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5An Analysis of The Handwriting of Elderly Chinese Subjects

A thesis

presented to

the faculty of the Department of Criminal Justice and Criminology

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Master in Criminal Justice & Criminology

by

Dongfang Liu

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John T. Whitehead, PhD., Chair

Larry S. Miller, PhD., Co-Chair

Dennis Hamm, PhD.

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Subjects

ABSTRACT

An Analysis of The Handwriting of Elderly Chinese Subjects

by

Dongfang Liu

Nowadays, one of the issues of concern that brought on by the aging population is legal disputes that have been increasing in number every year. One core problem in these legal disputes involves handwriting identification. There are however not many previous studies in China that have been concentrated on this field. Hence, the study on elderly Chinese subjects' handwriting has an extremely broad potential value for its application for academic usage and practical meaning. This study uses an empirical technique, gathering first hand data and analysing them by employing proper methods. There are 7 handwriting features and characteristics that have been found in the study to represent the key characteristics of the elderly Chinese subjects' handwriting . They are: Pen pressure, occurrence rate of traditional Chinese words, letter size, poor structure, tremor, half-way stop sign, and towing sign at beginning and end of strokes.

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CHAPTER 1

INTRODUCTION

In this century issues of the aging population have been increasing with the growing number of aging people. One of the issues of concern brought on by the aging population is legal disputes (civil disputes, economic contract disputes, inheritance disputes, and illicit acts) that have been increasing in number every year. One core problem in these legal disputes involves handwriting identification. Because elderly people's handwriting is largely affected by physiological and psychological factors, the indicator variables in elderly people's handwriting identification are numerous and unstable, which can be easily manipulated by intrinsic and extrinsic factors. Solving the problem in elderly people's handwriting identification requires more theoretical and empirical study in the field, and that is the major focus of this paper.

Although elderly people's handwriting identification is an ever-heated research subject today, there are not many previous studies in China that have been concentrated on this field. Hence, the study on elderly Chinese subject's handwriting has an extremely broad potential value for its application for academic usage and practical meaning. In this paper I use empirical techniques, namely gathering the elderly Chinese subjects' handwriting and young people's handwriting, and analyze the raw data by employing ASTM (American Society for Testing and Materials) standards for handwritten items. Hopefully, this study will be able to unveil the major characteristics of elderly Chinese people's handwriting, and based on the findings

about the typical characteristics of elderly Chinese people's handwriting, substantiate the common rules and principles of the research topic in order to assist the handwriting identification of elderly Chinese subjects in academic circles and eventually offer guidance and assistance for the juridical practice.

Definitions of the Study and Its Meaning

With the advent of 21st century, our world is encountering an era of an aging population. Based on the definition of the United Nations, a nation can be deemed as an aging society if it has more than 10% of its overall population whose age is 60 or above (or it has more than 7% of its overall population whose age is 65 and above). The history of aging population development demonstrates that the aging population has various degrees of impact on nearly all aspects of human society such as economic growth, savings, investment and consumption, labor market, pensions, taxation, social welfare, health care system, family structure and living arrangements, housing and migration, political system, social values and ideas, and traditional culture. (United Nations Document about "Aging Population Definition")

In China the aging population has grown to be 10% of the total population, and the number will continue to rise throughout this century. Revealed from the Fifth Population Census in 2000, Chinese society met the definition of an aged society with its aged population (people age 60 and above) reaching 0.126 billion and accounting for 10% of China's overall population, and people age 65 and above reaching 0.087 billion. The follow-up study from National Bureau of Statistics on this census also

showed that the aging population would continue to increase at a speed of 3% annually, indicating that there would be 0.144 billion people in China age 60 and above in 2005 accounting for 11% of the overall Chinese population. Based on the study's calculation, after 20 years there will be 0.3 billion people in China whose age is 60 and above amounting to 18.4% of China's overall population; after 30 years the number could be 0.4 billion which is one quarter of present population. An even more stunning fact is that at the time of the study China already had 11 million people whose age was 80 or above; a number that has continued to rise at an annual rate of 5%. In summary, the three major characteristics of the Chinese aging population are: high speed of increase, high age, and large cardinal number of the aging population. (The Fifth Population Census in 2000 of China)

With an ever growing aging population, their impact on society has become increasingly obvious, with the elderly currently in charge of most of the significant departments (politics, economy, etc.) of society. In the economic domain the aging of the population has influence on deposits, investments and expenses, labor market, pensions, tax revenue, and so on; in the social domain the aging of the population plays a role in social welfare, medical care, family structure, living arrangements, housing, and migration. In the political and cultural domain the aging population possesses the power to alter political policy, people's ideas and concepts, and traditional culture.

In addition, with the growing number of the elderly in China, law suits related to elderly people's handwriting identification in civil disputes, economic

contract disputes, inheritance disputes, and illicit acts have also been increasing.

Hence, the study of elderly people's handwriting in relation to handwriting characteristics, the variations of handwriting, and the methods of identification is necessary in order to solve the related issues in the justice system in China.

The Scientific Basis for the Study

How to Define the Elderly Chinese Subjects

In the elderly subjects' group, individuals at a similar age could have significant differences in degree of aging due to individual health conditions, economic conditions, living conditions, educational level, and occupational background. Because common belief agrees that the variables mentioned above (individual's health condition, economic conditions, living conditions, educational level, and occupational background) can largely influence a person's aging rate, most of the scholars such as Kim (2006) (professor of developmental biology and of genetics at the Stanford University School of Medicine) maintain that elderly subjects can be identified by year-order age and biological age. The former is the person's real age which has been counted since birth; while the latter resonates with the individual's body function and its aging rate.

Elderly persons' year-order age has differences according to different countries and different areas. In China the NBS (National Bureau of Statistic) regulates that people who are 45 years old to 59 years old are in the pre-elderly stage; people who are 60 years old and above are in the elderly stage (in some western

countries such as USA and UK, the elderly stage is 65 years old and above); people who are 80 years old and above are in the aged stage; and people who are 90 and above are in the nonagenarian stage. Specifically, in this paper I used year-order age to identify elderly Chinese subjects. The elderly Chinese subjects were segregated into four groups: 50-59; 60-69; 70-79; and 80-and above. Each group was asked to respond to handwriting related questions and give a short handwriting sample of some Chinese sentences.

On the other hand, elderly people's biological age is not counted by their real length of life but refers to cell age, which means the human body's aging rate. Because elderly individuals at a similar age could have huge differences in degree of aging and the extrinsic appearance differences about age are very obvious at the individual level, people's year-order age might not be consistent with their biological age. It is easy to understand the theory mentioned above when looking into the examples from our real life; common sense tells us that some people whose age is 70 years old or above may appear to be 50 or 60 years old; while some other people who are only 40 look like a 60-year old person. These extrinsic appearance differences are related to the aging rate for human structure and function. Although there are notable individual differences in elderly people, the elderly group still shares ordinary characteristics in their appearance caused by the aging body structure and function. Thus, this paper chooses year-order age as a threshold to identify each Chinese participant in this study.

In this elderly Chinese subjects' handwriting identification study, aside from

applying year-order age as a basic demographic variable and selection threshold, I also take biological age into consideration when analyzing the intrinsic elements that trigger the changes of elderly people's handwriting. Specifically, to analyze the subject's biological age concerning changes in elderly people's handwriting, the basic factors will be elderly people's writing action system and the nervous system (cheirokinesthetic center) that will be carefully illuminated in the Chapter 2 (Medical bases for causes of the elderly subjects' handwriting characteristics and handwriting habits).

Important Properties in Handwriting Identification

Handwriting identification aims to identify individuals by analyzing people's writing habits, which can be deemed as a nonconscious movement of the human body rooted in a myriad of routine practice. Moreover, people's writing habits should resonate with people's handwriting characteristics. Hence, studying people's handwriting characteristics can assist analyzing people's handwriting habits in handwriting identification. In general, people's handwriting possesses three major properties: specialty, consistency and modification, and reflection. These properties can also be applied to analyze elderly subject's handwriting.

1. Specialty in individual's handwriting habit.

The specialty in an individual's handwriting habits refers to an individual's overall handwriting characteristics and distinct manners of conducting handwriting movement. In other words, people normally possesses their own distinctive handwriting habits compared to their counterparts. The specialty in handwriting habits

stems from the learning process of handwriting skills and different methods of practicing handwriting, both of which contribute to form an individual's handwriting habits. In addition, people's different physical and psychological conditions and other extrinsic elements also play an important role in constructing an individual's handwriting habits.

However, different people's handwriting habits can also share a certain degree of similarity regardless of their distinctive characteristics. This phenomenon, named by academic circle, is group class character in handwriting. Because language is a tool for communication, people cannot conduct their handwriting with free will but follow certain social rules and regulation. For instance, similar education, similar living and working environments, and imitation from relatives, classmates, or coworkers are able to cause people's handwriting to be similar to one another.

2. Consistency and modification in individual's handwriting.

Handwriting habits are formed by repeated temporary connections in related nerve centers of the cerebral cortex. The connections in the cerebral cortex can be reinforced by constant stimulation or can be interrupted and replaced by new stimuli. Thus, individuals' handwriting habits are variable with the changing environment such as development of language, different job positions, and altered living conditions. In short, handwriting is modifiable.

On the other hand, handwriting consistency is representative of an individual's inertial means of conducting handwriting, and a society's consistent manner and regulation of using one language. If no influential factors occur to make it

change, this kind of consistent handwriting can maintain its natural appearance for a long steady state, and its basic features do not change dramatically, thus this consistency in handwriting can provide useful evidence and ground for handwriting identification. (Huber & Headrick, 1999, p. 108)

3. Reflection in individual handwriting

Reflection in individual handwriting means that handwriting habits can offer much meaningful information for handwriting identification. Individual handwriting habits as an existing element cannot be interpreted directly but indirectly by studying people's handwriting (writing sentence, clause, and signatures) to unveil the hidden information. However, the handwriting process is not only manipulated by extrinsic factors such as paper, pen, and other writing environments but is also affected by intrinsic factors such as physical and psychological conditions. The reflection characteristics in handwriting for elderly subjects are also influenced by intrinsic and extrinsic factors, and based on some previous study findings they have more obvious impact on the elderly subjects' handwriting than they do for younger subjects..

Handwriting process has its own autonomy, which is sometimes independent of an individual's subjective ideas. Although we realize that every human action including handwriting movement is controlled by our conscious mind (start to write, stop writing, control the writing, or change people's natural way of writing and imitate other's handwriting), the human handwriting process involves a high degree of immobility. After people have completed their learning process of handwriting skill and find a suitable way of writing, their handwriting becomes an automatic procedure

as with other routine activities. Under this circumstance people's handwriting act is a nonconscious process in normal conditions and it is hard to alter.

In addition, writing habits also have initiative, which means that people's handwriting achieves a certain degree of proficiency. This handwriting proficiency can be deemed as a driving force or established stereotypes to adapt to different writing conditions and to overcome outside interference. Individuals who possess their own handwriting initiative and proficiency can exhibit persistent characteristics inherent in their handwriting and overcome the negative writing conditions.

Goal of the Research

Analysis on handwriting identification is an ancient judicial inspection technique, which in China has been applied in litigation for nearly 2,000 years. When Chinese ancestors practiced the art of calligraphy, they also found that handwriting recognition has value in identifying an individual's identity and employed this skill in judicial practice. Because the Chinese language has a number of characters, various forms of complex structure, and diverse direction of strokes, Chinese letters are more difficult to write than their counterparts in western languages. Thus, after an individual's handwriting skills and handwriting habits are formed, their handwriting system exhibits more special stable characteristics than the other written languages, which, therefore, are the unique advantages for the Chinese character to provide sufficient scientific basis for handwriting identification.

With the development of science and technology, the latest technologies such

as print, copy, and fax have shrunk the scope of written documents' applications. However, an individual's signature and handwriting credential production are still significant and widespread in contemporary society. Especially, concerning the elderly, most of them still use handwriting as the major tool of recording daily facts and communications.

At present China is moving to an aging society. With the increasing proportion of the elderly population, legal disputes in the elderly community grow at the same time. Based on data announced by the Chinese Supreme Court in 2002, 45.8% of legal suits that involved elderly subjects were also related to issues about handwriting identification such as real estate contract disputes and inheritance disputes. Therefore, studying elderly subjects' handwriting characteristics and polishing handwriting identification methods are significant means to resolve such legal cases.

This research on elderly Chinese people's handwriting identification aims to reveal the distinct characteristics of elderly Chinese people's handwriting, which can be used to distinguish the handwriting of the elderly from other groups of people's handwriting. Hopefully, this research can be a supplement for previous ordinary handwriting identification pertaining to the study of a specific group of people's writing because unlike previous ordinary handwriting identification study that focuses on individual differences, this study is trying to analyze a special group of people's handwriting characteristics, in another words, the handwriting differences between groups.

The study not only measures the target from the surface, namely, that elderly people's handwriting is different from the handwriting of younger people (the first goal is to unveil the handwriting differences between the elderly and the young people), but also try to answer the question about how the differences are made (the second goal is to find the reasons that create differences between the elderly and the young people). For instance, if an elderly person had bad sight, the individual might write bigger size characters than younger people with better vision; in addition, elderly people normally have declined strength or effectiveness, thus their writing might appear to be powerless and slack.

In sum, based on the findings and discussion of the paper, the results from the research can be applied to assist resolving issues in elderly Chinese people's handwriting identification and offer an empirical research basis for future academic study.

CHAPTER 2

LITERATURE REVIEW

Previous Research on Chinese Handwriting Identification

Previous study of Chinese handwriting identification did not pay much attention to elderly people's handwriting but offered many contributing elements for this study pertaining to measurements and choosing what kinds of handwriting features can be easily measured. Because elderly people's handwriting can be manipulated largely by cognitive process and physical limitations, theories and methods that focus on those variables can also be used in this study.

