dynamic}} > 0.7 \\ 0.55, & \text{if } W_{\text{dynamic}} < 0.55 \\ W_{\text{dynamic}}, & \text{otherwise} \end{cases}$$

Finally, region $a$ should be merged into the region with largest merging likelihood.

3.1.4. The process of segmentation

In order to make it easier for readers to understand the proposed algorithm, we summarize it by an example with some intermediate results, shown in Fig. 6, as follows:

1. Assume $a$ is a region to be merged and $b$, $c$, $d$ are its neighboring regions, $S = \{b, c, d\}$.
2. Let $CD(a, k)$ denote the color distance between region $a$ and region $k$, $k \in S$.
3. Let $BL(a, k)$ denote the boundary length between region $a$ and region $k$, $k \in S$.
4. Let $RS(a, k)$ denote the region size of region $k$, $k \in S$.

Based on the assumption above, "Merging likelihood" is defined as:

$$ML(a, k) = w_1 \left( 1 - \frac{CD(a, k)}{\max_{k \in S}(CD(a, k))} \right) + w_2 \left( 1 - \frac{BL(a, k)}{\max_{k \in S}(BL(a, k))} \right) + w_3 \left( 1 - \frac{RS(k)}{\max_{k \in S}(RS(k))} \right)$$

(9)

where $w_1$, $w_2$, $w_3$ are the weights for color distance, boundary length and region size, respectively.

The $M_L(a, k)$ should be calculated for all $k \in S$. Finally, the region with largest $M_L(a, k)$ should be merged into the region with largest $M_L(a, k)$.

1. Assume $a$ is a region to be merged and $b$, $c$, $d$ are its neighboring regions, $S = \{b, c, d\}$.
2. Let $CD(a, k)$ denote the color distance between region $a$ and region $k$, $k \in S$.
3. Let $BL(a, k)$ denote the boundary length between region $a$ and region $k$, $k \in S$.
4. Let $RS(a, k)$ denote the region size of region $k$, $k \in S$.

Based on the assumption above, "Merging likelihood" is defined as:

$$ML(a, k) = w_1 \left( 1 - \frac{CD(a, k)}{\max_{k \in S}(CD(a, k))} \right) + w_2 \left( 1 - \frac{BL(a, k)}{\max_{k \in S}(BL(a, k))} \right) + w_3 \left( 1 - \frac{RS(k)}{\max_{k \in S}(RS(k))} \right)$$

(9)

Finally, region $a$ should be merged into the region with largest merging likelihood.

3.1.3. Similarity of important regions

After the merging process is complete, all the surviving regions are important. However, important regions may still be similar to their adjacent regions and should be further merged. The further checking criterion is to measure the color similarity with an adaptive threshold $T_s$. We define the adaptive threshold $T_s$ as in Eq. (10).

If the color distance between two connected important regions is less than $T_s$, they are similar and should be merged. Otherwise, they should be separate.
properties for each initial region and sort the regions by importance index with ascendant order.

9. Merge all less important regions in order based on the rules of “Merging likelihood”; the surviving regions are shown in Fig. 6(d).

10. Compute color distances between each of the surviving regions and compute the adaptive threshold $T_S$.

11. Merge the connected regions whose color distance is less than $T_S$, and the result is shown in Fig. 6(e, f).

The Corel Image Database is widely used in the simulation of image retrieval. Therefore, we chose one hundred images from the database as our test set.

4. Experiments

We have implemented the proposed algorithm on a Pentium 4 PC, 2.66 GHz CPU with 512 MB RAM using graphical user interface under windows XP. The algorithm is very computational efficient. For CIF format images, the average speed is around 0.4 second per image.

Due to the limitation of paper length, we present some test images and segmentation results to demonstrate the performance of our work, as shown in Fig. 7.
We have presented a new salient region segmentation approach for color images based on dominant color extraction and region merging.

5. Conclusion

Nonparametric density estimation was first employed to extract dominant colors and a fast color mapping algorithm was developed to quantize images in an efficient way. Computation rules of “Importance index” and “Merging likelihood” of regions were then developed to merge the initial regions generated in the quantization step. Finally, an adaptive threshold is used to further merge those important regions. The proposed approach efficiently extracts salient regions in color images. Experiments show that the segmentation results satisfied our definition of salience, and the proposed method effectively addressed the over-segmentation problem in traditional segmentation algorithms.


Fig. 7 Experimental results of our database (a) Source images (b) Quantized images (c) Segmentation results represented in mean colors (d) Segmentation results
retrieval: current techniques, promising directions and open issues,” Journal of Visual

References


Effects of Age and Gender on Intravenous Midazolam Premedication: A Randomized Double-blind Study
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Abstract

Backgrounds: Given the potentially important effects that age and gender may have on midazolam premedication, this study aimed at determining if these factors alter anxiety, sedation, and cardiorespiratory outcomes when administering two different doses of intravenous midazolam.

Methods: After randomization, patients were premedicated 1 hour before surgery with either intravenous midazolam 0.02 or 0.06 mg kg⁻¹ depending on their age and gender group. Levels of anxiety and sedation, heart rate (HR), respiratory rate (RR), mean blood pressure (MBP), and oxygen saturation (SpO₂) were measured before and 15 min after midazolam administration.

Results: A higher level of preoperative anxiety was more often observed in women than men, and in young than older patients. The female or younger patients showed significant anxiolytic benefits from midazolam. A deeper sedation level was found in man compared to women. Forty-two of 45 patients (93.3%) with excessive sedation received midazolam 0.06 mg kg⁻¹. The elderly patients receiving midazolam 0.06 mg kg⁻¹ showed a significant reduction in MBP, RR and SpO₂. Of
the patients with a \( \text{SpO}_2 < 90\% \), 72.7% had received midazolam 0.06 mg kg\(^{-1}\).

**Conclusions:** Age and gender differences in neuropsychological and physiological responses after midazolam premedication were evident. Midazolam is effective for producing sedation and anxiolysis at a dose of 0.02 mg kg\(^{-1}\), with minimal effects on cardiorespiration and oxygen saturation to patients. Dosage adjustments based on these covariates are, therefore, necessary.

**Introduction**

Midazolam is a short-acting benzodiazepine, widely used as an anxiolytic, sedative and anaesthetic adjuvant and has numerous advantages. Pharmacological anxiolysis is the most common method used in the holding areas of surgical rooms.

According to the Canadian Compendium of Pharmaceuticals and Specialties,\(^1\) the dose of midazolam recommended for premedication is 1–1.5 mg (≈0.02 mg kg\(^{-1}\)), and a total dose of midazolam should not exceed 3.5 mg or 0.07 mg kg\(^{-1}\) in the elderly. When midazolam is administered at the recommended dose, age and gender may also have clinically relevant effects on pharmacokinetics and pharmacodynamics. Only a few studies are published investigating the influence of either age or gender on some aspects of neuropsychological and physiological parameters when applying intravenous midazolam premedication.

This study was primarily undertaken to determine if these covariates alter anxiety, sedation, and cardiorespiratory outcomes when administering two different doses of intravenous midazolam (0.02 and 0.06 mg kg\(^{-1}\)). We postulated that a lower dose of midazolam might be clinically effective, without the unwanted side effects.

**Methods**

In total, 360 patients were recruited in the double-blind, randomized clinical study. Patients were stratified by age (young: 20-39, middle-aged: 40-59, and elderly: 60-79 years) and gender, thus, six study groups were generated. The groups, then, were randomized to one of the two dose groups (0.02 and 0.06 mg kg\(^{-1}\)). Each group had 30 subjects. The main inclusion criteria included: (1) American Society of Anaesthesiologists (ASA) physical status class I or II, and (2) older than 19 years. Exclusion criteria were: (1) an ASA physical status of class III or higher, (2) being pregnant, (3) patients with psychiatric disorders, and those taking antipsychotics, (4) chronic use of benzodiazepines, (5) use of \( \beta \)-adrenergic blockers or calcium channel blockers, and (6) hypersensitivity or allergy to midazolam.

**Neuropsychological and physiological investigations**

Assessments were carried out before and after intravenous midazolam administration in the surgical holding areas of operating rooms. Anxiety was evaluated by a visual analogue scale (VAS), which is a 100-mm horizontal line with ‘no anxiety at all’ (score 0) on one end and ‘extreme anxiety’ (score 10) on the other end.

Sedation depth was determined by the Observer’s Assessment of Alertness/Sedation (OAA/S) scale. The OAA/S measures sedation on a 1
to 5 [responds readily to name spoken in normal tone] scale. The acceptable level of sedation depends on the psychological and physiological state of the patient and the performed surgical procedure. For the purposes of the present study, a acceptable OAA/S was defined as a score $\geq 3$.