For instance, in Zhang and Wang's (1998) article *Studied Chinese character handwriting and personality*, the authors measured 1,053 normal male and 844 normal female handwriting samples using standard writing movement and self-selected writing movement in standard and free status. Writing style, speed, pressure, stability, character position, slope, upright and even and smooth, and special writing characteristics were indexed. By measuring the variables mentioned above, handwriting characteristics and maturity and mental characteristics, and the relationships of handwriting and types of nervous system and temperament were analyzed in age and schooling groups. In addition, Meng and Zhao's (1997) research on the relation of hard-tip pen handwriting variables and cognition and personality factors in rapid writing demonstrates that Chinese handwriting performances can be evaluated by 19 variables referring to writing pressure, speed, style, word length, size, position, and arrangement. Main factors of handwriting were summed up from those 19 variables with factor analysis and were assessed by tests. Their relations with

cognition and personality factors were studied by correlation analysis. The measured variables for handwriting identification listed in the two studies are sufficient to evaluate the diversities between different handwritings, and some of the variables will be also applied in this paper's study.

Zhang and Wang (1998) hold that because handwriting is an important agent for people to deliver thinking, emotion, and perspective, individuals should possess their own unique characteristics and figures in handwriting, which are affected by people's personal physical and psychological factors. Normally as age increases people's handwriting appears to have certain stable characters; that is the consistency property. There are few distinct figures for people at the early stage of learning and practicing handwriting, but people's handwriting embodies diversities and varieties in many forms at the sophisticated stage of handwriting process. As mentioned above, Zhang and Wang point out a very interesting perspective (although it is not a new notion but has been stated before by many scholars such as Osborne) that subjects' nervous systems and physiological conditions (intrinsic factors) and extrinsic factors (such as writing environment, pen, and paper) can largely affect their performance in handwriting.

Similar to the findings of Zhang and Wang (1998), Liu and Zheng (2005) also link writers' psychological and psychological factors together as critical diagnostic indicators for handwriting identification. Their research briefly summarizes the previous studies on Chinese handwriting identification and points out the future research directions based on the current evidence. Zhang and Wang hold that

handwriting movement is an acquired conditioned reflex activity that is controlled by related susceptors, nerve centres, and effective apparatus. In other words, the handwriting process requires coordination of the whole human body's nervous system and locomotor system. In addition to that, the handwriting process is also modified and influenced by some other contributing factors. Thus, it is safe to conclude that handwriting characteristics and habits are formed by the full operation of social environmental influences and psychological and psychological factors. Educational background and experience can also impact elderly Chinese subjects' handwriting because different educational experiences could alter people's word selection (modern Chinese and traditional Chinese) to write. This paper tests this part in the following section.

In addition to the studies about Chinese handwriting identification, there was a serial research project on the topic from Li, Yang, Poon, and Fung (2007) that should be introduced. Li et al. (2007) and his team started approaching the research target by examining the structural characteristics of Chinese words. Researchers systematically discussed the development of Chinese characters and style dating back 3,500 years by evaluating the strokes, radicals, and other features. The first part of their work was carefully elaborated in order to help later occidental document examination. Then, Li et al. conducted their study by employing various techniques of discriminating diagnosis for identifying questioned handwriting. The basic methods that the researchers used were measurable (width and height ratio, symmetry factor, slant, and tilt) and qualitative parameters (physiological reasons, psychological

reasons, etc.). What I found very useful in their research is their study results. The results for the study were reported in the form of statistical analytical techniques and revealed that measurable parameters are consistent enough for identifying authorship. In actual practice adding qualitative parameters inherent in handwriting characteristics and figures can play a significant role in improving the accuracy of the handwriting examination. Due to these findings Li et al. claim that the practice of multivariate analysis that combines measurable and qualitative parameters is able to improve the classification rate. In my own study I also applied multivariate analysis to investigate handwriting characters.

Finally, handwriting identification research that specifically involves elderly human subjects was conducted by Chan and So (2009). The researchers evaluated how different task factors affect performance and noted user subjective preferences for three different age groups of Chinese subjects (6-11, 20-23, 65-70 years) when writing Chinese characters by hand. The subjects copied Chinese character sentences with different settings for the task factors of writing plane angle (horizontal 0°, slanted 15°), writing direction (horizontal, vertical), and line spacing (5 mm, 7 mm, and no lines). Writing speed was measured and subjective preferences (effectiveness and satisfaction) were assessed for each of the task factor settings. The results showed that there was a conflict between writing speed and personal preference for the line spacing factor; 5 mm line spacing increased writing speed but it was the least preferred. It was also found that: vertical and horizontal writing directions and a slanted work surface suited school-aged children; a horizontal work surface and

horizontal writing direction suited university students; and a horizontal writing direction with either a horizontal or slanted work surface suited the older adults.

Medical Basis for Causes of the Elderly Subjects' Handwriting

Combining some of the research methods and measurement standards from the previous studies, this paper aims to analyze the distinct characteristics of elderly Chinese people's handwriting that can be used to distinguish the handwriting of the elderly from other groups of people's handwriting. Hopefully, this research can be a supplement for the previous ordinary handwriting identification pertaining to the study of youth writing, because unlike the previous ordinary handwriting identification studies that focus on individual differences, this study is analyzing a group of people's handwriting characteristics. In other words, the handwriting characteristics of the elderly and their young counterparts are evaluated.

This paper also wants to determine if the Chinese elderly people's handwriting is influenced by the elements that are the same as their western counterparts (the western elderly people), because based on the description of Huber and Headrick (1999), factors such as physiological reasons and psychological reasons can affect elderly people's handwriting in all condition.

Physiological Reasons

Franke (2005) claims that the conduct of handwriting is controlled by the human nervous system and system of writing movement, therefore, with the aging of these systems and functions, changes in handwriting correspond with changes in

nervous system and system of writing movement. Those physical changes such as bone and joint ankylosis (abnormal adhesion and rigidity of the bones of a joint), muscle aging, and the aging of elderly people's nervous systems, should be studied for proper handwriting analysis of the senior population.

Based on Rochman's (1988) study on clinical pathology in the elderly, with advanced age physiological changes in elderly subjects' handwriting systems (which includes bones, joints, muscles, and other) become increasingly relevant. Physiological function appears to be degraded in the aging subjects and it is an objective and inevitable process for the human body. The changes in the human body's physiological functions correspond with the related physical elements. The first sign of the change is the aging of muscle. For normal elderly people, their muscle's intracellular water decreases, fluid between cells increases, muscle is atrophied with loosened elasticity, and muscle volume decreases; or because of increasing fibrous tissue in muscle tissue, muscle appears to experience pseudo-hypertrophy and ligaments abdominal muscle atrophy become rigid.

The following section notes changes of bone aging due to muscle aging. Handwriting action is a complex process achieved by the coordination of finger, wrist, and arm movements. The movement of the wrist involves 29 bones that are supported by more than 40 muscles. Due to muscles' stretching spin coordination, a person's fingers and wrist are able to do the extension, flexion, adduction, abduction, rotation, and other fixed acts.

Handwriting movement involves organs from the bones and nerves, muscles,

and other soft tissue composition. Each of these organs has its own specific activity mechanisms. It is the allied activities mechanisms from these organs working together that complete writing activities. In writing each part of each organ on the limb skeleton has its own duty of function. Shoulder, arm, and elbow main bones operate as a leverage to support the handwriting movement and to measure the degree of handwriting movement in bend, length, distance, and transfer. Rochman found that in elderly subjects' aging process organic materials in bone decreases or disappears. The ends of long bones and pelvic bone turn into a sponge like state, and osteoporosis occurs which caused the iliac bone to become very brittle. At the same time, the elderly people's joints change with the bone's change. Articular cartilage becomes fiberized, worn, and ossificated; costal cartilage becomes calcified, brittle, and easily broken; and synovial joints become stiff. Sometimes the cartilage can completely disappear, which causes two joints of the elderly people to interact directly in the movement. Due to these changes in elderly people's physiological function, their handwriting habits and characteristics are influenced and affected proportionally.

In addition, elderly persons' nervous systems also become degraded. The nervous system includes the brain and spinal cord. From the bottom of the two parts, there are numerous nerve cells distributed throughout the human body. The brain in the cranial cavity consists of six parts, which are the brain, the diencephalon, the midbrain, the pons, the medulla oblongata, and the cerebellum. Specifically, the midbrain, pons, medulla oblongata, and synthesis compose the brain stem. The brain has left and right brain hemispheres. The brain is the most advanced and sophisticated

part of the central nervous system. The brain surface is covered by a layer of gray matter known as the cerebral cortex. Thousands of nerve fibers in the spinal cord or in a special sensor link the human body. Based on the complexity of the brain's overall synergies, human's physiological function is achieved. Hunt (2008) and his team found that during the aging process for the elderly, the weight of the brain gradually reduced with increasing age. Dura grow thick and the subdural arachnoids are fibrosis and calcified. While the brain's abilities to manage and coordinate are decreased, all parts of human movements are encountering a synchronized downturn.

Human's movements are supported by limb bones. Huber and Headrick (1999) made a clear statement in their book that in the handwriting process all the movements are controlled and manipulated by the coordination of specific cerebral cortex nerve organs from joints. In other words, written motions are achieved by the movement of each organ nerve fascicle's contraction and relaxation. The nervous system from brain to hand and then from hand to brain is a closed-loop automatic control system in every writing campaign. It is a two-way contact in the controlling area (the central nervous system) and the controlled part (body system). The cerebral cortex sends writing information signals to the hand (output process), and then the nerve endings at the hand in timely fashion deliver feedback (input process) to the cerebral cortex. This closed-loop automatic control system in writing campaigns is able to correct and adjust continuous activities and deliver input and output information, in order to achieve precise control of writing organ movement. For elderly people as the age of the nerve cells increases, the number of the cells gradually

reduce; and lipofuscin (the name given to finely granular yellow-brown pigment granules composed of lipid-containing residues of lysosomal digestion) in nerve cells increases with the age growth.

At the same time, nerve's conduction velocity becomes slow. Physiological studies from Guntena et al. (2004) have shown that 20 to 30 year-old people's R nerve conduction velocity is 7.5 m/s, while 80 to 90 year-old people's R nerve is 5.2 m/s. When people age their perception sensitivity for touch and vibration becomes slow and numb due to changes in their physiological condition, so handwriting action tends to be slow.

In sum, the elderly people's overall coordination of physiological function for handwriting movement undergoes degeneration of operation with increasing age. Handwriting movement is a complex mechanism that requires allocation and coordination from almost all the nerve centers of speech movements, language related nerve centers, and language related organs. Thus, a seemingly simple process, handwriting, actually embodies a very sophisticated movement system of the human body.

Under normal circumstances writing activities are conducted by writing motor areas in the cortex. The specific areas in the cortex issue an instruction through the efferent innervations on muscle that contains the information for muscle rotation order, moderation, and stretching rhythm. At the same time, feedback from the nerve ends at the fingers relying on vision, finger (or limb) muscle pressure sensation, and finger touching sensation is sent back to the cortex in order to monitor and regulate

the location of pen to paper, strike direction, strike line, strike angle, strike intensity, and strike speed to complete the handwriting movements. Due to the decline of elderly people's physiological functions, their locomotors systems and nervous systems become difficult to be coordinated by their bodies. And the deteriorated function of an elderly person's body system decreases the abilities of the normal nerve conduction and normal handwriting movement. For all the changes mentioned above, an elderly person's handwriting should have its own unique characteristics and traits.

Psychological Reasons

As human beings age and also experience changes in social status, diseases, death, and fear of death, elderly people unavoidably suffer psychological changes. Based on the study from Zhang and Wang (1998), the psychological changes of elderly people mainly include: 1. significant deterioration of listening and vision, which leads to the low perceptibility in listening and vision. The eyeballs' ability of adjusting decreases, so the impaired vision cannot effectively monitor the handwriting process. 2. The significant deterioration of memory. Hyponasty is a major indicator of senility. As a human being grows into senility, the information of structures and shapes of characters stored in the brain blurs. In addition, decreased demand to write and less frequent writing activities cannot provide enough repetition to retain the memory. Thus, there are possibilities of forgetting the structures of words right before writing, slips of the pen or sudden stops during the writing movement, and repeated tracing and correction, etc.

Zhang and Wang claim that those mental state changes mentioned above can

cause changes in handwriting features such as slow writing with poor coordination, more gentle writing force, larger word size, inaccurate stroke structure, loose structure, reverting to the old style of writing and usage of the traditional Chinese words. With the decreased abilities to write, the abilities of disguised handwriting are also reduced.

CHAPTER 3

METHODOLOGY

This paper used an empirical research method. A survey about the target topic was distributed in the Chinese community of the Tri-City, TN (Bristol, VA) area, in order to collect the information for the research.

The study tests the primary hypothesis that the elderly people's handwriting should be different from the young people because the elderly people's handwriting has been altered due to intrinsic factors such as their physical function (e. g. bad sight, and loose muscle strength), as well as extrinsic factors such as they were taught to write traditional Chinese rather than simplified Chinese.

The study analysed the handwriting samples of 26 people whose ages are from 50 and above and try to find the distinctive figures in elderly people's writing compared to 20 ETSU Chinese students' handwriting (the students' ages ranged from 18-30). In the end, the paper discusses the findings from the sample analysis and tries to make some contributing propositions for elderly people's handwriting identification.

Data Collection

Data were collected at Chinese restaurants and the ETSU campus in the Tri-City, TN and nearby areas. The whole data collection process lasted for 3 weeks from early November 2010 to late November 2010. The targets were all Chinese subjects. All the participants were totally voluntary and protected by ETSU IRB protocol, which means that all the participants were free to quit the research at any steps of the

study. The content of the survey was carefully designed and conveyed no threats or created any unsatisfactory feelings in subjects. The participants, however, were free to refuse to answer any of the questions in the survey they thought were inappropriate.

The elderly participants were asked to complete a short survey pertaining to questions of their age and their own evaluation of what elements currently affect their handwriting and possibly alter their handwriting from how it had been when they were young. Finally, the elderly group was asked to write a content-fixed sentence (includeing 30 characters) for three times, thus 1,800 Chinese characters were gathered. In addition, all the 20 ETSU Chinese students were asked to write the same content as the elderly and imitate one handwriting sample from the elderly subject.

Data Analysis

After the data had been gathered, all the handwriting samples were classified into two groups: genuine groups from the elderly people's handwriting and the comparison group from the ETSU students' handwriting. Handwritings of the two groups were analyzed, compared, and evaluated based on ASTM standards (American Society for Testing And Materials). All the measurement in the study was at the nominal level.