Vital signs, including the heart rate (HR), respiratory rate (RR), mean blood pressure (MBP), and percutaneous arterial oxygen saturation ($\text{SpO}_2$), were continuously monitored for safety reasons.

**Intervention procedures**

After patients had been transported to a pre-operative holding area adjacent to an operating room, and the patients’ admission processes were completed, all patients were equipped with ECG electrodes and other measurements.

A blinded co-investigator recorded neuropsychological and physiological outcomes before midazolam administration as the baseline data. Midazolam (0.02 or 0.06 mg kg$^{-1}$) was diluted in normal saline to a total volume of 6 ml. The syringe containing midazolam was dispensed by an anaesthetist. All outcomes were measured again by the same co-investigator 15 minutes after the midazolam administration. Complications after the midazolam administration, including apnea (intermittent respiration pause of > 10 seconds), cardiac arrhythmia, hypotension, and subjective complaints of discomfort by the patients, were noted and recorded. A subject was judged to require supplemental oxygen at 5 L/min if the $\text{SpO}_2$ value fell below 85%. After completion of the experiment, patients were ready to be transported to the operating room.

**Results**

**Influence of age on midazolam sedation**

Almost all patients (98.9%, n = 356 out of 360) suffered from anxiety of various levels of severity when they entered the surgical holding area. Anxiety was significantly decreased with midazolam in all age groups ($P < 0.0001$). In addition, younger patients showed higher anxiety scores before and after midazolam administration (Fig. 1). Particularly, patients showed an age-dependent relationship in anxiety reduction between prior to and after midazolam administration ($P < 0.01$).

The majority of patients (87.5%) achieved satisfactory sedation after midazolam administration. The sedation scores differed significantly with age ($P < 0.0001$). Patients with an OAA/S score of $< 3$ (12.5%, n = 45) were primarily found in the group 60-79 years (n = 26). Midazolam caused deeper sedation in elderly patients compared to younger ones ($P < 0.01$).

A reduction in MBP by midazolam was observed in all age groups (Fig. 2). Meanwhile, HR showed significant negative correlations with age before and after midazolam administration ($P < 0.01$). RR increased after midazolam administration (Fig. 2). $\text{SpO}_2$ levels before and after midazolam administration and $\text{SpO}_2$ changes were negatively correlated with age ($P < 0.01$).

**Influence of gender on midazolam sedation**

Anxiety and sedation were significantly different in both gender ($P < 0.0001$), and remarkable difference appeared in the 40-59 year group
Women showed higher levels of anxiety than men before and after midazolam premedication ($P < 0.01$). A deeper sedation level was found in men compared to women ($P < 0.01$).

MBP was significantly lower in women than men before and after midazolam administration ($P < 0.0001$) (Fig. 2). Compared with men, women displayed significantly higher HR before and after midazolam administration ($P < 0.0001$). Remarkable HR difference occurred in the 20-39 and 40-59 years groups (Fig. 2). When we further examined both the HR and MBP data, a clear gender-related separation with a compensatory pattern was found between HR and MBP before the midazolam intervention (Fig. 3).

RR was significantly higher in women than in men before midazolam administration ($P < 0.05$). Women showed higher SpO$_2$ levels than men before and after midazolam administration ($P < 0.0001$), particularly in the 20-39 year group (Fig. 2).

**Influence of dose on midazolam sedation**

No significant difference was found in the anxiety level between the two doses of midazolam ($P > 0.05$). Sedation index indicated that the midazolam-induced sedative effects were more pronounced among patients receiving midazolam 0.06 mg kg$^{-1}$. Most patients (93.3%, $n = 42$ of 45 patients) with excessive sedation (OAA/S score $< 3$) had received midazolam 0.06 mg kg$^{-1}$.

MBP significantly decreased as the midazolam dose increased ($P < 0.01$) (Fig. 2). The dose of midazolam produced little effect on HR ($P = 0.66$). The dose of midazolam caused a
significant effect on RR ($P < 0.0001$). After the midazolam administration, RR increased as the midazolam dose increased ($P < 0.01$). There was a significant effect of midazolam dose on $\text{SpO}_2$ ($P = 0.05$). The negative correlation between RR and $\text{SpO}_2$ was evident in all groups, particularly for the group $0.06 \text{ mg kg}^{-1}$. When we further correlated response patterns of both RR and $\text{SpO}_2$, higher RR was frequently accompanied by a lower $\text{SpO}_2$ after midazolam administration (Fig.

Fig. 2 Comparison of the mean blood pressure (MBP), heart rate (HR), respiratory rate (RR), and percutaneous arterial oxygen saturation ($\text{SpO}_2$) among the groups before and after midazolam administration. * $P < 0.05$ vs. before; $\$ P < 0.05$ vs. $0.02 \text{ mg kg}^{-1}$ of midazolam; $+ P < 0.05$ vs. 40-59 yr; $\# P < 0.05$ vs. 60-79 yr; $\ddagger P < 0.05$ vs. woman. Data are presented as the mean ± SEM. (Adapting from Sun et al., British Journal of Anaesthesia, 101, 632-639, 2008)
adverse events before anaesthetic induction. Midazolam produced a significant decrease in the anxiety levels. This is consistent with previous studies.5,6 Furthermore, midazolam is known to reduce blood pressure, lower oxygen level, and increase sedation level.5,7 A high MBP in the elderly patients may be due to an age-related decrease in the baroreflex sensitivity,8-10 age-dependent changes in basal sympathetic nerve activity,10 and a reduction in systemic vascular responsiveness.10 The deeper sedation, and lower SpO₂ observed in the elderly patients after midazolam administration are consistent with several previous publications.5,7,11 The increased pharmacological effect of midazolam in the elderly patients may imply that aging increases the phar

**Discussion**

This study demonstrates that age and gender have clinically relevant effect on midazolam premedication and may provide valuable information about gender-related alterations in both neuropsychological and physiological parameters before and after midazolam administration. The safety of midazolam 0.02 mg kg⁻¹ was found to be acceptable as only rarely did patients receiving midazolam 0.02 mg kg⁻¹ develop clinically important adverse events before anaesthetic induction.

No patient showed a drop in the SpO₂ to < 85% 15 minutes after midazolam administration. There was a higher incidence of apnea 5 minutes after premedication in group 0.06 mg kg⁻¹ (n = 6) and in group 0.02 mg kg⁻¹ (n = 2).

Fig. 3 Scatterplots of changes in the correlation between the HR and MBP by midazolam according to age and gender factors. The upper panel shows HR-MBP distribution of midazolam 0.02 mg kg⁻¹ and the lower panel of midazolam 0.06 mg kg⁻¹. Men are represented by circles and women by triangles. Filled symbols represent the situation before midazolam intervention and open symbols after midazolam. Data are presented as the mean ± SEM. (Adapting from Sun et al., British Journal of Anaesthesia, 101, 632-639, 2008)
significant effect on RR ($P < 0.0001$). After the midazolam administration, RR increased as the midazolam dose increased ($P < 0.01$). There was a significant effect of midazolam dose on SpO$_2$ ($P = 0.05$). The negative correlation between RR and SpO$_2$ was evident in all groups, particularly for the group 0.06 mg kg$^{-1}$. When we further correlated response patterns of both RR and SpO$_2$, higher RR was frequently accompanied by a lower SpO$_2$ after midazolam administration (Fig. 4). No patient showed a drop in the SpO$_2$ to $< 85\%$ 15 minutes after midazolam administration. There was a higher incidence of apnea 5 minutes after premedication in group 0.06 mg kg$^{-1}$ ($n = 6$) and in group 0.02 mg kg$^{-1}$ ($n = 2$).

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Fig. 4 Scatterplots of changes in the correlation between the RR and SpO$_2$ by midazolam according to age and gender factors. The upper panel shows RR-SpO$_2$ distribution of midazolam 0.02 mg kg$^{-1}$ and the lower panel of midazolam 0.06 mg kg$^{-1}$. Men are represented by circles, and women by triangles. Filled symbols represent the situation before midazolam intervention and open symbols after midazolam. Data are presented as the mean ± SEM. (Adapting from Sun et al., British Journal of Anaesthesia, 101, 632-639, 2008)
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We observed that women received remarkable benefits from midazolam. This observation is in agreement with the results of a previous study.14 The gender-related differences we observed are in contradiction with some other studies7,11,15. The reason for this gender discrepancy with midazolam premedication may be due to the fact that young women may experience the endogenous actions of sexual hormones, such as estrogen and progesterone, which strongly affect mood and control of the autonomic nervous system.16-17 Female hormones can potentially influence the GABA receptors of the hippocampus and other portions of the affection-related limbic system,18 which are the same target of midazolam. Female hormones decline with age. This may explain why several gender-related significant differences occurred in young patients.