All the handwritings were analysed according to ASTM standards. Among the features to be considered are the writing elements of abbreviation, alignment, arrangement, formatting, and positioning; capitalization; connectedness and disconnectedness; cross strokes and dots, diacritics and punctuation; direction of

strokes; disguise; embellishments; formation; freedom of execution; handedness; legibility; line quality; method of production; pen hold and pen position; overall pressure and patterns of pressure emphasis; proportion; simplification; size; skill; slant or slope; spacing; speed; initial, connecting, and terminal strokes; system; tremor; type of writing; and range of variation.

Potential limiting factors such as age; illness or injury; medication, drug or alcohol (intoxication or withdrawal); awkward writing position; cold or heat; fatigue; haste, or carelessness; nervousness; nature of the document, use of the unaccustomed hand; deliberate attempt at disguise or auto-forgery were also considered.

In this study, 60 surveys were distributed, and 51 usable surveys were gathered. Among the returned surveys, 25 are handwriting samples of ESTU students and 26 are handwritings samples and questionnaires of elderly subjects. Based on the regulation of the State Statistical Bureau of China and the practice of handwriting identification, the handwriting samples are divided into four groups: 50-59 year olds (4 samples), 60-69 year olds (6 samples), 70-79 year olds (10 samples), and 80-above (6 samples) to be investigated.

In addition, the elderly subjects were divided based on health condition and education in the evaluation process. In the survey people who marked "Do not know" for the second question were deemed as the healthy group, and the others who mark the options other than "Do not know" were considered as the unhealthy group. About education, subjects who chose learned traditional Chinese were evaluated compared to the ones who did not learn traditional Chinese.

After examining the handwriting samples of the elderly Chinese subjects based on ASTM standards, there are seven handwriting features and characteristics that have been selected to represent the key characteristics of the elderly Chinese subjects' handwriting due to their quantitative significance. They are:

1). Pen pressure: which can be reflected by the width of stroke line. In the study pen pressure was measured by the width of stroke line. The wider the handwriting line is, the higher degree an individual's pen pressure has. All handwriting samples were scanned, amplified, and measured by computer. The group of subjects with highest pen pressure on average was assigned the value 10 (to present their pen pressure) without any unit and serves as the standardized group, so the rest of groups can be assigned a proper number based on the comparison to standardized group. See Figures 1 and 2:



Figure 1. Pen Pressure: 10



Figure 2. Pen Pressure: 4

2). Occurrence rate of Traditional Chinese words: is calculated by the formula- $P=n/N$. n is the time of occurrences of traditional Chinese words in the handwriting samples; while N is the total number of the words appeared in the handwriting samples.

3). letter size (font): letter size is defined as the length from the top of a letter to its bottom. In this study all the handwriting samples were scanned into electronic files and measured by Micro-Soft Word 2010. Any group of subjects with largest letter size on average was assigned 10 (to present their font) without any unit and serves as standardized group, so the rest of group can be assigned a proper number based on the comparison to standardized group. See Figures 3 and 4:



Figure 3. Letter Size: 6

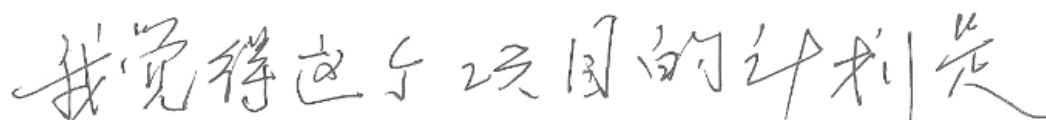


Figure 4. Letter Size: 10

4). Poor structure (formatting): poor structure is deemed as handwriting words that are barely readable by the researcher. The poor structure rate is calculated by the formula- $P=n/N$. n is the time of occurrences of poor structure words; while N

is the total number of the words appeared in the handwriting samples. See Figure 5

below:

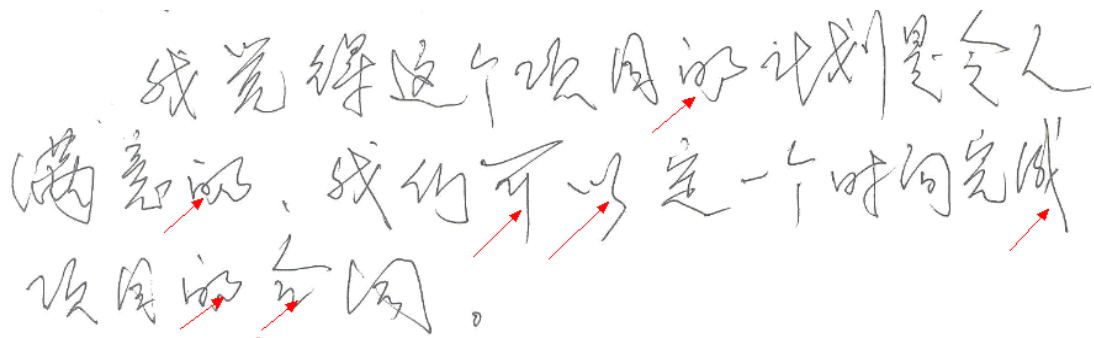


Figure 5. Poor Structure Sample (see the red arrows)

5). Tremor: tremor refers to waves that appear in people's handwriting, and the normal form of tremor is uneven (or unsmooth) line quality. The tremor rate is calculated by the formula- $P=n/N$. n is the time of occurrences of tremor on Chinese words while N is the total number of the words appeared in the handwriting samples.

See Figure 6 below:

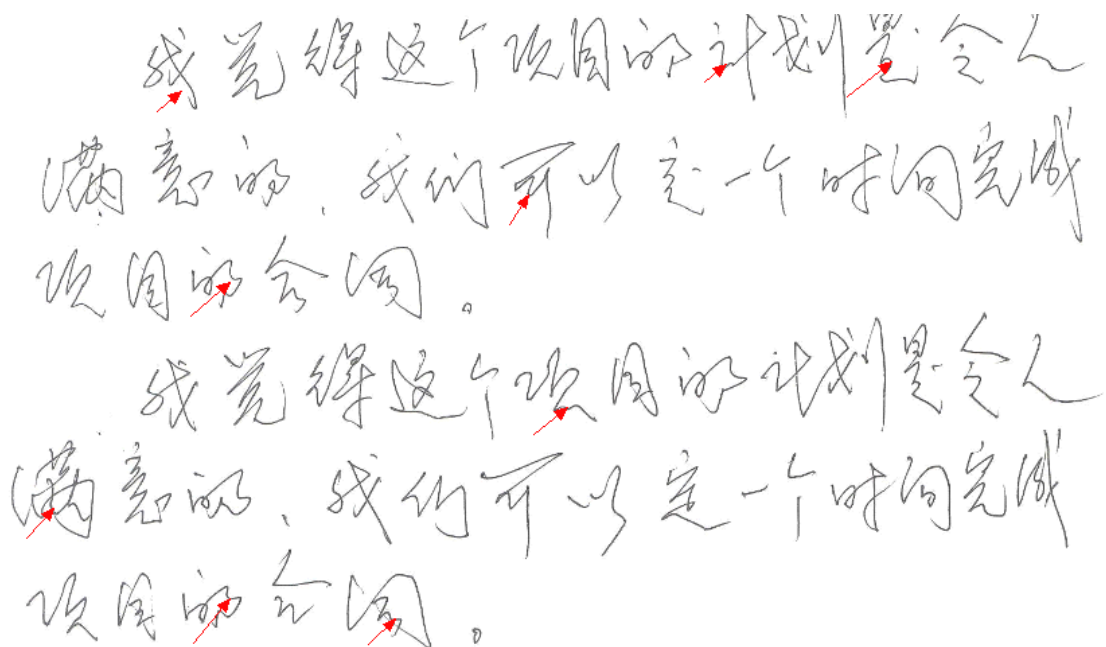


Figure 6. Tremor Sample (see the red arrows)

6). Towing sign at beginning and end of strokes: this phenomenon is defined

as unusual stroke that extends longer than the normal length. Towing sign rate is calculated by the formula- $P=n/N$. n is the number of occurrences of towing signs, while N is the total number of the words appeared in the handwriting samples. See Figure 7 below:

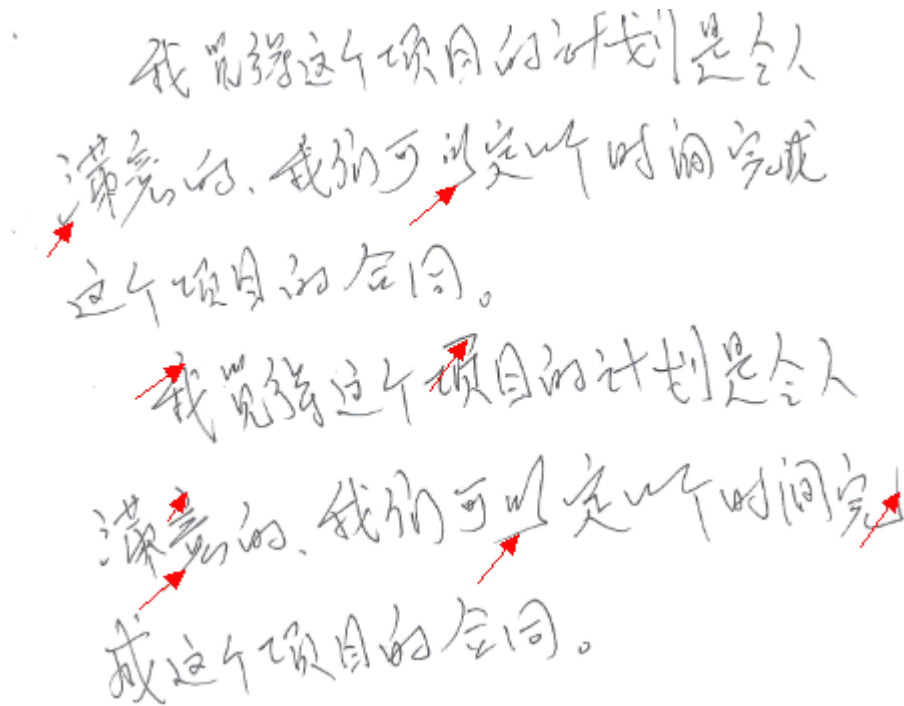


Figure 7. Towing Sign Sample (see the red arrows)

7). Half-way stop sign: this is defined as a single stroke that was broken up into several parts due to abnormal stops. The half-way stop rate is calculated by the formula- $P=n/N$. n is the time of occurrences of this phenomena, while N is the total number of the words appeared in the handwriting samples. See Figure 8 below:



Figure 8. Half-way Stop Sign Sample (see the red arrows)

CHAPTER 4

RESULTS

Quantitative Analysis of the Data

In the part I applied quantitative techniques to evaluate the key characteristics mentioned above combining the information collected from the distributed surveys.

In the evaluation process the key characteristics were assigned to certain variables (subjects' age, health condition, and education) as a pair. Statistic of evaluation results were presented in the form of charts demonstrating the correlation between certain variables and key characteristics. There are 13 pairs that have been composed for statistical evaluation. They are: 1) pen pressure-age; 2) pen pressure-health condition; 3) use of traditional words-educated by traditional Chinese; 4) letter size-age; 5) letter size-health condition; 6) poor structure-age; 7) poor structure-health condition; 8) tremor-age; 9) tremor-health condition; 10) half-way stop sign-age; 11) half-way stop sign-health condition; 12) towing sign at beginning and end of strokes-age; and 13) towing sign at beginning and end of strokes-health condition.

In Figure 9, the 50-59 age group has highest degree of pen pressure, and this group was used as reference to the rest of three groups. The number 10 without any unit was assigned to the 50-59 age group to represent the pen pressure, thus subsequently rest of the groups possess relative numbers for pen pressure.

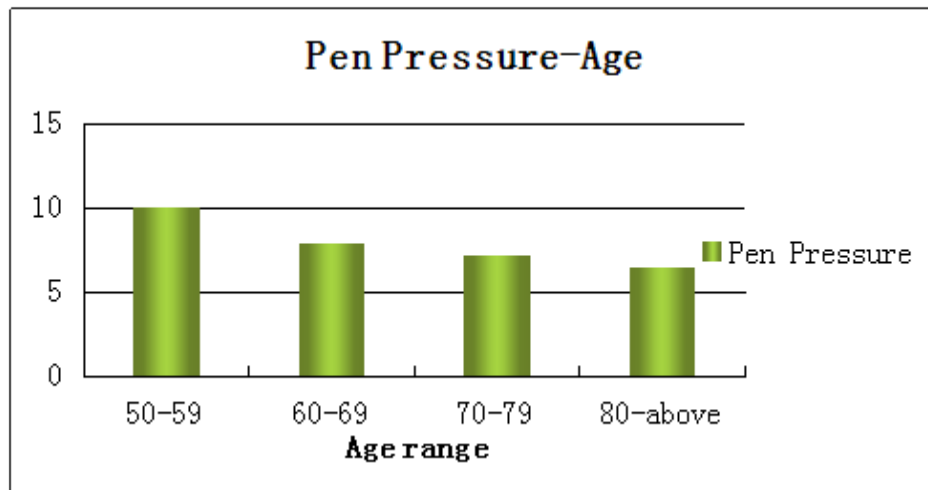


Figure 9. Pen Pressure-Age

In Figure10, the healthy group has higher degree of pen pressure, and this group was used as reference for the unhealthy groups. The number 10 without any unit was assigned to health group to represent pen pressure, thus the unhealthy group possesses relative number for pen pressure.