**Conclusion**

Midazolam has been shown to be effective when used for preoperative sedation. Excessive sedation is often accompanied by low oxygen saturation during midazolam administration.5,7 We also observed a similar phenomenon, particularly for patients who received midazolam 0.06 mg kg⁻¹. In addition, a high RR was accompanied by a low SpO2 with the two doses of midazolam. Possible reasons for the generation of a higher RR with midazolam administration may be associated with compensatory regulation of hypoxemia,5,7 a reduction in the tidal volume,7 and/or alteration of sensitivity to blood oxygen levels in the peripheral or central nervous systems.19

An optimal premedication dose of intravenous midazolam should provide sufficient sedation and comfortable anxiolysis as well as allow a smooth anaesthetic induction without associated adverse effects. Accordingly, the present study provides evidence about the advantage of the 0.02 mg.kg⁻¹ midazolam dose. Preoperative anxiety was significantly reduced by both 0.02 and 0.06 mg.kg⁻¹ midazolam doses, without any difference between the two dosages. Midazolam produced a sufficient sedative effect at the dose of midazolam 0.02 mg kg⁻¹, but may increase the risk of excessive sedation at a dose of 0.06 mg kg⁻¹. Additionally, a significant reduction was shown in MBP after midazolam 0.06 mg kg⁻¹ administration in all groups, but only a minor decrease appeared with midazolam 0.02 mg kg⁻¹. RR was significantly elevated by midazolam 0.06 mg kg⁻¹, but only a slight change took place with midazolam 0.02 mg kg⁻¹. Finally, decreases in SpO₂ were significantly greater after sedation with 0.06 mg kg⁻¹midazolam. Thus, midazolam 0.02 mg kg⁻¹ was relatively safe and effective, particularly for patients above 60 years.

Results from anxiety, sedation, and physi-
ological outcomes with regard to effects of age and gender indicated a potential benefit of the dose of midazolam 0.02 mg kg$^{-1}$. We encouraged that dosage adjustments based on these covariates are, therefore, necessary for midazolam premedication.

**References**


Current Oral Appliance Therapy for Obstructive Sleep Apnea in Taiwan

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1 Department of Neurology and Sleep Disorders Center, 2 Department of Dentistry, E-Da Hospital

Abstract

Obstructive sleep apnea syndrome (OSAS) is a disorder distinguished by short pauses in breathing during sleep and is often characterized by loud snoring and coughing or choking while sleeping. It is now widely recognized in many countries of the world as a highly prevalent sleep breathing disorder with potentially life-threatening consequences. Treatment for OSAS with oral appliance was officially recognized in the Practice Parameters of the American Sleep Disorders Association in 1995. In Taiwan, the adjustable mandibular advancement oral appliance therapy was initially introduced in E-Da Hospital, I-Shou University since 2005. The overall polysomnography (PSG) results of the oral appliance treatment (OAT) in 139 patients with OSAS in the Sleep Disorders Center, E-Da Hospital, between 2005 and 2008, showed significant efficacy with 66.5% reduction of the average Apnea-Hypopnea Index (AHI). We further divided the patients who received OAT according to the severity of AHI into three groups, mild, moderate and severe group, to analyze the results of OAT. In the subgroup of 30 patients with mild OSAS, the OAT efficacy was 72.3% reduction of the average AHI. In the subgroup of 41 patients with moderate OSAS, the OAT efficacy was 77.9% reduction of the average AHI. In the subgroup of 68 patients with severe OSAS, the OAT efficacy was 63.9% reduction of the average AHI. The OAT efficacy in REM sleep was 46.4% reduction of the average AHI. In
NREM sleep, the OAT showed superior efficacy with 73.6% reduction of the average AHI. We conclude that the adjustable mandibular advancement OAT is very effective in treating Taiwanese patients with OSAS.

**Introduction**

The obstructive sleep apnea syndrome (OSAS), first described over 30 years ago, is characterized by repetitive obstructive apneas and hypopnea that disrupt sleep and cause daytime sleepiness.

The etiology of OSAS is a complex interplay between neural, hormone, muscular and structural anatomical factors. OSAS occurs when the palatal, glossal and pharyngeal muscles relax enough to cause the airway to narrow and partially obstruct the flow of air despite the preserved breath efforts. It is often aggravated by increased body weight, micrognathia, macroglossia, smoking and alcohol consumption.

The consequences of OSAS are associated with premature cardiovascular disease affecting the heart and the brain as well as impaired neurocognitive and psychiatric functions, increased motor vehicle accident rate, and reduced quality of life.

The idea of advancing the mandible with a monoblock functional appliance to treat airway obstruction in infants with micrognathia was first described in 1934 by Pierre Robin. In 1995, the American Academy of Sleep Medicine (formerly the American Sleep Disorders Association) first published a position paper on the clinical use of oral appliances in the treatment of snoring and obstructive sleep apnea. Ever since then, oral appliances have been increasingly used as a treatment modality for patients with OSAS.

In Taiwan, the main stream of treatment for obstructive sleep apnea was uvulopalatopharyngoplasty, because it is reimbursed by the national health insurance system. In the recent few years, adjustable mandibular advancing oral appliances were extensively used in the Sleep disorders Center in E-Da Hospital. There are solid data showing the clinical effectiveness of oral appliance therapy in patients with mild to moderate OSAS, and to a lesser extent in patients with severe OSAS or in patients who had recurrent OSAS due to previous unsuccessful uvulopalatopharyngoplasty.

**Materials and Methods**

Patients with snoring and symptoms suggestive of obstructive sleep apnea syndrome (OSAS) received polysomnography (PSG) to identify the severity of OSAS. For patients who had mild to moderate OSAS, or severe OSAS who were not tolerant or did not want to use nasal CPAP treatment were referred to sleep dental clinic. A cephalometric and full-mouth periapical x-ray films were taken to evaluate the dental condition, and the feasibility to use OA (mandibular advancement device) was decided. Assessment forms and questionnaires were used to evaluate the compliance and tolerability of the patients. A follow-up PSG was done at two months after reaching maximal titration of mandibular advancement of the oral appliance.

Between January, 2005, and December, 2008, there were total number of 486 patients
with OSAS who received the OAT, but only 139 of them had completed the 2nd PSG. The genders of the 139 patients include 10 female patients and 129 male patients. The average age was 45.2 ± 8.6 years old. The average BMI was 27.5 ± 3.0 kg/M$^2$, and the average of the neck circumference was 39.7 ± 2.4 cm.

The average of the mandibular protrusion was between 65% and 70% of the maximal protrusion, and the average of the vertical opening of the mouth was 5 to 7mm. There was no significant change of their BMI values and cervical circumferences during the period of titration.

## Results

<table>
<thead>
<tr>
<th>Size:139</th>
<th>AHI</th>
<th>AI</th>
<th>AHI -REM</th>
<th>AHI-NREM</th>
<th>SaO2%</th>
<th>Nadir O2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>without OA</td>
<td>40.6 ± 20.1</td>
<td>33.1 ± 20</td>
<td>40.1 ± 25.2</td>
<td>43.8 ± 44.3</td>
<td>92.5 ± 1.6</td>
<td>69.7 ± 10.2</td>
</tr>
<tr>
<td>with OA</td>
<td>13.6 ± 12.1</td>
<td>9.2 ± 9.9</td>
<td>21.5 ± 16.5</td>
<td>11.5 ± 16.5</td>
<td>94.7 ± 1.6</td>
<td>78.1 ± 9.7</td>
</tr>
<tr>
<td>T test</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Median</td>
<td>AHI</td>
<td>AI</td>
<td>AHI -REM</td>
<td>AHI-NREM</td>
<td>SaO2%</td>
<td>Nadir O2%</td>
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<tr>
<td>without OA</td>
<td>36.7</td>
<td>28.2</td>
<td>39.55</td>
<td>37.95</td>
<td>92.7</td>
<td>70.4</td>
</tr>
<tr>
<td>with OA</td>
<td>6.9</td>
<td>2.8</td>
<td>13</td>
<td>4.55</td>
<td>95.3</td>
<td>81</td>
</tr>
</tbody>
</table>

Subgroup analysis:
1) Success rate: AHI < 10 and AHI reduction ≥ 50%
2) Response rate: AHI ≥ 10 and AHI reduction ≥ 50%
3) Treatment efficacy = Success rate + Response rate

Group 1. Mild OSA (AHI: 5-20/h)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>success</td>
<td>83.3 % (25/30)</td>
</tr>
<tr>
<td>response</td>
<td>0</td>
</tr>
<tr>
<td>failure</td>
<td>16.7 % (5/30)</td>
</tr>
<tr>
<td>Efficacy</td>
<td>83.3%</td>
</tr>
</tbody>
</table>
The results of our study may suggest that the adjustable mandibular advancement oral appliance such as the modified Herbst appliance or the TAP device is very effective in treating Taiwanese patients with OSAS, even in those severe cases. The careful pre-application selection and dental evaluation of the patients and stepwise titration of mandible protrusion is important to guarantee a successful treatment. The PSG monitoring and assessment forms and questionnaires before and after the application are mandatory to evaluate the effectiveness and tolerability of the OA treatment.