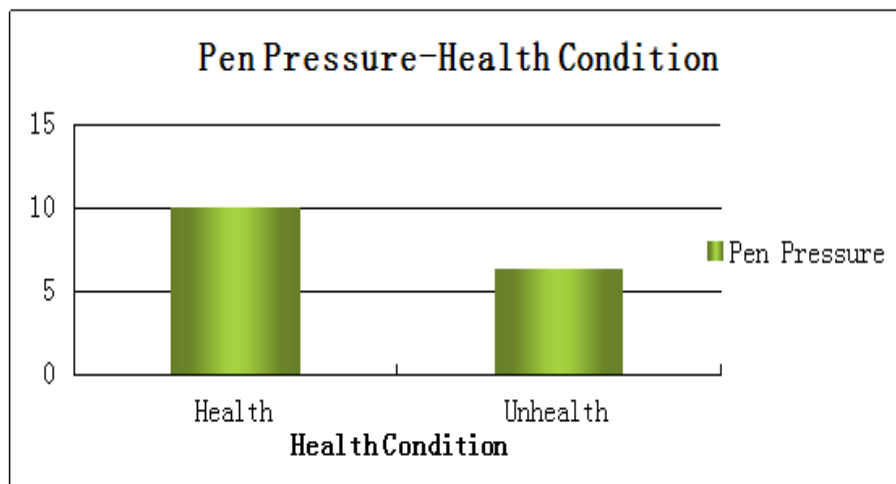


Figure 10. Pen Pressure-Health Condition

In Figure 9 we can see that with the increasing age, people's pen pressure decreases constantly. In general, people whose ages are 50-59 have the highest degree of pen pressure compared to their counterparts in the research; while on the contrary, the 80-and above group exhibits lowest pen pressure. In Figure 10 research subjects

have been classified by their self-evaluation of health condition, namely the healthy group and the unhealthy group (people reported in the survey with some kind of psychological or physiological problems). The results are consistent with my prediction that the healthy group has a higher degree of pen pressure compared to their counterparts (the unhealthy group) in the research.

In Figure 11, the traditional education group has a higher degree of traditional words usage. Based on the calculation of the formula- $P=n/N$, the occurrence rate for Traditional Education group is 5%, while to the other group who has no experience in traditional education, the occurrence rate is zero.

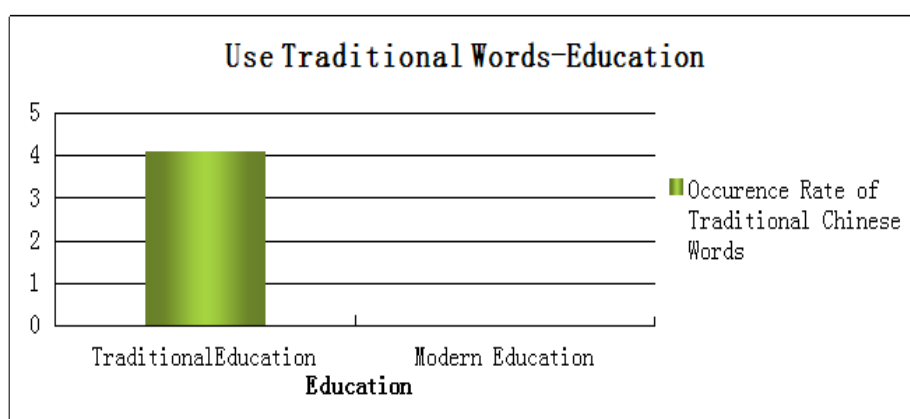


Figure 11. Use of Traditional Words-Education

Figure 11 shows the correlation between handwriting education and use of traditional Chinese words in practice. Based on Figure 11, people who experienced traditional education in writing traditional Chinese characters have much higher probabilities than their counterparts in using traditional Chinese words in their handwriting. In fact, there are no examples available in the study that people who undergo modern education of handwriting employed the traditional Chinese words in their handwriting.

In Figure 12, the 80-and above group has biggest letter size and this group has been used as reference to the rest of three groups. The number 10 without any unit was assigned to 80-and above group to represent general letter size, thus subsequently rest of the groups possess relative numbers for letter size.

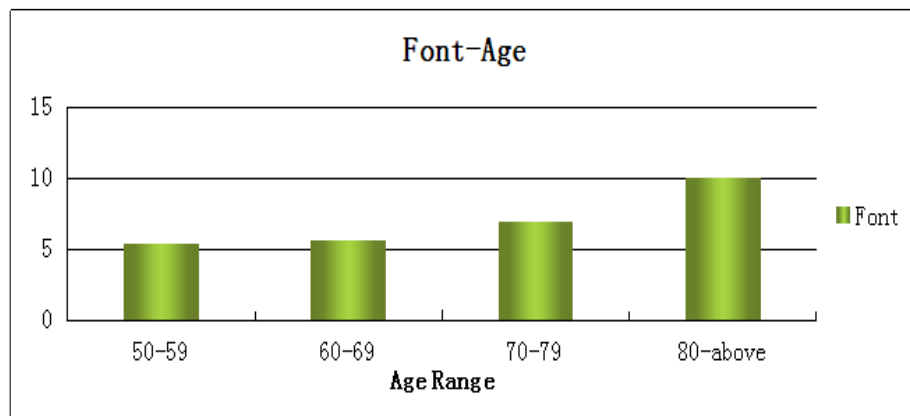


Figure 12. Letter Size-Age

In Figure 13, the unhealthy group has bigger letter size, and this group has been used as reference to the healthy groups. The number 10 without any unit was assigned to the unhealthy group to represent letter size, thus the healthy group is shown with a relatively small number for letter size.

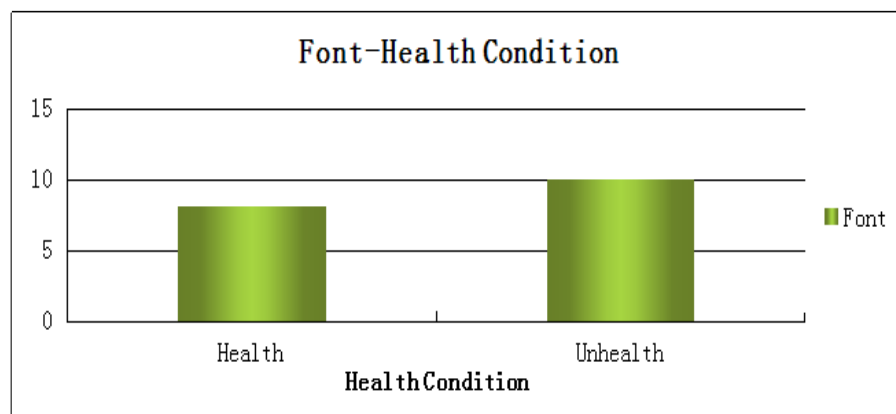


Figure 13. Letter Size-Health Condition

Figure 12 reveals a prevalent trend in the study that the letter size for people's handwriting goes up with the increasing age of research subjects, expect the

60-69 group whose general letter size is relatively smaller than 50-59 group. In Figure 13, we can see that people who report themselves as unhealthy have relatively larger letter sizes than that of their counterparts, the healthy group.

In Figure 14, the 80-and above group has highest occurrence rate of poor structure in handwriting and this group was used as reference to the rest of three groups. Based on this calculation, the occurrence rates for poor structure for 50-59, 60-69, 70-79, and 80-and above were 5.5%, 7.2%, 4.5%, and 9.8% respectively.

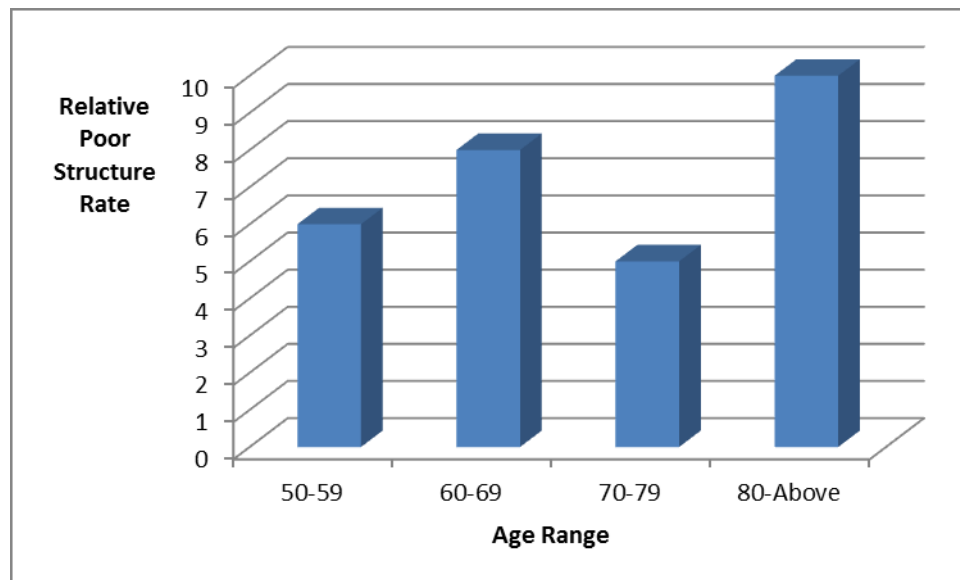


Figure 14. Poor Structure-Age

In Figure 15, the healthy group had a higher occurrence rate of poor structure. The occurrence rates for poor structure for healthy group and unhealthy groups were 9% and 3.9% respectively.

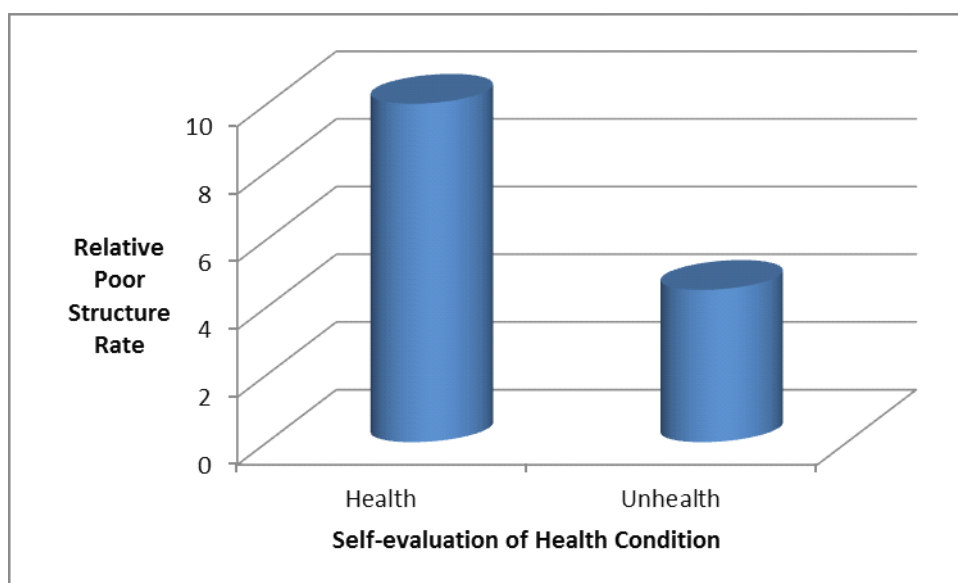


Figure 15. Poor Structure-Health Condition

Figure 14 shows that, when it comes to poor structure in handwriting there is no absolute trend in age trend. In the chart we can see that the 80-above group has highest rate of poor structure in handwriting in general, while the 70-79 group has lowest degree of poor structure in handwriting. In addition, based on the information from Figure 15, the healthy group exhibits a higher degree of poor structure rate compared to the unhealthy group. The phenomena impressed me to some extent, because I originally held that the unhealthy group probably had higher degree of poor structure rate. But after analyzing the younger subjects in my study, I surprisingly found that some of the young subjects' handwriting had even worse structure. Based on the findings from this study, I would assume that aging issues have less impact on poor structure in handwriting, which may be more likely to be correlated with individual natural differences in handwriting.

In Figure 16, the 80-and above group has highest rate of tremor occurrence in handwriting. The occurrence rates for tremor in handwriting for 50-59, 60-69, 70-79,

and 80-above group were 3.8%, 4.3%, 7.2%, and 9.5% respectively.

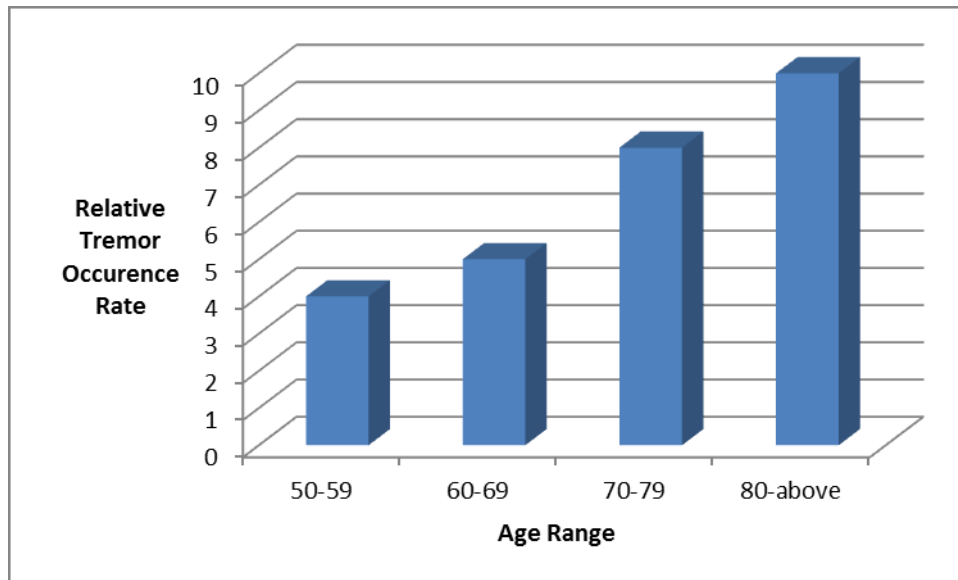


Figure 16. Tremor-Age

In Figure 17, the unhealthy group had a higher degree of tremor occurrence rate. The occurrence rates for tremor in handwriting for the healthy group and unhealthy group were 4.7% and 9 % respectively.