**Conclusion**

The results of our study may suggest that the adjustable mandibular advancement oral appliance such as the modified Herbst appliance or the TAP device is very effective in treating Taiwanese patients with OSAS, even in those severe cases. The careful pre-application selection and dental evaluation of the patients and stepwise titration of mandible protrusion is important to guarantee a successful treatment. The PSG monitoring and assessment forms and questionnaires before and after the application are mandatory to evaluate the effectiveness and tolerability of the OA treatment.

**Reference**

1. Meng-Chen Tsou, Shih-Pin Hsu. Oral Appliances treatment in patients with Obstructive Sleep Apnea Syndrome in Taiwan- A Clinical Study of 59 Patients. Sleep Medicine, 7: S96-S97. 8th World Congress on Sleep Apnea, Montreal, Quebec, Canada, Sep. 27-30, 2006
4. Meng-Chen Tsou, Shih-Pin Hsu. Oral appli-
ances treatment in patients with obstructive sleep apnea syndrome in Taiwan - A clinical study of 59 patients. Sleep Medicine, Volume 7, S96-S97, 2006


Effect of Doctors’ Emotional Intelligence on Patient Doctor Relationships

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Abstract

BACKGROUND: Current studies have found limited evidence for an association between a doctor’s emotional intelligence and the patient-doctor relationship. The study explored the associations among a doctor’s emotional intelligence, patient trust, and the patient-doctor relationship by using multi-source and multi-level approaches.

METHODS: Nine hundred and sixty-five outpatients and 37 doctors representing 11 specialties were surveyed.

RESULTS: The doctor’s self-rated emotional intelligence was not significantly correlated with any variables rated by the patients. The nurse-rated patient-doctor relationship and the emotional intelligence score for the doctor were positively associated with patient trust at a significant level.
CONCLUSIONS: Multi-sources for assessment of doctor emotional intelligence may be more objective and predictive than doctor self-ratings in ascertaining the associations among patient trust, patient-doctor relationships, and patient satisfaction. Emotional intelligence coaching for doctors and interdisciplinary collaboration among clinicians are needed to optimize the efficient and therapeutic function of the patient-doctor relationship for patients.

Key Words: emotional intelligence, trust, patient-doctor relationship, patient satisfaction

Introduction

Emotional intelligence (EI) is recognized as an important personal attribute involved in nurturing the patient-doctor relationship (PDR) and is thus increasingly being included in the medical education curriculum. At a time of heightened competition for patient loyalty, those doctors who are more aware of their patients’ emotions are more successful in treating them than their less perceptive colleagues. Accordingly, the doctor is assumed to be a key figure in facilitating and managing the PDR by influencing the way patients perceive and feel about their treatment and illness. As a result, interpersonal communication skills have been designated as one of the six areas of professional competence for doctors by the Accreditation Council for Graduate Medical Education. EI is included as one of the assessment items under affective and moral domains. Accordingly, medical professionals have begun to recognize that some doctors are trained to be clinically competent, but have inadequate social skills for practice. Indeed, assessment of EI is now used as part of the selection process for some medical school applicants in an effort to consider an applicant’s competence in interpersonal skills. However, recent studies offer limited evidence regarding the association among a doctor’s EI, PDR, and patient satisfaction. Studies regarding the factors which influence the PDR have focused mainly on a doctor’s demographic characteristics, whether or not a patient sees the same doctor on a regular basis, and the doctor’s interview style, etc. The literature focusing on a doctor’s characteristics, specifically in EI, is scanty.

The current study explored the association between a doctor’s EI, patient trust, and the PDR through the use of a multi-level and multi-source data approach. Compared with previous EI studies, the current study is unique. First, our study used multiple sources, rather than just using the self-ratings of doctors. Second, our study used doctors as research targets, rather than using medical students as research targets. Third, our sample included 37 doctors representing 11 different specialties, rather than focusing on doctors who were board-certified in one specialty. Finally, we used doctors, rather than the patients, as the unit of analysis, which allowed us to observe the contextual effects of the same doctors in encounters with patients in a similar way. Most studies have ignored the methodological issues by using individual patients as the unit of analysis. In this way, the variations of the associations of the doctor’s characteristics and the PDR may be explained by...
those doctors who had larger patient samples. In other words, the individual differences among doctors may not have been detected.

**Literature Review**

**EI: Nature and Debates**

Though EI is a new construct in the past decade, it has gained considerable attention from sociological, psychological and neurological professions. EI has been historically rooted within the rubric of social intelligence which refers to the ability to understand and manage people. There have been serious academic debates on whether or not EI is a construct that is distinct from personality traits or a mixed model which combines both. Salovey and Mayer originally used the term “emotional intelligence” in 1990, by defining EI as the ability to monitor his/her own and other’s feelings and emotions in order to guide one’s thinking and actions. In 1997, the definition of emotional intelligence was further refined as “the ability to perceive emotion, integrate emotion to facilitate thought, understand emotions, and to regulate emotions to promote personal growth.” Davis et al. argued that EI seemed to be an elusive and fluid construct. They offered a four-dimensional definition to further clarify the EI construct: 1) appraisal and expression of emotion in oneself, 2) appraisal and recognition of emotion in others, 3) regulation of emotion in oneself, and 4) use of emotion to facilitate performance.

**EI, PDR, Trust and Patient Satisfaction**

Much of the literature pertinent to management supports the notion that service providers with high EI receive higher customer satisfaction scores. Among the variety of social relationships valued by people, the PDR is more important than it has been given credit for. Magee indicated that second only to family relationships, the PDR is considered to be extremely or very important by 67% of those surveyed, surpassing the relationship with spiritual advisors (52%), pharmacists (45%), and co-workers (44%). However, there was little literature in the medical field that explores the association between the doctor’s EI and PDR, although there is considerable interest in exploring the predictors of the PDR. Wagner et al. published the first study that focused on a doctor’s EI and the PDR. They found only one sub-scale of EI was related to higher patient education. Stratton et al found that the EI of medical students were positively correlated with communication skills. Given the limited evidence for an association between a doctor’s EI and the PDR, these findings should be considered preliminary.

**Hypotheses**

In line with the aforementioned reasoning, our hypotheses comprised a model which includes antecedents and consequences of a doctor’s EI and the PDR. First, we hypothesized that the patient’s age, education, and the ratio of follow-up would be significantly correlated with his/her trust toward doctors and perception of PDR. Second, the doctor’s EI would be significantly correlated with the patient’s trust, PDR, and doctor satisfaction.
Methods

Research Sample and Data Collection

The study was reviewed and approved by the Institution Review Board of E-Dah Hospital, KaoShiung, Taiwan. Consent was obtained from the 37 participating doctors and 965 patients respectively. To avoid the common method bias produced by a single source or rater in behavioral research, this study collected data from three sources: the patients, the doctors themselves and three nursing directors (Table 1). At the patient level, in which the patient was nested under each doctor, data was obtained from patient’s questionnaires by face-to-face interviews conducted by nurse practitioners in the outpatient department. The patient response rate was 98.5%. At the doctor level, data was assessed from a self-rated source from the doctor himself/herself and external source from three nursing directors.