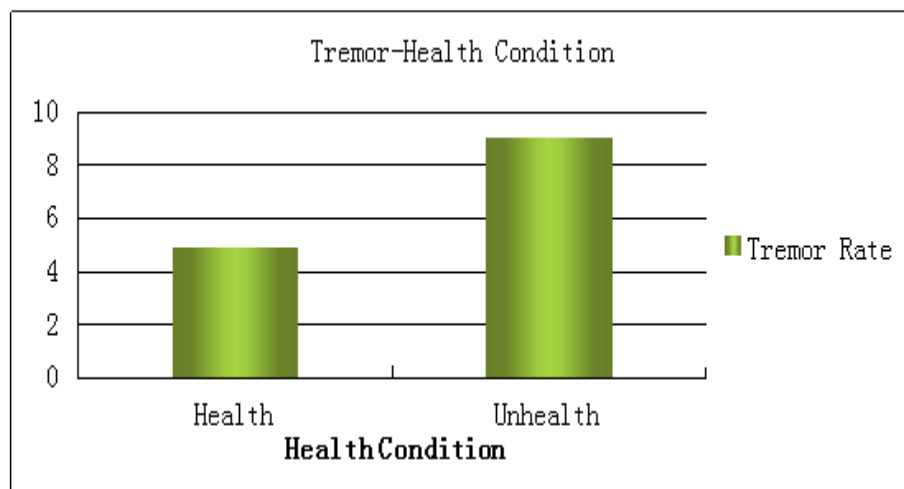


Figure 17. Tremor-Health Condition

Figure 16 and Figure 17 exhibit that there were significant impacts of aging and health condition on elderly people's handwriting pertaining to the tremor factor. Figure 16 shows that the older the individual, the more tremors that would be found in

their handwriting. In addition, Figure 17 informs us that unhealthy people possess more tremors in their handwriting than the healthy subjects.

In Figure 18, the 80-and above group had the highest degree of half-way stop occurrence rate in handwriting. Based on the calculation, the occurrence rates for half-way stop for 50-59, 60-69, 70-79, and 80-and above group were 5.8%, 7.5%, 9.1%, and 9.3% respectively.

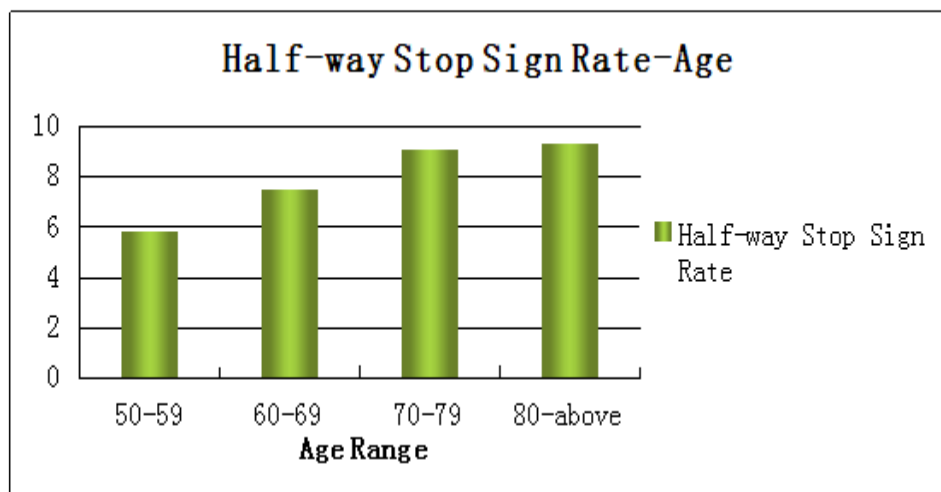


Figure 18. Half-Way Stop Sign-Age

In Figure 19, the unhealthy group had a higher half-way stop occurrence rate. The occurrence rates for half-way stop for healthy group and unhealthy group were 4.3% and 9 % respectively.

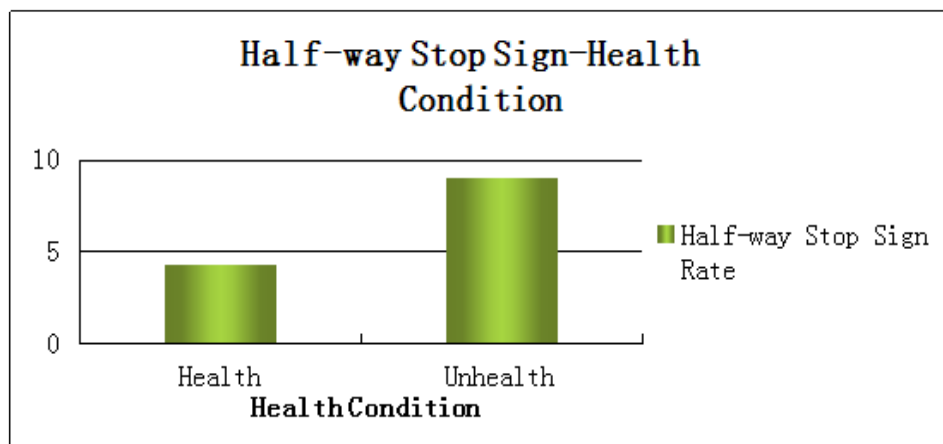


Figure 19. Half-Way Stop Sign-Health Condition

Figure 18 shows that as elderly subjects' age increases, the individual's half-way stop rate goes up. As shown in the chart 10, the 80-above group had the highest half-way stop rate, while on the contrary the 50-59 group obtained the lowest half-way stop rate. In addition, according to the Figure 19, the half-way stop phenomenon is more prevalent in the unhealthy group than the healthy group.

In Figure 20, the 80-and above group had the highest towing sign rate in handwriting. The occurrence rates for towing sign for 50-59, 60-69, 70-79, and 80 and above were 3.9%, 4.8%, 6.4%, and 9.6% respectively.

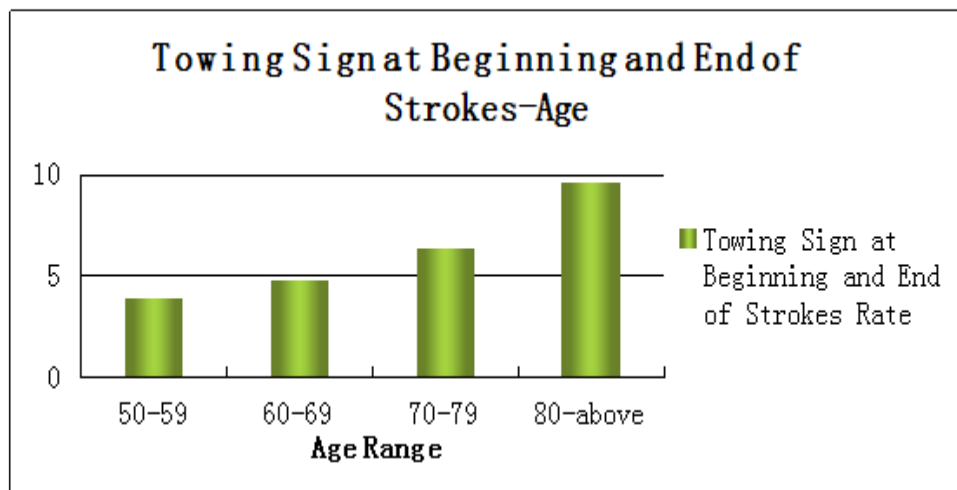


Figure 20. Towing Sign at Beginning and End of Strokes-Age

In Figure 21, the unhealthy group had higher towing sign rate. The occurrence rates for towing sign were 6.2% and 9.3% respectively.

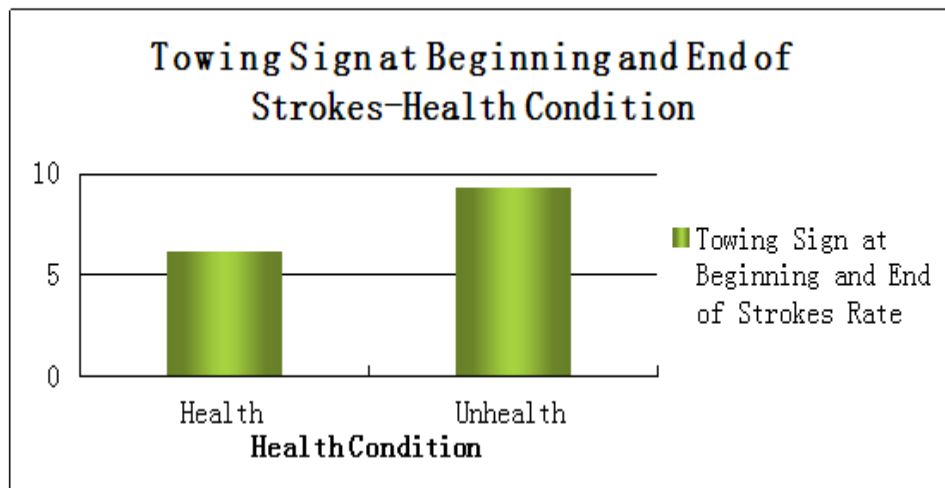


Figure 21: Towing Sign at Beginning and End of Strokes-Health Condition

Brief Summary on the Data

After the qualitative and statistical analysis of experimental samples for causes of the elderly handwriting, a brief summary of the characteristic of elderly Chinese handwriting can be drawn as follows:

1. Elderly subjects' handwriting appears to be larger in glyph size but loosely structured. Gathered data for elderly subjects' handwriting demonstrates a trend that the size of the handwriting gradually increases with age.

2. Elderly subjects' handwriting appears to have bending strokes, half-way stop signs, and towing signs at the beginning and end of the stroke (e.g. Figure 22).

After human subjects enter old age, with the growing age, their pen movements show various degrees of vibration and bending, half-way stops, and signs of towing at the beginning and ending of strokes. This phenomenon has certain connections with people's handwriting skills and pathological factors. That is to say, elderly subjects who are frequently engaged in handwriting activities do not exhibit obvious instability

in their handwriting, otherwise the phenomenon is notable for the elderly who are not so frequently engaged; in addition, elderly subjects who have writing related physical or psychological problems are inferior to the people who are relatively healthy in handwriting proficiency. Especially for the elderly subject who is older than 70, handwriting has palpable vibration and bending, half-way stops, and signs of towing at the beginning and ending of strokes. Shown in Figure 22 is a handwriting sample from a 77-year-old person who is suffering from arthritis. For the whole handwriting process, the subject's pen movement appeared to be trembling which made some of the stroke very bending. Moreover, there are numerous signs of towing at the beginning and ending of strokes.

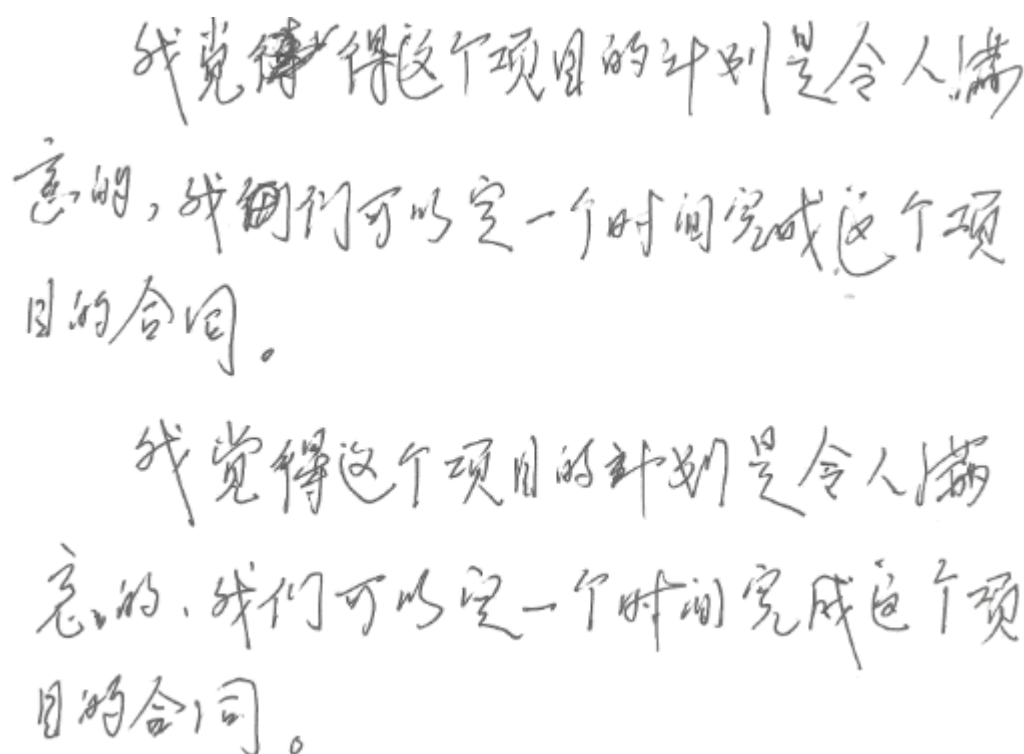
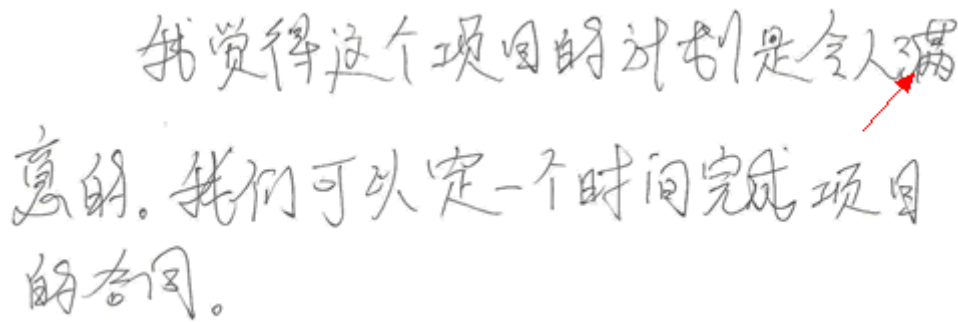


Figure 22. Samples of Bending Stroke, Half-Way Stop and So Forth

3. Elderly subjects tend to use traditional characters and variant forms of words with modern norms (e.g. Figure 23). This phenomenon is not common for the

elderly group whose handwriting skills and education level is low. With increasing ability in handwriting and level of education, elderly subjects' handwriting sample reflect the characteristics. Some of the gathered sample from ETSU Chinese faculty demonstrates this argument clearly.



我觉得这个项目的计划是令人满意的。我们可以定一个时间完成项目的合同。

Figure 23. Sample of Use Traditional Characters in Handwriting

4. Elderly subjects used vertical lines in their handwriting and wrote some old phrases (e.g. Figure 24). Before the founding of new China, a variety of newspapers, magazines, and books were basically written in vertical lines, so till now there were many old people who still like to write vertical lines rather than the modern rows. Meanwhile, some of the elderly people are inclined to convey their handwriting express in the form of the old phrases.

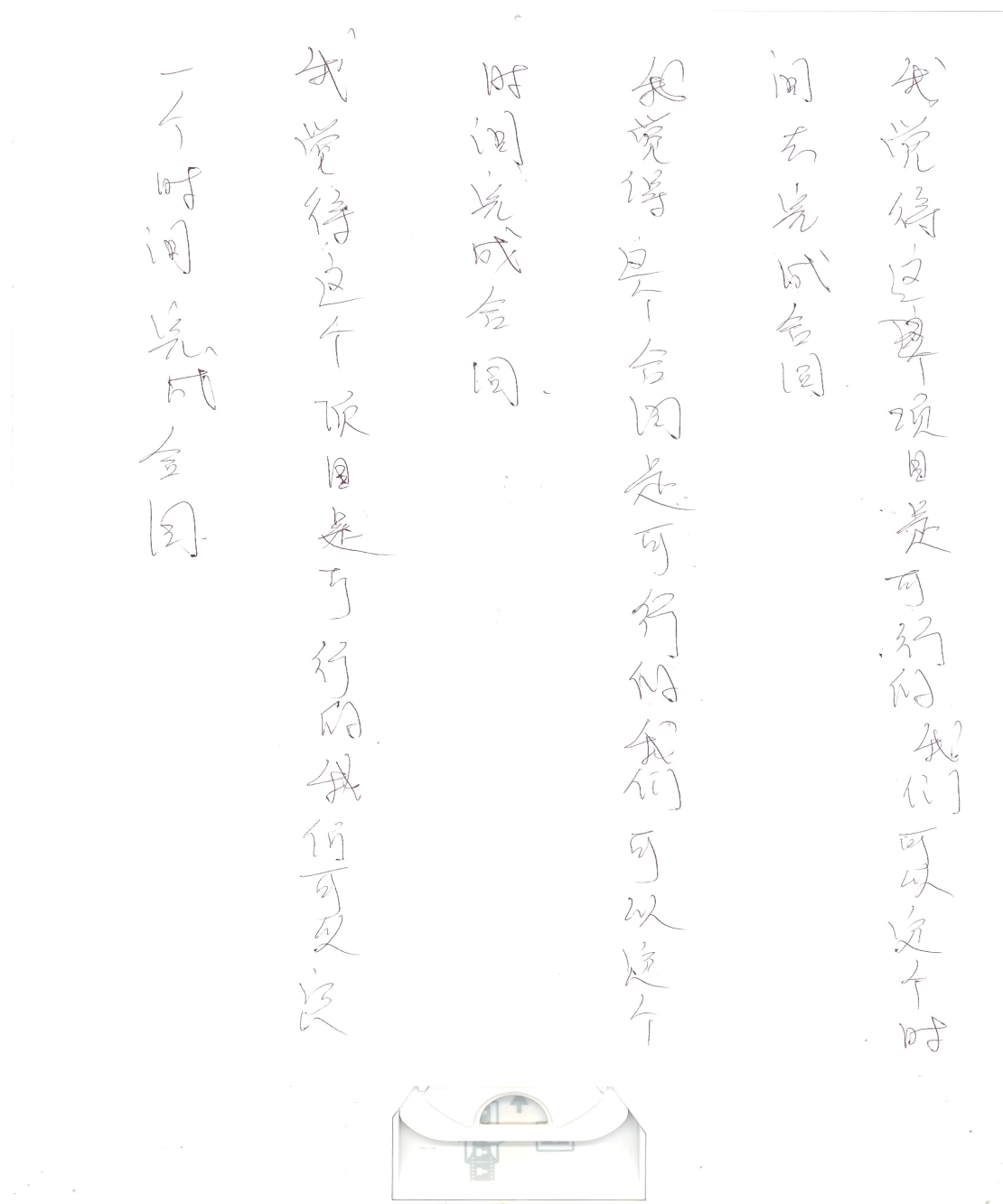


Figure 24. Sample of Use Traditional Formating

Comparison of the Data

Elderly Subjects' Handwriting and ETSU Students' handwriting

Contrary to the summary of the handwriting characteristics and habits of the elderly subjects in 4.2, the young subjects' (ETSU students) handwriting exhibits

almost opposite features compared to their counterpart in the study (e.g. Figures 25 and 26).

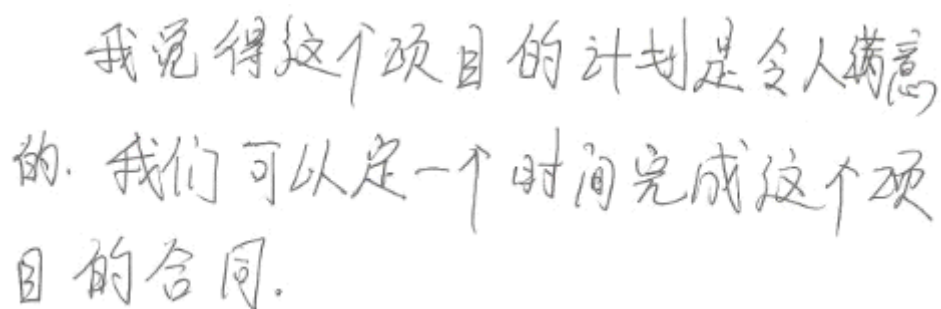
A sample of handwritten Chinese text from a younger subject. The text is written in a relatively compact and clear style. The characters are: 我觉得这个项目的计划是令人满意的。我们可以定一个时间完成这个项目的合同。

Figure 25. Sample of A Younger Subject

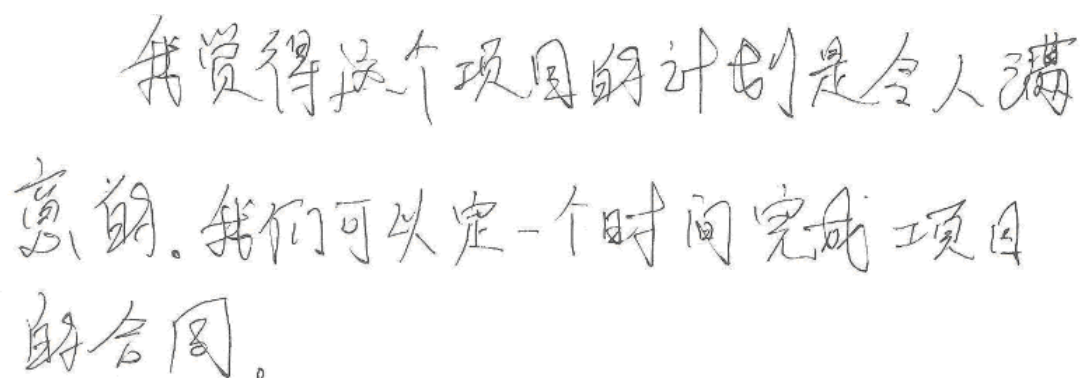
A sample of handwritten Chinese text from an elderly subject. The text is written in a more relaxed and larger style compared to the younger subject. The characters are: 我觉得这个项目的计划是令人满意的。我们可以定一个时间完成项目的合同。

Figure 26. Sample of An Elderly Subject

First of all, as presented before, gathered data from the elderly subjects show that their handwriting normally has bigger letter size and loose character structure with increasing age. The young subjects' handwriting, however, has no correlation between letter size and age. Importantly, compared to the elderly subjects' handwriting pertaining to the letter size and character structure, the young group's handwriting shows notably smaller font and well-constructed structure.

In addition, this study found that the elderly subjects' handwriting possesses distinct features such as bending strokes, half-way stops, and towing signs at beginning and end of the stroke; the younger group's handwriting tends to be very neat and clear, and no sample in the study shows that the young subject wrote

hesitantly. The phenomenon is understandable, for the young subjects in the study are at their summit of intelligence quotient and physical condition, while the elderly subjects are facing the downturn of their physiological and psychological condition (some of the participants even have severe writing related physical problems) that hinder the handwriting ability. Thus, when they were conducting handwriting, the elderly subjects' pen movements possessed various degrees of vibration and trembling, half-way stops, and signs of towing at the beginning and ending of strokes. Especially, the elderly subjects whose age was above 70 and who had writing related physical or psychological problems were inferior to the people who are relatively healthy in handwriting proficiency.

Another crucial difference between the elderly subjects' handwriting and the young group, found in the study, is that some of the elderly used traditional characters and variant forms of words mixed with modern forms. However, not all the elderly subjects' handwriting in the study reflected such characteristics. Some of the gathered samples from the participants with higher education degrees (such as ETSU Chinese faculty) demonstrate this argument very well. On the other hand, none of the young participants' handwriting has traditional characters and different forms of character structure other than the modern forms because none of the young subjects in the study had undergone the traditional Chinese handwriting education. Even though some of the young subjects knew how to write in traditional Chinese, they would not exhibit the special handwriting ability under normal circumstances, which is overwhelmed by the modern Chinese language.

Finally, this study found that one of the notable differences in handwriting of the two groups was that the elderly subjects used vertical lines edition and wrote some old phrases. This phenomenon can be explained by the social context. Before the founding of new China, a variety of newspapers, magazines, and books were basically written in vertical lines, so even now there are many old people who still like to write vertical lines rather than the modern rows. Meanwhile, some of the elderly people are inclined to convey their handwriting expressly in the form of the old phrases. Because those cultural forms of traditional Chinese dominated the era far from the age of the young subjects, none of the young participants' handwriting practices exhibited the vertical lines edition and old phrases that the elderly applied in their response.

Elderly Subjects' Handwriting and the Imitation Handwriting

Based on observation of ETSU Chinese students' imitation handwriting of the elderly subjects, there are mainly three ways for the student subjects to practice their imitation process: trace, imitation by observation, and imitation by memory. Trace means that the study subjects put another paper on the given sample and tried to copy every single stroke of the handwriting on the sample. This is the most frequent method that the student subjects used for the imitating errand because it depends less on writing skills and can be easily controlled and modified. The second method that the young subjects tended to use was imitation, which refers to imitating another's handwriting by watching the sample; the least common method was imitation by memory, which means that people imitate others' handwriting by their memory.

The study results show that the outcomes of imitation handwriting were

varied level due to different imitation methods, handwriting habits, handwriting class, and the other contributing elements. But basically there are five notable characteristics for the imitation handwriting data as followings:

1. Slow pen movement. The normal form of pen movement appears to be smooth and natural with a harmonious sense of rhythm. Especially with beginning and ending strokes, the normal pen movement demonstrates high degrees of consistency and coordination. On the contrary, the simulation handwriting's pen movement is inclined to be hesitating and show a low degree of coordination. In addition, there is less variety in line quality, thus the whole imitation handwriting looks like a duplicate product made by copy machine rather than by hand.

2. Pen pressure is steady and gentle. In order to achieve high degree of similarity to the original handwriting, imitation handwriting was limited by their action system. Thus, the pen pressure for imitation handwriting shows less difference in thickness. Specially, in the imitation handwriting samples that were traced by participants, the strokes from the beginning to the end lack obvious changes and writing rhythm. In some cases the pen movement at joints does not have rapid moving connection but exhibits delayed and hesitating pen movement.

3. Half-way stop. When imitating handwriting people only focus on imitating the shape of the handwriting characters but ignore coordinating with connections and speed of pen movement. Hence, in the study it is often observed that there are some half way stops or multiple breaks in single stroke because the imitator only focused on the copying process but ignored that there are certain relationship between strokes.

4. Modified the strokes. During the imitation process if subjects found some parts of their imitation strokes were not similar enough to the target handwriting or showed too many obvious features of their own handwriting, they tended to add, change, or apply other suitable strategies to remedy the situation in order to make their imitation handwriting reach the ideal standard.

5. Bending strokes (abnormal shape). This handwriting characteristic is typically for imitators who try to simulate handwriting by observation. Because the imitators were conducting the writing movement while watching the given samples, it was easier for the imitator pay too much attention on watching the target handwriting and lose certain control of their pen movements that caused a bending stroke (abnormal stroke shape) at turn points or joints.

Based on the findings for imitation handwriting characteristics from this study, it is safe to claim that the notable characteristics for the imitation handwriting were: abnormal pen movement (some of the collected samples demonstrate that the writer's pen moved fast and slowly without any rhythm, pen pressure was steady lacking natural changes, and bending strokes, make-up strokes, and half-way stops appeared frequently), different writing class (in the handwriting sample the characters exhibit diverse size, slop, line quality, etc.), and poor arrangement (in the handwriting sample, the space between the same character or sentence reflects poor arrangement).

After gaining the basic knowledge of characteristics of the imitation handwriting, the study found a basis to distinguish elderly subjects' handwriting from the imitation handwriting. The following aspects require the examiner's careful

investigations:

1. Pen movement difference. Due to declining physical ability or other contributing factors, the elderly subjects' pen movement generally demonstrates very natural and regular tremor throughout the writing process, which makes some of the strokes bendy and some of the characters poorly constructed. Specially, if the subject's age is advanced and he or she struggled with severe physical dysfunction, every single stroke of his or her handwriting has a number of tremors and the degree of tremor is notable; while imitators' handwriting samples only had unnatural tremors at some parts of strokes (at connection turn or joints)

2. Differences in character structures. The elderly subjects' handwriting, due to declining handwriting skills, show less accuracy pertaining to the character size and construction manner. Elderly subjects' handwriting characters normally have a bigger font and poor structure in general compared to their younger counterpart's handwriting. On the contrary, imitation handwriting in the gathered data has various sizes of characters, structures, and slop. In sum, it is easy to notice that the characters in the imitation group did not match each other very well compared to the elderly subjects' handwriting.