Measures, Instruments and Statistical Analysis

As shown in Table 1, the patient survey included an 11-item trust scale19 with items such as “Your doctor is extremely thorough and careful.” Patient doctor relationship was measured using a 9-item PDR from PDR920 with items such as “I can talk to my doctor.” Doctor satisfaction was measured using 2-item questions with “I am satisfied with the care provided by my doctor”, as an example. Hospital satisfaction was measured using 2-item questions, such as “I would recommend this hospital to my friends and family.” The satisfaction items were derived from the Patient Satisfaction Questionnaire.21 At the group level, the doctor survey included a 16-item EI from the WLEIS scale.13 The scale consists of 16 items relating to self-emotional appraisal, other-emotional appraisal, use of emotion, and regulation of emotion. Sample items are “I really understand what I feel” and “I have a good control of my own emotions.” The EI items are scored on five-point scales (1=strongly disagree, 3=neutral, 5=strongly agree). The EI scale and PDR for doctors were rated by the doctors themselves, and by three nurse directors, respectively. The patient’s trust towards the individual doctor was rated by three nursing directors as well. The ratings by the three female nursing directors were combined into a single measure derived from a consensus following a brief discussion about the 39 doctors. The survey also included questions on doctor demographics. The ratio of patients complying with follow-up visits for each doctor was obtained from the claim data. Cronbach’s alpha for the patient’s variables ranged from 0.78~0.95. Cronbach’s alphas for the doctor’s self-rated variables ranged from 0.82~0.94. The descriptive analyses were performed using the Statistical Package for Social Sciences (SPSS, version 12). The unit for Pearson correlation analysis was the individual doctor. The patient’s data were aggregated to an individual doctor by averaging the scores given each variable.

Results

Patient demographics are shown in Table 2. The gender of the patients was nearly equally divided. The mean age of the subjects was 47.52 ± 23.25 years. The majority of the patients had follow-up visits (89.4 %) to a same doctor. Most subjects (73.1 %) were married and the educational level was at the elementary school level or
<table>
<thead>
<tr>
<th>Variable</th>
<th>Respondent</th>
<th>Questionnaire Source</th>
<th>Item number</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient Level:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td>Patient</td>
<td>Hall, Fabian, Elizabeth et al. (2002)</td>
<td>11</td>
<td>.78</td>
</tr>
<tr>
<td>PDR</td>
<td>Patient</td>
<td>Van der Feltz-Cornelis, Van Oppen, Van Marwijk et al. (PDR9) (2004)</td>
<td>9</td>
<td>.92</td>
</tr>
<tr>
<td>Physician satisfaction</td>
<td>Patient</td>
<td>Self-designed</td>
<td>2</td>
<td>.95</td>
</tr>
<tr>
<td>Hospital satisfaction</td>
<td>Patient</td>
<td>Self-designed</td>
<td>2</td>
<td>.86</td>
</tr>
<tr>
<td><strong>Physician Level:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEA</td>
<td>(1) Physician</td>
<td>(2) 3 nurse directors</td>
<td>4</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td>(2) 3 nurse directors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OEA</td>
<td>(1) Physician</td>
<td>(2) 3 nurse directors</td>
<td>4</td>
<td>.94</td>
</tr>
<tr>
<td></td>
<td>(2) 3 nurse directors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UOE</td>
<td>(1) Physician</td>
<td>(2) 3 nurse directors</td>
<td>4</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td>(2) 3 nurse directors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROE</td>
<td>(1) Physician</td>
<td>(2) 3 nurse directors</td>
<td>4</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>(2) 3 nurse directors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPR</td>
<td>(1) Physician</td>
<td>Van der Feltz-Cornelis, Van Oppen, Van Marwijk et al. (PDR9) (2004)</td>
<td>9</td>
<td>.77</td>
</tr>
<tr>
<td></td>
<td>(2) 3 nurse directors</td>
<td></td>
<td>9</td>
<td>--</td>
</tr>
<tr>
<td>Trust</td>
<td>3 nurse directors</td>
<td>Hall, Fabian, Elizabeth et al. (2002)</td>
<td>11</td>
<td>--</td>
</tr>
<tr>
<td>Demographic variables</td>
<td>Physician</td>
<td>Age, gender, years of experience, education, and specialty</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>Patient follow-up ratio</td>
<td>Claim data</td>
<td></td>
<td>1</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: PDR = patient doctor relationship; SEA = self-emotion appraisal; OEA = other emotion appraisal; UOE = use of emotion; ROE = regulation of emotion
less (53.3%). The majority of subjects were recruited from the gastroenterology clinic (23.1%), with the fewest number of subjects recruited from the neurology clinic (2.1%). Doctor demographics are shown in Table 3. The doctors were predominantly male (89.2%), with a mean age of 42 ± 7.32 years, a bachelor degree of medicine from medical school (78.4%), and board certification in internal medicine (67.6%). The average number of years since the doctor received the medicine degree was 15.97. The number of doctors in each specialty ranged from 1 to 9. The most common specialty for doctors was gastroenterology (n=8). All doctors representing pediatrics, nephrology, and neurosurgery participated in the study. Only one doctor from dermatology, hematology and oncology, and neurology, participated in the study. The number of patients studied for each doctor ranged from 9 to 64, with a mean of 24.28.

Table 4 depicts the relationships among the ratings of multiple sources for the doctor’s EI and patient trust, the PDR, and patient satisfaction toward the hospital and doctors. The relationships were examined using Pearson correlation coefficients with two-tailed tests of significance. The results indicated, from the patient’s perspective, patient trust, the PDR, and patient satisfaction toward the hospital and the doctors were positively correlated. Patients who were older, less educated, and more compliant with follow-up visits
EI were not significantly correlated with any variables rated by the patients. Three dimensions of a doctor’s EI (i.e., other emotions appraisal, use of emotions, and regulation of emotions) rated by the nursing directors were positively correlated with patient trust at a significant level.

Table 3 Demographics of Physicians (n=37)

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>33</td>
<td>89.2</td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>10.8</td>
</tr>
<tr>
<td>Mean age (years): 42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD: 7.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min: 33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max: 58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baccalaureate</td>
<td>29</td>
<td>78.4</td>
</tr>
<tr>
<td>Master’s</td>
<td>5</td>
<td>13.5</td>
</tr>
<tr>
<td>PhD</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Internal Medicine</td>
<td>25</td>
<td>67.6</td>
</tr>
<tr>
<td>Surgery</td>
<td>12</td>
<td>32.4</td>
</tr>
<tr>
<td>Average number of patients in the OPD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean: 24.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD: 12.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min: 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max: 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Specialty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dermatology</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>Family Medicine</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>8</td>
<td>21.6</td>
</tr>
<tr>
<td>Hematology and Oncology</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>Nephrology</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Metabolism and Endocrinology</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td>Neurology</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>5</td>
<td>13.5</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>4</td>
<td>10.8</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>7</td>
<td>18.9</td>
</tr>
</tbody>
</table>

gave higher ratings on patient trust, the PDR, and patient satisfaction with the hospital and the doctor. From the nurse’s perspective, the individual doctor’s PDR was positively associated with patient-rated trust toward a certain doctor (r=.138; p<.05). Four dimensions of the doctor’s self-rated
The significant association among a doctor’s EI, patient trust, the PDR, and patient satisfaction found in our study, but not in other studies,\(^6\) may have resulted from using the external rating sources for the doctor. Our findings showed
that there was no significant association between a doctor’s self-reported EI and the patient-rated trust, as well as the PDR. However, the patient’s rating of trust was significantly correlated with the ratings of the nursing directors. Our findings affirmed the findings of previous studies. A systematic review indicates that a doctor’s self-assessment has poor or limited accuracy; these findings are independent of the level of training, the specialty, the domain of self-assessment, or the manner of comparison. Epstein and Hundert have indicated that a doctor’s self-assessment may be biased or influenced by their psychological sense of self-efficacy and self-confidence, rather than more appropriate criteria, even among bright and motivated individuals. In line with the reasoning from the literature, the lack of accuracy and validity for a doctor’s self-reported EI may be the major reason that there is limited evidence of an association among a doctor’s EI, the PDR, and patient satisfaction in previous studies, and not just the result of a small sample or the validity of the EI assessment.

A nurse’s sensitivity regarding patient thoughts and mindset also merits serious consideration. Our study indicates that the PDR rated by the doctor, had no significant association with the patient’s rating. However, given a nurse’s observational and intellectual skills, nurses may be more reliable in including sensitivity within the context of healthcare, the patient’s clinical physiological and psychological status, and family needs and concerns. In other words, the nurses’ work brought them closer to the patients and their families. On the contrary, doctors were more result-oriented. Doctors may ignore the subjective feelings of the patients since they were primarily occupied in treating the patient’s disease. In general, nurses spent more time in getting along with the patients or their families. In addition, the PDR was an interaction pattern involving at least two individuals, the patient (or the family members) and the doctor. It would not have been appropriate to adopt only either the patient’s or the doctor’s perception of the PDR.

**Emotional Intelligence: Abilities Rather than Personality Traits**

Our findings have shown that the ratings of a doctor’s emotional intelligence by three nursing directors were positively correlated with doctor age ( \( r = .482, p<.01 \)) and experience ( \( r = .403, p<.05 \)), findings which were consistent with previous studies. They found that emotional intelligence increases with age and experience. Wong and Law argued that emotional intelligence is positively associated with age among incumbents of six different types of jobs. Again, our findings affirm that emotional intelligence is developmental in nature. We are more inclined to view emotional intelligence as a mental ability, rather than personality traits, since mental ability allows for a greater likelihood to change than personality traits do.