3. Character arrangement. Elderly subjects' normal handwriting concerning the overall layout, and character or sentence arrangement will not be the same as that for the imitation ones, which illustrate irregularity in the overall layout, and character or sentence arrangement

CHAPTER 5

DISCUSSION

Based on the findings about elderly Chinese subjects' handwriting features in Chapter 4, further discussion and summary about handwriting identification of elderly Chinese subjects are presented in this chapter. This section provides some standards for operation of identification of elderly Chinese subjects' handwriting.

Because handwriting is a complex process and each person faces different levels of aging problems that can affect his or her handwriting ability, the characteristics of elderly subjects' handwriting might not fit into defined groupings. For instance, in the study there is an instance available that even though the subject's age is more than 80 years old he or she is still very capable in writing sentences fluently. Thus, when it comes to investigate a true case of handwriting identification involving elderly subjects, examiners should be vigilant with this fact and take full account of the relationship between individual character and general condition.

First of all, the findings in this study reveal that in order to better examine the questioned documents, examiners should gain as much knowledge as they can about the background of the case. Knowledge about the questioned document refers to the potential author's age, race, educational level, career, personal experience, writing skills, interests, and physical and mental condition. If the potential author's age is advanced, aging related factors (physical dysfunction and diseases) should be deemed as indicator variables in the handwriting identification process.

It has been reported by Supreme Court of China that in some of heritage disputes, due to poor health condition or other health related justifications, elderly

subjects asked their family members, children, colleagues, or friends to write their will for them and only sign their name at the bottom of the will. Investigating cases of this kind, examiners should firstly possess full knowledge of the whole context and plot details in order to understand the case and avoid investigation errors.

In addition to obtaining background knowledge of handwriting identification cases, the major goal for elderly subjects' handwriting identification focuses on the study of the questioned document sample and the known files. This study found that similar to the normal people's handwriting, elderly people's handwriting can be classified by three kinds: normal handwriting, affected handwriting, and disguised handwriting. No matter what kinds of handwriting, examiners should first determine whether the characteristics of the questioned documents share the features of elderly subjects' handwriting. Namely, examiners should try to find some basic evidence that indicates the questioned documents are possibly related to an known elderly authorship.

As presented in the previous section, young adults' normal handwriting possesses the following characteristics: their handwritings are consistently fluent throughout the writing process, pen movement speed remains stable, and unreasonable exaggerated written forms are absent; and each stroke has a very natural relationship with other strokes and each character presents a reasonable transitional written form; connection stroke at turning, bending, circling, and other joints points have reasonably natural structure. On the other hand, due to physiological and pathological factors, the elderly subjects' handwriting exhibits tremors and other

unusual features in their handwriting movement. In addition, the specific height and width of the glyph for elderly subjects' handwriting has a certain stability. Namely, elderly subjects' handwriting in general shows a homologous form of regularity.

The discussion above about elderly subjects' handwriting demonstrates that the main outcomes for the changes of an elderly individual's handwriting are: declined writing speed and compromised writing coordination. All these changes are triggered by subjects' internal conditions (intrinsic factors) and external conditions (extrinsic factors). As already mentioned above, intrinsic factors include elderly subjects' physical and psychological factors. In the following section, I briefly analyze the extrinsic factors which affect people's handwriting.

Extrinsic factors that affect elderly subjects' handwriting include unusual writing instruments, unusual writing surface, and abnormal writing posture (such as elderly subjects conduct the writing process while standing, crouching, or lying in bed; in other circumstances, elderly subjects conducted their handwriting in a dark environment)

In this study it was common to observe instances of subjects' standing, crouching, or lying in a wheelchair, and losing a certain degree of balance and automatic control in their writing postures. As a result, the elderly subjects' handwriting demonstrate features such as unstable pen pressure, inaccurate stroke direction, uneven alignments, and towing signs at the beginning and end of strokes. Hence, when examiners are investigating elderly subjects' handwriting, they should take those extrinsic factors into consideration and analyze specific cases in the context

of the handwriting environment. One of the notable examples in the study is that an elderly subject was under extreme physical condition, so his relatives helped him or her (holding the subjects' hand) to complete the handwriting (this elderly subject's right hand was hurt badly from work, and when I invited him to join this study, his forearm was still covered by plaster). In practice, this type of situation has two possible versions. First one is as my provided example: the elderly subjects finish their handwriting process with assistance of the other people. In this circumstance, due to the force from the outside, elderly subjects' handwriting would exhibit inconstant tremors, half-way stops, weak pen pressure, loosen structure, abnormal slopes, unusual font fonts for a few characters, unusual bending strokes, and so forth. In other cases, elderly subjects are barely able to complete the handwriting process, so it requires other people to operate the handwriting on behalf of the elderly.

Finally, concerning the elderly subjects who want to disguise their handwriting, there are no such examples available in my collected samples, and based on other research studies (e.g. Zhang and Wang (1998)), disguised handwriting is not a normal phenomenon for elderly subjects. Basically, the reason for the declined disguised handwriting for the elderly subjects, on one hand, is that the elderly participate in fewer social activities, preferring a simple and quiet life in general, and also they do not want to be engaged in any illegal activities (such as economic fraud and the like). On the other hand, with the decreasing ability of handwriting, elderly subjects' ability to use disguised handwriting also declines relatively. For both of the reasons mentioned above, elderly subjects' disguised handwriting is scarce. Zhang

and Wang (1998) claim that the most common means for elderly subjects to conduct disguised handwriting is to slowly write and imitate others' handwriting. The degree of such disguised handwriting, however, is limited.

Analyze the Questioned Elderly People's Handwriting

Based on the findings in this study, elderly subjects' handwriting identification must first examine whether the handwriting sample can be tested. This is the basis and premise to guarantee an objective test in order to reach an accurate conclusions. The following paragraphs will illuminate a few crucial factors in elderly Chinese people's handwriting identification processes.

1. To determine whether the suspicious handwriting sample has suitable conditions to be identified, the first process is to test if the handwriting is clear enough to be readable. A clear handwriting sample does not necessarily indicate that the sample has value to be identified. A valuable sample has not only clear writing but also shows specific features. This requirement is important because elderly subjects' handwriting samples normally have modified and repeated strokes, and the abnormal strokes can make the handwriting samples blurred and unreadable. Because handwriting identification is tested by comparing the similarities and differences of known handwriting and suspicious handwriting samples, determining the authorship of an elderly subject's handwriting requires that the obtained handwriting samples exhibit certain appropriate characteristics. If the obtained handwriting samples are not clear enough to provide useful information, the handwriting identification cannot be

conducted, because there are not enough characteristics to be compared and tested. Of course, due to diversity and complexity of handwriting samples, we cannot demand every single word in handwriting sample to be completely clear and readable. As long as the tested handwriting samples are able to reflect sufficient individual characteristics, the test conditions should be considered.

2. Elderly handwriting identification should be conducted based on the original evidence. It is required by Chinese Civil Litigation Law that the original documentary evidence should be submitted and the evidence must be the original. If submission of the original document is difficult, copies, photographs, duplicates, or extracts from the original author are required. In sum, providing sound evidence for handwriting identification is an important part in litigation activities, thus handwriting samples should be original in order to ensure the quality of identification. Examiners who try to analyze the dynamic handwriting features of elderly subjects' handwriting, must be able to access original handwriting samples, which means that all the handwriting identification should be conducted with handwriting samples of original authorship.

3. In handwriting identification handwriting samples must have a certain or minimum amount of characters (Meng & Zhao, 1997, p.8). Specifically, in the process of elderly subjects' handwriting analysis, "a certain amount" refers to a number of the current handwriting samples, and also includes the elderly subject's handwriting samples from the past periods of time. Because the handwriting is characterized by aging, if examiners obtain no knowledge of the elderly subjects' handwriting in an

early life stage, they cannot be able to select representative handwriting features to determine the characteristics of handwriting. In turn, handwriting identification would be hard to conduct and this would eventually affect the integrity of the handwriting identification processes. Therefore, only a comprehensive collection of handwriting samples for older persons can meet the standard of inspection such as different angles and levels of comparison and lay a desirable foundation for substantial identification.

4. Examine the comparability of elderly subjects' handwriting samples (Huber & Headrick, 1999, p. 154). Huber and Headrick point out that the known handwriting samples and suspicious handwriting can be compared by the same radical and strokes of the same word. This requirement argues that there are sufficient samples with the same strokes and radicals in handwriting.

How to Test the Questioned Handwriting

Through the analysis from the second and third sections of this paper, I can carefully state that the common characteristics of elderly subjects' handwriting are: loose writing structure, larger letter size, tremors, half-way stops, and towing signs at beginning and ending strokes. In the following section, I analyse the basic elements in handwriting identification.

The Basis for Systematic Analysis

The systematic analysis of elderly Chinese subjects' handwriting identification aims to reveal the elderly Chinese subjects' handwriting habits, special properties, and normal characteristics, in order to assist the identification process.

Based on the results of this study, there are four aspects needed to be considered properly.

1. Dynamic characteristics and static characteristics for elderly Chinese subjects' handwriting. Dynamic handwriting features refer to pen pressure, writing speed, and pen movement during the handwriting process. Because these characteristics (pen pressure, writing speed, pen movement, etc.) are largely manipulated by physiological and pathological factors with people's aging, to carefully examine those factors is the foundation of handwriting identification. For most of the elderly subjects' handwriting that the researcher witnessed in this data collection, their pen speed was reduced, pen pressure was flattened, and there were notable tremors and towing signs at the end and beginning of strokes. Those characteristics become obvious when it comes to advanced age subjects. Thus, when examiners conduct handwriting identification for elderly subjects, they need to carefully evaluate the formation of handwriting based on a dynamic perspective. On the other hand, the static characteristics of the elderly subjects' handwriting are defined as the outcome features of the handwriting samples. In another words, static characteristics are shown from the obtained handwriting sample, such as stroke direction, letter size, writing class, connection ways, and so forth. With increasing age, people's static handwriting characteristics change along with the changes of their dynamic handwriting characteristics. Hence, if examiners carefully study the differences between the dynamic and the static characteristics of handwriting, they are able to reveal the hidden nature and characteristics of elderly subjects' handwriting.

2. Dominant and recessive characteristics of elderly Chinese subjects'

handwriting: the dominant features of elderly subjects' handwriting refers to the handwriting features that can be easily discovered and noticed, which reflect the habits of handwriting action. These characteristics dominate the major aspects of handwriting characteristics. Recessive characteristics of elderly Chinese subjects' handwriting are difficult to find and mainly reveal themselves in details and small movements in handwriting processes such as the subtle aspects of letter shape and strokes. Recessive characteristics represent secondary aspects of handwriting. In elderly subjects' handwriting identification, examiners need to use their best knowledge to reveal the facts from recessive characteristics aside from evaluating the dominant characters. According to the study of analysis elderly subjects' handwriting, the researcher holds the belief that a comprehensive handwriting test requires experimental analysis and careful scrutiny for both dominant and recessive characteristics, in order to provide scientific basis for the final result.

3. The elderly subjects' natural handwriting features and additional features:

the elderly subjects' natural handwriting features refer to those characteristics that are inherent in the elderly's routine writing performance, and they are barely varied when the similar movement repeats. In the evolution of the elderly subjects' handwriting habits, the spelling features, stroke features, special written words, the proportions of the basic form, phrase arrangements, and other combinations of features do not change dramatically when the elderly conduct handwriting movements, and this stability pertaining to handwriting habits reflecting the elderly subjects' natural

handwriting features. On the other hand, additional features of the elderly's handwriting are that the characteristics are not the crucial factors and ingredients but less significant characteristics in handwriting. Additional features of the elderly subject's handwriting include: deliberately disguised handwriting, handwriting movement was conducted under abnormal mental states; handwriting was practiced under special handwriting manners (such as special writing environment and conditions) and others. These additional characteristics of handwriting features reflect false writing habits and interfere with the identification process by creating confusion, so the sample cannot be reliable upon as the basis is not for an accountable analysis.

4. The elderly Chinese subjects' handwritings' stability and changes: based on handwriting identification's perspective, stability in handwriting refers to the handwriting proficiency, handwriting pressure, and characteristics of the font and writing class. Based on the findings of this study, handwriting stability mainly manifested in handwriting formation and writing class such as the use of traditional characters and the variant methods of constructing letters and radical, and these characteristics would not change greatly when people grow old. Changes in handwriting refer to the fact that under general conditions, the elderly's pen pressure changes consistent with their degree of aging. As presented above, the pen pressure of elderly subjects' handwriting in the research appears to be weak and feeble. In addition, the stable characteristics of elderly's handwriting include pen movement, stroke direction, and structure arrangement. Among them, the elderly's pen movement and stroke direction do not change much except that there are some towing signs at

the end and beginning strokes and half-way stops in pen movement.

How to Choose The Comparison Features

A feature is a specific manifestation of different objects applied to distinguish each other. Features are different from specific phenomena, which are certain forms of conclusion for the general nature of objects and resonate with the characteristics of the object. Any feature must have real and specific meaning. Therefore, when it comes to select the features of elderly subjects' handwriting, we must pay attention to pick up specific phenomena in order to distinguish characteristics. According to the researcher's interpretation through the study, the methods for selecting handwriting features are:

1. The method to choose handwriting features: the basic requirement is to select all the major features from the obtained sample. In order to prevent missing features from the profile, the selection processes can start from general features to specific phenomena, from single phrase to the text symbol, and so forth.

First of all, according to the normal pen movement laws, handwriting features can be selected from repeated words, radicals, and strokes. The more times certain writing characters repeat, the more stabilities that features would have. And it is more valuable for examiners to test and classify the distinctions and differences from one sample to another one. Thus, if the tested sample has a large number of words, examiners should first pay attention to repeated words, radicals, and strokes of high frequency. In addition, if the tested sample has a smaller number of words, or possesses few repeated words and radicals, examiners should focus on other

contributing factors such as letter structure and formatting, stroke directions and orders, and writing class.

Second, when an individual's handwriting habit starts to form routine customs, he or she would be inclined to concentrate on the major strokes of writing words and often ignore the minor radicals and characters in the writing. Thus, such ignoring factors in people's handwriting reflects the nature of the individual's handwriting habits, and to successfully examine that can assist examiner's identification work.

Then, concerning some special cases in handwriting identification such as disguised handwriting features selections should start with characters with fluent writing, when examining samples that scattered words and poor structure, examiner should place priority on choosing characters that can be easily identified and readable. Aside from choosing text features to identify people's handwriting, an individual's writing habits can be reflected in some other aspects, so examiners cannot select features only from handwriting body but also pay attention for some other details such as types of pen and paper usage (Zhang & Wang, 1998, p. 301).

2. The method to determine the selected handwriting features: handwriting features substantially represent the concrete signs of personal handwriting, writing skills, and personal handwriting habits. Thus, handwriting features show certain forms of stability. Although aging problems (such as physical function recession) affect elderly subjects' handwriting performance to some extent, their personal handwriting habits still reflect natural handwriting movement dynamic. Specifically, as presented

in previous section, repeated words, characters, and radicals from handwriting samples of the same subject have high degrees of personalized written form and are valuable for handwriting identification. When the comparison sample has a satisfactory numbers of words, it offers adequate information to conduct the identification process. Based on the method mentioned previously, samples can be tested and compared. On the other hand, if the questioned sample does not have enough words to be compared with a sample from known authorship, examiners should consider the following method to test their sample: because the number of the words from the handwriting samples is relatively small, determining the handwriting feature needs to take full advantage of strokes of each word and some other related components. Conduct a comprehensive analysis of line quality, arraignment, stroke direction, structure manner, and morphological characters from one word to another and try to reveal all the useful hidden feature information.

3. A few problems that need attention when choosing elderly subjects' handwriting features: when choosing elderly subjects' handwriting features, examiners should be aware of the potential problems in following areas:

Firstly, due to the change of writing speed and other contributing factors for the nonelderly people (specially to the people with low education), their handwriting can also generate towing pen marks and other characteristics that frequently occur in elderly subjects' handwriting. Therefore, when selecting features from samples to identify handwriting, examiners must be aware of the differences between normal pen towing signs at beginning and end of strokes and the special characteristics of the

elderly people's. I use Figure 27 to illustrate the problem:

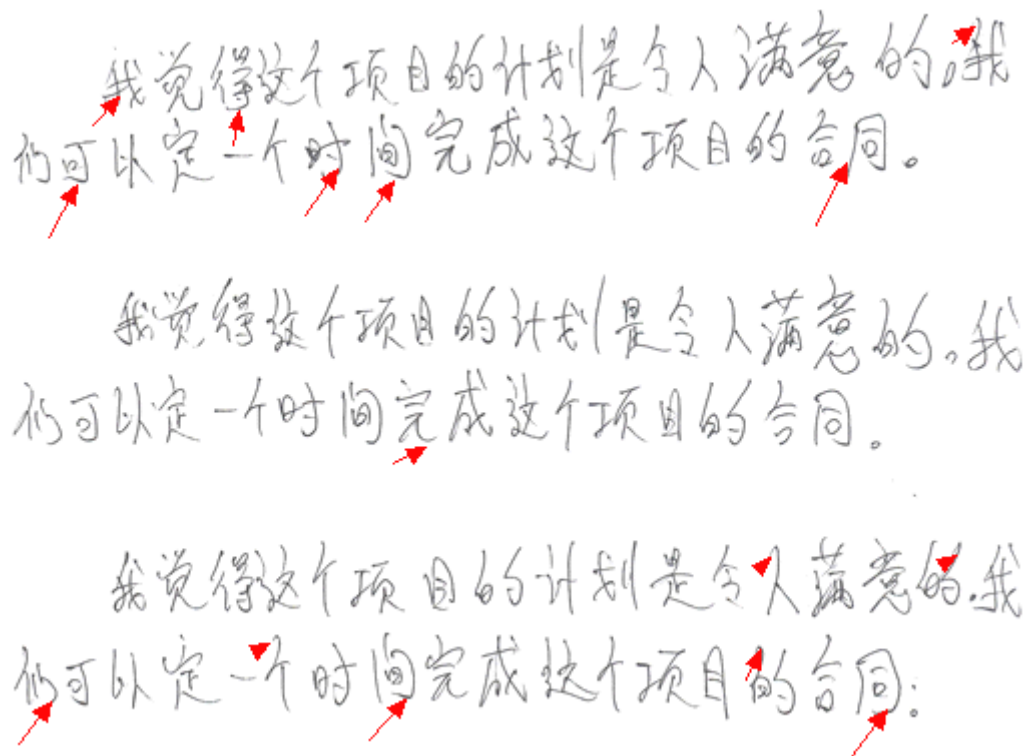


Figure 27. Sample of Towing Signs from An Elderly Subjects

Secondly, applying different writing tools for writing movement can also trigger different forms of handwriting characteristics. For instance, when selecting handwriting features from the elderly, if the elderly used a ballpoint pen to complete the handwriting, examiners should evaluate the handwriting features based on terms of defects in line quality, pen pressure change, morphological differences, and other factors in order to accurately reveal differences or find consistency from the sample. See Figure 28:

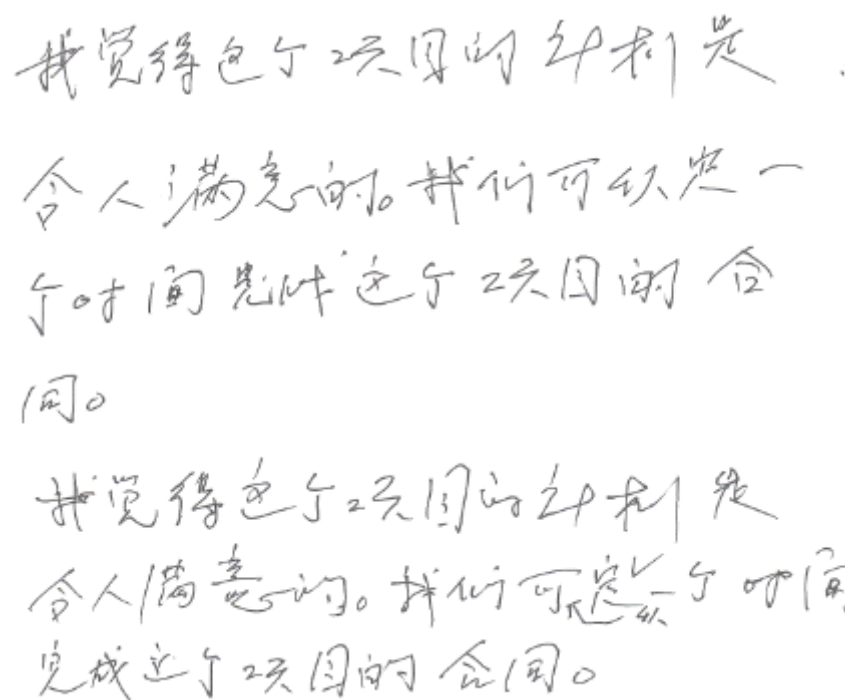


Figure 28. Samples of Using Different Writing Instruments (difference in pen pressure, line quality, connections, and so forth)

Evaluation of the Questioned Elderly People's Handwriting

The procedure to evaluate the questioned elderly people's handwriting is to compare and determine differences and variety between questioned documents and known authorship samples by investigating their features and characteristics in order to find basis for handwriting identification.

Investigating the general characteristics of the elderly subjects' handwriting, is mainly to examine the pen pressure, font, alignment; arrangement, formatting, and positioning; capitalization; connectedness and disconnectedness; cross strokes and dots, diacritics and punctuation; direction of strokes; disguise; embellishments; formation; freedom of execution; handedness; legibility; line quality; method of production; pen hold and pen position; overall pressure and patterns of pressure

emphasis; proportion; simplification; size; skill; slant or slope; spacing; speed; initial, connecting, and terminal strokes; system; tremor; type of writing; and range of variation, and other general characteristics (Huber & Headrick, 1999. P. 54).

Letter Based Evaluation

Based on the study, the researcher developed two methods to investigate elderly Chinese subjects' handwriting. The first one is letter based evaluation, which means that the examiner tries to use single character letters as a basis for the evaluation and identification and extract information from each single character letter. Specifically, it uses the letters from the obtained samples to find and compare their similarities and differences between the selected features. In the comparison process, examiners should concentrate on the same words, the same stroke, and the same components from the handwriting sample as indicator variables, try to find the similarities and differences among those selected elements, and make a record of each finding.

Common Features Based Evaluation

The second method is common features based evaluation. By applying this method, the examiner should carefully investigate the same strokes, the same components, and the same words from the questioned document and a known sample, and try to reveal the significant differences or notice the valuable commonalities. Examiners can use radicals and strokes from different words, components of the similar words, and same order of strokes (or same directions of strokes) as indicator variables. Again, in the identification process, the examiner should be alert about

differences between the common towing signs at beginning and end of strokes (and some other confusing features) from the nonelderly subject's and the natural change of elderly subjects' handwriting characteristics.

Conclusion

After discussing the methods for analysing, comparing and evaluating the handwriting samples, we have collected enough information to summarize the study with a comprehensive perspective of elderly Chinese subjects' handwriting identification.

How to Evaluate Differences in the Handwriting

Based on the investigations, it is safe to claim that some of the changes of elderly subjects' handwriting are due to individual differences, not from the aging effects on elderly subjects; while to the other summarized features for the elderly subjects' handwriting (big font, usage of traditional Chinese words, tremor, etc.), these general characteristics revealed from the study can be applied to identify elderly subjects' handwriting.

Due to the effects of aging on elderly subjects, their handwriting is compromised. Hence, examiners should be very alert because if the handwriting sample was from a long time ago, it would appear to be different from the contemporary handwriting of the same author. When facing cases such as this, current handwritings or handwritings from a recent period of time are required for identification. Specifically, it is necessary for examiners to obtain knowledge of the

elderly subjects' medical history to see if there are any medical facts should be considered in the identification processes.

In addition, the study reveals that different features of elderly subjects' handwriting were formed by diverse environmental factors. For instance, elderly subjects' handwriting is different because they adopt disguised handwriting (such as the elderly subjects used the nondominant hand to conduct the writing movement), different manner of pen movement and pen pressure, different writing instruments and mediums, different applied writing gestures, different writing emotions and so forth. For the analysis of such characteristic differences, examiners can simulate the writing conditions of the handwriting samples or produce experimental samples in order to determine the specific conditions at the time of writing activities. If through the stimulation and experiment the causes of a difference can be proven, the difference is significant enough to be identified.

How to Evaluate Similar Features in the Handwriting

In this study I employed a simple statistical method to assist my analysis. It can be defined by a simple formula: $P(A) = A/N$, where $P(A)$ is the probability of the occurrences of A features and N is the total number of statistical objects. Through the calculation, the occurrence rate of different features can demonstrate the general commonality among the elderly group's handwriting. I found that some of the features have a high frequency of appearance in elderly subjects' handwriting: such as large font, poor structure, and traditional Chinese; and specifically, to the elderly subjects whose age is above 70, half-way stop signs, towing signs at beginning and end of the

stroke, and tremor are dramatically identifiable in their handwriting. In the comprehensive evaluation of the handwriting identification process, these obtained characteristics are very valuable and useful to help examiners identify and recognize the differences and similarities between questioned handwriting and know sample.

Due to social norms, there should inevitably be common aspects of handwriting in different people. In the elderly people's handwriting, the features and characteristics that are consistent with the old written language norms and rules do not possess high value for the identification, such as complex (traditional) characters, and variant characteristics; on the other hand, those features and characteristics deviant from the old writing or violating the rules or norms for the current writing standards (such as spelling, stroke orders, wrong uses of wording, and so forth) have high value for identification.

Conclusive Analysis

When it comes to conclusive analysis of handwriting identification, the first methodology that examiners should adopt is quantitative investigation, which refers to application of statistical techniques to calculate the number of different and similar features in the handwriting samples. This calculation can reveal information to determine the identification outcomes. In general, the features that have overwhelming quantity in number would partially support the final analysis outcome. For instance, if two handwriting samples share more similarities and have less dramatic differences, the phenomena can soundly illustrate that the probabilities of different authorship for the two handwriting samples are less likely to be significant.

On the contrary, if the handwriting samples have overwhelming numbers of diverse characteristics, this information from the handwriting samples indicates the opposite conclusion.

In addition, the comparison of the similarities and differences from the handwriting samples is not only based on the accumulative amount; examiners should also carefully classify the similarities and differences and determine which type of features are more integrated and dominant to reflect the overall handwriting habits and characteristics of the known author. Only the handwriting features that are integrated and dominant pertaining to indicating the known author's general handwriting characteristics, handwriting habits, and other contributing features can be deemed as authentic dominance in quantity and in turn contribute to the final conclusion.

Aside from quantitative investigation, qualitative evaluation should be introduced in handwriting identification in order to fulfill the requirement of a comprehensive analysis. Qualitative evaluation focuses on determining the value of different features. For instance, in the elderly subjects' handwriting samples, those features and characteristics such as special manners of constructing words, misspelling, different stroke order, and unusual matching do not have high frequency of occurrence. Thus, if the handwriting sample in question matches the known sample in the features mentioned above, the matching features have high value in handwriting identification. On the contrary, in the elderly subjects' handwriting samples, characteristics like large font, tremors, half-way stops, and towing signs at beginning

and end of strokes have high frequency of occurrence. Thus, if the handwriting sample in question does not match with the known one in the features mentioned above, the unmatched features indicate a significant difference between the two samples.

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VITA
DONGFANG LIU

Personal Data:

Date of Birth: January 13, 1986

Place of Birth: Chongqing, China

Marital Status: Single

Education:

Chongqing No. 1 Middle School, Chongqing, Chongqing, 2004

Chongqing University, Chongqing, China:

B.S. Electrical Engineering, July 2009

East Tennessee State University, Johnson City, TN:

M.A. Criminal Justice & Criminology, May 2011

North Dakota State University, Fargo, ND :

Candidate for PhD. in Criminology, Present.

Professional Experience:

Graduate Assistant

Dept. Criminal Justice/Criminology 2009-2010

Honors and Awards:

Tuition Scholarship

Dept. Criminal Justice/Criminology 2009-2010

Full Research Assistant Scholarship

Chongqing University, China 2008

Excellent Undergraduate Student

Chongqing University, China 2007

Scholarship for Outstanding Single Course

Chongqing University, China 2006