**Limitations of the Study**

Our findings should be viewed as tentative and interpreted with caution, as there are several limitations to the study. First, selection bias may have occurred since the doctors who agreed to participate may have been nicer and friendlier
in handling the PDR while being studied and scrutinized. Though our study covered 11 specialties, a small sample from each specialty made the differences within and across specialties difficult to discriminate statistically. Patients who agreed to participate may have been in favor of the doctors or hospitals. Also, the patients who valued the PDR may have been more likely to respond. However, the high response rate of patients (98.5%) reinforced the robustness of our results. Patients who experienced malpractice by certain doctors may have been excluded from the sample. Second, the findings of the present study lack external generalization to other settings and other samples. The context effect of inpatient and emergency departments on patient trust and the PDR would differ from those in the outpatient department. Third, the Hawthorn effect may occur since the doctors who agreed to participate might have pretended to be nicer to patients than they usually did during the time the study was being executed.27

Conclusions

Our findings highlight the importance of the doctor’s EI in patient trust, the PDR, and patient satisfaction. First, we believe that comprehensive “know-how” for handling the PDR cannot be fully learned in school, nor can it be purchased in the market place. As Sade et al.28 indicates, the ability of emotion management is hard to teach in the medical school; therefore, EI may be considered as one of the salient criteria for selection of future doctors. We suggest that the selection of medical students should be based on both academic achievement and EI ability. Second, the multi-source ratings or feedback from the stakeholders are feasible means of assessing the competence of doctors. Future studies should consider multiple sources of subjective measurement, such as 360° degree feedback. The measurement of the doctor’s EI, which distinguishes it from personality traits, needs to be refined in order to achieve sound validity and reliability in methodology.

References


24. Denney NW, Palmer AM. Adult age differences on traditional and practical problem-


Complexity and Agent-based Modelling for Social Science Research

Jie-Shin Lin

Department of Public Policy and Management I-Shou University

Abstract

In social science research, a field of study that is increasingly attracting research interest is the study of using computers as the basis of a research method, and in particular, agent-based computational modeling. Agent-based computational modeling is highly associated with complexity theory research of the Santa Fe Institute. The focus of complexity theory is to investigate the relationships between different components or parts of a system and how they interact as well as resulting consequences, whereas agent-based computational modeling uses analyzed results from computer simulations to understand the nature of complex systems. Agent-based computational modeling is a multidisciplinary research field that combines areas of studies such as biology, computer science, cognitive science and psychology, and applies them to social sciences such as economics, politics, public policy and sociology. Its goal is to provide a basic analysis based on the characteristics of the agent and its environment, system or organization. Here, the two important viewpoints are the concepts of “interaction” and “bounded rationality” and an important observation is the emerging property. Agent-based models focus on a collection of heterogeneous agents, and therefore the decentralized nature of heterogeneous agent interaction and the collective behavior generated to assess their effects on the system as a whole. In contrast to the conventional representative agent concept which emphasizes complete information, perfect foresight and super rationality through powerful computation ability, agent-based modeling research utilizes a collection of heterogeneous, limited and adaptive agents. Inherent in agent-based
modeling is the behavior of searching for opportunities and information present anywhere. This behavior reflects the agent’s limited knowledge, information and its processing power to handle uncertain situations. In this paper, we explain the complexity theory and agent-based modeling and provide an illustration. Therefore, we encourage that in social science research, this type of research not only makes up for the limitations for existing research, but also reinforces and revises the theory as well as making a step in the direction of innovating a new theory.

**Keywords:** Complexity, Agent-based Models, Emergence, Interaction

**1. Introduction**

In social science research, a field of study that is increasingly attracting research interest is the study of using computers as the basis of a research method, and in particular, agent-based computational modeling (ABM). ABM is highly associated with complexity theory research of the Santa Fe Institute. The focus of complexity theory is to investigate the relationships between different parts of a system and how they interact, whereas agent-based computational modeling uses analyzed results from computer simulations to understand the nature of complex systems. ABM is an integrated idea from some underlying disciplines, such as biology, computer science, economics and cognitive science, which has been created by comparing them in terms of their power and adequacy for solving various problems in reality. ABM aims to provide an analysis of socio-economy that credible builds on verifiable assumptions about the nature of human agents and institutions, communities or society in which they work. These studies question the idea of (1) the absence of interaction and (2) ‘super-rational’ agents. A credible alternative to these questions is a range of models based on the concept of the socio-economy as a number of boundedly rational, adaptive agents interacting through a number of bounded institutions, communities or society. An important benefit from these models is to allow researchers to investigate implications of individual-level learning and decision making on aggregate outcomes, and add to the insights that have resulted from the concepts of cumulative, self-reinforcing aspect of institutions and routines, positive feedback and lock-in, complex adaptive system, and artificial life. Individuals in these models are represented as adaptive artificial agents where the agent’s behaviour evolves.

In next section, we take a review on complexity perspective and agent-based models. But, for many social scholars, complexity concepts and technologies like agent-based modeling are not familiar and intuitive. Therefore, we provide a computational model of political election as an illustration. Finally, we offer some concluding remarks and points forward.

**2. Complexity Theory and Agent-based Modelling**

In recent years, social scientists have been

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1 The Symposium of Public Administration Quarterly 2005 marks the first time in its edition that complexity study has been featured as a theme. This will help to direct additional resources and attention toward advancing complexity studies and agent-based computational modelling.
an increasing interest in complexity study. A variety of different concepts or meanings of something like complexity are captured to all our intuitive ideas about what is meant by complexity. In fact, researchers using complexity language in their theorizing are not all of the same ilk and they are on different ontological levels, but are united by some broad and interrelated themes. Some active themes are described in earlier family resemblance of complexity research, in particular, applications of nonlinear dynamics. While chaos has been replaced from its place in mid-1980s, the perspectives of positive feedback or increasing returns, path dependence and lock-in have come to the core. Increasing returns are best seen as dynamic processes with random events and positive feedbacks. In contrast to diminishing-returns, the positive feedback or increasing-returns makes for many possible novelties. But, once random events select a particular path, the choice may become locked-in regardless of the advantages of the alternatives (Arthur, 2000). Over time, increasing returns magnifies the cumulative effect of such events to select the outcome randomly. There are emerging properties resulting from the cumulative self-reinforcing process or path-dependent.

In scientific discourse, complexity is also seen as a system with multiple elements or entities adapting or responding to the pattern they create. In many systems, a very large collection of relatively simple entities or agents, operating with no central control and/or limited communication among themselves, collectively produce highly complex, coordinated, and adaptive behaviour. The entities might be cells in a cellular automaton or an immune system. They behave and therefore react to neighborhoods (neighboring cells), states and the patterns they respond to vary from one context to another. In particular, the entities adapt to the world they co-create (Arthur, 1994). Such systems also naturally can be found in the socio-economic sphere. The view of a decentralised, evolving system is by no means new and goes back at least to Adam Smith’s “invisible hand” metaphor in economics, and Darwin’s “evolution by natural selection” in biology. They share the same view of how a mindless, purposeless, mechanical process can produce order and seemingly purposeful design or consciousness, the “as if” statement. The fuel of the process of development is the “division of labour” for Smith and “variety” for Darwin. For Smith, the incentive to the process of development is the “pursuance of self-interest” underlying the specialisation in the division of labour and, for Darwin, it is the “struggle for existence” underlying the characteristic of variety. The modern general study of systems innovation (Arthur, 1994) suggests that an organisation cum technological complex, a set of instructions for translating input into output for a purpose. This complex is constituted by a set of routines to guide behaviour, routines which collectively constitute the knowledge base of the particular activity.

2 Metcalfe (1998) suggests that an organisation cum technological complex, a set of instructions for translating input into output for a purpose. This complex is constituted by a set of routines to guide behaviour, routines which collectively constitute the knowledge base of the particular activity.
of how such emergent adaptive behaviour or emergent properties come about has been called the study of ‘complex adaptive systems’ (CAS). Three main themes to be noted are (i) the absence of heterogeneity (ii) and therefore interaction, as well as (ii) rationality problem (Lin, 2002).

Traditional perspectives fail to describe the interaction processes and resulting emergent properties, in which the state and its novelties changes over time. In addition, they cannot represent the distinction between agent- and system-levels, in particular, the problem of heterogeneity. This induces the existence of interaction relationships between these heterogeneous agents and brings the significance of innovative learning processes that are distributed between agents or institutions. The distributedness of learning i.e. a distributed innovative learning process varies in degree, and takes a variety of dynamic forms. A possible source of creativity in knowledge is through the amalgamation of different underlying learning, so that already existing but previously separate ideas may fertilize each other and therefore produce a sum greater than their constituent parts. Several developments based on learning concept have a family resemblance in that they take some inspiration from biological evolution. In addition, the heterogeneity also represents source of competition between agents. While we view competition as a dynamic process, it explains a set of concepts which are variety, selection and development (Metcalfe, 1998). Therefore, agents learn (induced by the heterogeneity i.e. variety among agents) and adapt (selection among variety) in order to survive in the environment (toward to a new development).

Learning is an adaptive behavior, or equivalence of class in terms of evolution, which means agents have bounded rationality. The term “bounded rationality” is used to “designate rational choice that takes into account the cognitive limitations of decision-makers” this includes limitations of both knowledge and computational capacity (Simon, 1996). By reference to this, modelling heterogeneous bounded rational agents involves tackling the decentralised decision-making process. Beyond a certain level of complication, whatever that is, the human logical apparatus ceases to cope. In other words, human rationality is bounded and bounded in its abilities to be aware of ubiquitous opportunities, to compute known variables or estimate unknown variables, and to take cognisance of perceived opportunities. So we are forced to make decisions according to subjective beliefs and subjective beliefs about subjective beliefs rather than objective, well-defined, and shared assumptions. Humans reason by inductive approaches.5

‘Modern psychology tells us that as human

5 Induction “sometimes as a logically demonstrative form of causal proof and sometimes as a non-demonstrative method of confirming a corroborating causal generalizations” (Blaug, 1993). By deduction, so often we resort to some special cases that tractable to prove general results. Induction may determine a value without guarantee and deduction cannot serve as an instrument for a creative process. Blaug (1993) suggests “adduction” instead of induction and concludes that science is based on adduction followed by deduction.
we are only moderately good at deductive logic, and we make only moderate use of it. But we are superb at seeing or recognizing or matching patterns-behaviours that confer obvious evolutionary benefits. In problems of complication then, we look for patterns; and we simplify the problem by using these to construct temporary internal models or hypotheses or schemata to work with. We carry out localized deductions based on our current hypotheses and act on them. And, as feedback from the environment comes in, we may strengthen or weaken our beliefs in our current hypotheses, discarding some when they cease to perform, and replacing them as needed with new ones. In other words, where we cannot fully reason or lack full definition of the problem, we use simple models to fill the gaps in our understanding. Such behaviour is inductive' (Arthur, 1994, pp. 2).

The process of inductive reasoning implies searching behaviour (commitment-seeking) in order to perceive opportunities and the perception of opportunities varies from agent to agent. The agent recognises information and hence ‘perceived opportunities’ resulted. In particular, the agent also develops cognitive skills through recognition. Both the recognition of information and the development of cognitive skills are the result of behaviour. The process of searching represents the process of selection between rival patterns of objectives, being described in terms of frequency measures of their relative advantages. The purpose is to make adaptation to the environment where they live in. In terms of Darwin’s evolutionary concept, it is survival or struggle for existence. Particularly, the fitness of individual agents is not a measure of intrinsic values relevant to the problem domain only, but in the terms of Metcalfe (1998, pp.30), a measure of the ‘differential tendency of competing’ candidates to ‘expand as a joint result of environment effects and behaviour traits’. As a result, a change in the agents’ behaviours will change the system landscape and then redistribute the fitness across individual agents. In other words, an individual’s fitness has a selective advantage over its rivals in one environment may not have that advantage in a different environment. It is state-dependent i.e. the interaction of the agents consequently changes the environment, and this effect feeds back to the fitness of individuals.

Holland & Miller (1992) defined a complex adaptive system (CAS) as follows: (1) it consists of the networking of interacting agents; (2) it is dynamic and there is an emerging property; (3) the emerging property can be described without detailed knowledge of the behaviour of individual

6 Pattern or structures can be considered as schemata. A schema [plural: schemata] is a similarity template, or equivalence class in terms of institution (Hodgson, 1993), which can be used to identify the key elements that are passed on to succeeding generations through reproduction. The concept of schemata just resembles Dawkin’s memes and Lamarckian’s acquired characteristics, where selection actually operates over schemata, memes or routines. Arthur (1994) suggested that inductive reasoning makes excellent sense as an intellectual process.

7 In a network economy where agents link with each other, an agent gets information through communication i.e. contacts. Over time, agents not only perceive opportunities or information but also develop their own communication strategies to recognise information. See Lin (2005) for details.
agents. Also, an agent in the CAS is adaptive if (1) the action of the agent in the system environment can be assigned a value in terms of performance, utility, payoff, fitness, or the like, and (2) the agent’s behaviour evolves. In short, a complex adaptive system contains adaptive agents, networked so that the environment of each adaptive agent includes other agents in the system. Yet, complexity does not mean the structural complication even if it is really complicated. Indeed, it is that interactions among agents and between agents and the environment and their resulting consequences can be complex. Such the framework involves a complex hierarchical network of active objects. In the sense, the complex adaptive system evolves through a hierarchical dynamic i.e. stable intermediary forms are used to construct stable higher level structures, which in turn are used to construct even higher level structures, and so on. It is that a higher level emerges from its constituent parts and their interactions at the lower level. Hierarchies can sustain themselves. These hierarchies are overlapping so that their vertical structures are interlaced with those of other hierarchies in multiple horizontal networks. Figure 1 below is an example of this hierarchical structure.

Complex systems frequently take the form of a nearly decomposable, hierarchical structure, exhibiting the nature of emergence. Given the decentralised, evolving complex system with an implicit hierarchical structure, the best way to learn about complex systems is to try to construct the systems, one of the tenets of artificial life, or at least, models and simulations of the systems (Resnick, 1998). Such ideas hold for socio-economic systems which consist of humans or economic agents. In fact, it will be very difficult to think of such systems without the existence of a reasonable algorithm to use. While Darwin had
presented the principle of natural selection “as deducible by a formal argument- if the conditions are met, a certain outcome is assured”, implicitly, he had in mind the idea of “evolution as an algorithmic process” (Dennett, 1995). Algorithms are for sorting, winnowing, and building things, making use of chance or randomness.

“Evolutionary algorithms ....- not because what they are guaranteed to do is interesting to us, but because what they are guaranteed to tend to do is interesting to us.... The power of an algorithm to yield something of interest or value is not at all limited to what the algorithm can be mathematically proven to yield......These are typically investigations into what an evolutionary algorithm might produce, or could produce, or is likely to produce, and only indirectly into what such an algorithm would inevitably produce” (Dennett, 1995, pp.57).

Simon (1996) considered simulation first, as a technique for achieving understanding and predicting the behaviour of systems, second, as a source of new knowledge, and third, as a supplement to poorly understood systems. Once we have a complex adaptive perspective, this would seem to relate to the fact that there are a variety of disciplinary approaches involved, such as biology, computer, cognitive science, economics, politics and a variety of problems are being addressed. While complexity is resulted from these consequences that are recurrent casual chains connecting individual agents, institutions, interactive networks, so as to the whole system, this intricate multi-way feedbacks between individual-level and macro-scope makes very difficult to manage. Aided with computers and new theories, in recent years, an increasing area in social sciences is the computer-based study, in particular, agent-based computational modeling (ACM).

ACM aims to provide an analysis of socio-economies that builds on verifiable assumptions about the nature of human agents and the institutions in which they work. An important benefit is to allow researchers to investigate implications of individual-level learning and decision making on aggregate outcomes, and add to the insights that have resulted from the concepts of cumulative, self-reinforcing aspect of institutions and routines, positive feedback, or increasing-returns and lock-in, and complex adaptive behaviour. Typically an agent-based computational model recognizes the bounded rationality of human agents and their institutions. A credible alternative to super-rational players is a range of models based on the concept of the economy as a number of boundedly rational, adaptive agents interacting through a number of bounded institutions, namely local networks of agents (Lin, 2005).8 A particular interesting feature of local networks is their ability to adapt to change and their robustness to shocks when compared to centralized and well-defined devices. This network economy has the overlapping hierarchies structure as mentioned above i.e. a multiple horizontal networks structure, that is a decentralized system consisting of large numbers of adaptive agents involved in local interactions. These local interactions give rise to macroscopic regularities, for example

8 Kirman (1993; 1997) is a good survey of economies as evolving networks.
behavioral norms and institutions which in turn feedback into the interaction relationships. Thus, these may come up with Schumpeterian “creative destruction” and emerging property.

In addition, it has argued that the object oriented concept has its significance on agent-based modeling, and has made it a straightforward and powerful tool. The object orientation approach allows for an overview of the complex adaptive system by looking at the object structure and their relationships that are interfaces implemented and variables passed from an object to the other. In addition, it is possible to go inside the objects to observe their internal functioning. This greatly facilitates researchers to gain a coherent understanding of the main aspects of the system. In addition, researchers can easily edit and extend the objects as needed. More importantly, the object oriented concept fits our intuition and is a natural way to describe the entities or agents and thus identify the emergent properties (Lin & Hsiao, 2007).

Much of the study on agent-based computational modeling is associated with the study of complexity, in particular, the Santa Fe Institute. A useful overview of this work is presented in Arthur et al (1997). In turn a good deal of this research has been based on computer simulations of such models and a major influence in computational works have been John Holland’s work on genetic algorithms (GAs) and classifier system. See Holland (1992), Goldberg (1989) and Mitchell (1998). My own work has, in part, looked critically at complex social, economic and political systems. Below, we will illustrate a computational model of political election with the focus on learning of voters and parties. It incorporates the innovative concepts on modeling an election model. First, the political model is a spatial framework. Second, a party is adaptive, in a sense that it is allowed to modify its political platform adaptively i.e. boundedly rational, adaptive party. Finally, we incorporate the formation and change of individual preferences through a network economy with mass media broadcasting.

3. A Computational Model of Political Election

3.1 The underlying Model

Image each party is represented some candidates, each with a political platform. In the current example, we view a population of strings as a representation of candidate. Each candidate will be a potential platform to represent the party in an election to compete with the other party. These candidates represent a number of voters’ preferences, more or less the configuration of the voters’ preferences. Each party attempts to find a candidate or platform in the issue space that defeats the winning party. In other words, the party is in a position to learn i.e. adjust platforms. In addition, there is a n-dimensional issue space and v voters. Each voter’s preferences are represented by a vector of n integers, which give the voter’s ideal positions and strengths on the n issues. The following notations are used in the model:

\[ y_i^j \]: platform position of party j on issue i

\( s_v \): voter v’s preferred position on issue i.

\( s_v \): voter v’s strength on issue i.

The utility to a voter from party j’s platform, y, is given by:

\[
\begin{align*}
    u_v(y) = -\sum_{i=1}^{n} s_i \left( y_i - x_i \right)^2.
\end{align*}
\]

In an election, individual voter evaluate his utility from each party platform. Then he casts a ballot for the party with the higher utility. In a series of elections, parties compete for votes by change their platforms. In other words, each party’s platform moves in the issue space i.e. an election landscape. For the office-seeking party, their primary goal is to win the election. Therefore, the utility function to a party can be simply defined by:

\[
F_j(y) = v(y : x) \quad (2)
\]

where \( v(y : x) \) is the number of votes a party receives if it takes platform y and voters’ preferred positions x on the n issues. Therefore, each parties attempts to get as close to voters’ preferred positions as possible and therefore to maximize votes. Parties in search of more votes try to find a better platform in terms of voters’ preferred positions. At the same time, voters are to form and change their own preferences through many interpersonal communications. This will affect many aspects of the competition between parties and therefore the final political outcome.

One task in this study is to investigate the electoral outcome. We use a version of goodness called “centrality” to evaluate the trajectory of electoral outcomes. The centrality of an outcome, \( c(y) \), is the number by which the sum of median voter utilities is divided by the sum of voter utilities (squared weighted distance), in other words:

\[
c(y) = \frac{\left[ \sum_v u_v (\text{median}) \right]}{\left[ \sum_v u_v(y) \right]} \quad (3)
\]

\( u_v (\text{median}) \) indicates voter v’s utility if the winning party were located at the median on all issues, and \( u_v(y) \) is the sum of all voters’ utilities resulting from the winning party in the election.

3.2 Agent Learning

In every political competition, public opinion becomes particularly significant, while the parties, candidates or pollsters try to spy on the shifting preferences of the electorate. Public opinion reflects common reactions to events, issues and images shared through different communication and diverse concerns arising out of economic and social environments (Harton & Bullock, 2007). In particular, opinion reflects an outcome resulting from a dynamic process of people interactions and daily routine contacts within the confines of a group, organization or a modern society as people discuss their beliefs, preferences and impressions with relatives, friends, neighbors, coworkers, and others. Opinion is subject to the constraints of time, people, space and issues. While these certain factors are concerned, individual voter opinion will receive the property of complexity, for example, polymorphism, path-dependence and feedback effect. Thus individual opinion changes or evolves over time.

Consider a group of interacting individuals, each having a more or less opinion towards an issue, e.g. positions on defense expenditure or government deficit. Individuals will take into account the opinion of others to a certain extent in
forming their own opinion. While the individuals communicate each other they may formulate their own opinion, the others’ opinions may influence their own opinion. This causes a population-wide opinion formation and change. A cognitive processes responsible for social propagation is social impact, broadly meant as the process by means of which agents’ acquisition of new information is caused or favoured by their being exposed to one another in a common environment (Bandura, 1977; Blume and Easley, 1993). When there is communication in an interactive setting, there are two underlying processes, a change in the perception of the underlying environments and a change in these environments themselves. It can generally be the case that the dynamics of communication and those of the underlying forces as such will interact with each other. As a whole, communication is a co-evolutionary process.

During election, opinion is also affected by competing parties and political elites. See for Markus and Converse (1979), Carmines and Stimson (1989), and Zaller (1992). Moreover, there is a problem raised here the attitude-behaviour relationship, for example, Zanna and Fazio (1982), Fazio (1986), Fazio, Powell and Williams (1986), Kraus (1995) and Petric et al. (2002). Opinion dynamics is based on interactive systems of heterogeneous agents and thus rejects the single representative individual. Also, in the developmental process, individual communication produces complex and structured networks of interacting agents in day-to-day life or social systems. An economy can be characterised by such a complex network of relationships. Individuals communicate with others in order to gather information and perceive as many opportunities as possible. Such a network economy may exhibit links relationship or a searching behaviour between individuals. Networks are very evident in the physical world and particularly in social structures. Human social networks comprise individuals that interact with each other through family, work, recreation, community, social and other activities etc. Common to these interactions is the establishment of relationships that rely on connection and information exchange processes. Individuals are able to identify each other in the system, the spatial and temporal relationships between them and their intrinsic properties. In addition, mass media exerts an influence on opinion dynamics. In modern society, people do receive information from mass media and under certain environment show loyalty to specific media in a systemic way (Slater, 2007). In this model, we used a version of network economy model by considering local clustering, access to mass media and long distance visiting, to represent individual agent regularly makes contacts and exposures to media that constitute agent’s important information sources. Figure 2 shows the social network communication with media environment.

4. The Result

In order to see the implication of the computational election model, we simulated two ex-


11 For the network economy model, see Lin (2005) for details.
5. Conclusion

In this paper, it has been argued that the complexity perspective on many studies has to recognize the significance of the bounded rationality and adaptive behavior or learning in a so-called complex adaptive system taking the framework of multiple horizontal networks. The crucial role of adaptation and, connected with this, the learning are the reflection of interactions relationship among the bounded rational agents. The interactions relationship, from individual cognitive process to social cognitive process or collective cognitive process, is a distributed innovative learning process and consequently produces emerging properties. Agent-based modeling is a computational study of complex adaptive system evolving through hierarchical dynamics and thus is a methodology to complexity studies. As an illustration, we construct a computational model of political election and considered the key aspects of information processing that the formation and change of voters’ opinions undergo a
network economy, representing a picture of social communication. In addition, we consider the consequence of mass media to affect the social communication and therefore the political outcome.

Although the agent-based modeling may be far from being an effective and persuasive method to capture the essence of public policy and indeed it is still in question for now on, it is necessary to approach social science research from a complexity perspective and constructing...
it in a computational way. This type of research not only makes up for the limitations for existing research, but also reinforces and revises the theory as well as making a step in the direction of innovating a new theory. Furthermore, it is a belief that the computational modeling will lead to breakthroughs and fundamentally alter how we understand both the physical and social worlds. A potential contribution is that the computational modeling and resulting outcomes could generate the rich empirical predictions for future studies. In conclusion, it seems to be a further work whether the significance the computational results are empirically effective, and until this can be sorted the intention here is hoped to contribute to the way social science research analyzed and create a framework to link the research to the complexity theory and agent-based models.

References


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Speech

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  Date: October 08, 2009
  Place: Auditorium 6F, E-DA hospital

• Stem cell and cancer stem cell
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