Chapter 6

# Investigation of Emotion Characters of Internet Abusers Using Psychophysiological Signals

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.73692

**Abstract**

Because of ubiquitous Internet and devices, the numbers of the Internet users rapidly increase. Internet addiction (IA) is also a fast growing, serious, and unavoidable problem around the world. The fifth version of Diagnostic and Statistical Manual for Mental Disorders suggested that IA should be studied in a scientific manner, and more related data must be acquired. Emotion was one important character of IA, and emotion-related syndrome was also reported in these years. IA contains psychological and physiological features and usually is assessed by IA scales. However, self-reporting scale is a subjective measurement tool that may be biased. Furthermore, scales or questionnaires assess the long-term developed states of IA rather than the developing states of IA or short-term change. The physiological signals of IA abusers can provide objective, short-term, dynamic change information instead. Therefore, the dynamic physiological regulation and the psychological and physiological responses to emotion of IA abusers, particularly respiration and respiratory sinus arrhythmia, were studied. IA abusers tended to perform thoracic movement for emotion regulation, whereas people without IA tended to perform abdominal movement. IA abusers exhibited stronger RSA reactivity following negative emotion, but exhibited weaker RSA reactivity following positive emotion.

**Keywords:** Internet addiction, Internet gaming disorder, emotion, physiological signal, respiration, respiratory sinus arrhythmia, heart rate variability, complementary ensemble empirical mode decomposition

## 1. Introduction

Internet has fast developed over these 2 decades and is widely used worldwide. The population of Internet users has reached 3.8 billion in 2017 [1], and the Internet is now an integral

part of life. In UK, USA, South Korea, and Taiwan, the Internet users are over 80% of the population [2], and in Asia, the Internet users of the world total are 49.7% [1]. Some users, however, excessively use, rely on, and even addict to the Internet, and suffer from negative consequences on physical and mental functions, social and occupational problems [2, 3]. Such excessive Internet use is called Internet addiction (IA). IA, first proposed in 1995 by Goldberg, was regarded as a behavioral addiction, and the widely used definitions of IA include preoccupation with online activities, withdrawal, craving, tolerance, mood modification, conflict, relapse, and negative consequences [2, 4, 5]. If users used computer or the Internet over 10 h/day and 6 days/week [6], they have difficulty in finance and in family relationship, poor performance of school or work, etc. [2, 3]. Such users might be potential IA abusers. The definitions of IA given by several researchers are listed in **Table 1**.

The prevalence rate of IA investigated by several countries, such as Norway 0.7%, the US 1%, Europe 1.0–9.0%, and Asia 2.0–18.0%. The rate varied from different countries (0.7–26.8%) [2].

| Authors and Years | Proposed definition |
|---|---|
| Goldberg [7] | A mal-adaptive pattern of Internet use, leading to clinically significant impairment or distress. |
| Young [8] | 1) Reported the very first case of Internet addiction,<br>2) Defined addictive use of the Internet. |
| Young [9] | 1) Proposed the Internet Addiction Scale,<br>2) Proposed two definitions: first definition: behavioral addiction, second definition: Internet-related disorders. |
| Young [10] | 1) An uncontrollable urge,<br>2) Often accompanied by a loss of control,<br>3) A preoccupation with use,<br>4) Continued use despite problems caused by the behavior. |
| Leung [11] | Internet addiction has been used to describe problematic, excessive, or mal-adaptive use of the Internet. |
| Shaw and Black [12] | 1) Time consuming,<br>2) Causes distress or impairs one's functioning in important life domains. |
| Block [13] | 1) Excessive Internet use,<br>2) Withdrawal,<br>3) Tolerance,<br>4) Adverse consequences. |
| Spada [2] | An addictive behavior<br>An impulse-control disorder |
| Brand et al. [14] | 1) Internet use disorder,<br>2) Specific Internet-use disorders |

**Table 1.** Definitions of IA in literatures.

http://dx.doi.org/10.5772/intechopen.73692

Asian countries have higher prevalence rate (e.g., Hong Kong 17–26.8%, Taiwan approximately 20%) [15, 16]. Young reported five types of IA, namely cybersexual addiction, cyber-relationship addiction, net compulsions, information overload, and obsessive computer game playing [17]. The population of computer game players has over one billion in 2012 [18], and the situation that people addicted to the Internet game is called Internet Gaming Disorder (IGD) [19]. IGD is a large population of Internet addicts, and the related research results were the most reported.

The fifth version of Diagnostic and Statistical Manual for Mental Disorders (DSM-5) suggested that IGD/IA should be further studied and more related data must be acquired [13, 20]. DSM-5 addresses and suggests nine criteria for IGD in 2013 [21], including preoccupation, withdrawal, tolerance, reduce/stop, give up other activities, continue despite problems, deceive/cover up, escape adverse moods, and risk/lose relationship/opportunities. The psychological syndromes of IA usually are assessed by IA scales [3, 4, 9]. However, self-reporting is a subjective measurement tool that may be biased, even unintentionally, by a reporter's feelings or forgotten details. Furthermore, scales or questionnaires assess the long-term developed states of IA rather than the developing states of IA or short-term change. Nevertheless, the physiological signals of people with IA can provide objective and short-term information on the condition. In recent years, although a few physiological features of IA were studied [22], the psychological and physiological features rarely investigated together, and the regulation of physiological reactions was little discussed. Both the features can be acquired through emotions, and the physiological regulation can be observed using noninvasive physiological signals. Furthermore, noninvasive physiological signals can provide short-term, dynamic changes of IA, and is a biofeedback means.

### 1.1. Psychological and physiological syndrome, emotion character of Internet addiction abusers

The behavior, psychological characters, and physiological features of IA abusers were reported, such as mood-altering use of the Internet, guilt, emotional, and social withdrawal from real relationship, craving, and fatigue, and users are vulnerable to disease [3, 23–27]. In clinical contexts, IA has been associated with mental disorders, such as substance use disorder [28] and depressive disorder [29]. IA abusers experienced positive feelings (e.g., pleasure, gratifying sensations, security, calm, and belonging) or negative feelings (e.g., frustrate and lonely) when they are able or unable to use the Internet [2, 3], and they express emotional withdrawal symptoms when offline, such as anxiety and depression [5]. The perceived benefits keep people coming back to the addictive experience [30].

Emotion was one important character of IA and IGD. For example, users feel pleasure [23], control, and excitement when online, but feel anxiety and alone when offline [3], and shift emotional states through the Internet or online activities [5]. Emotion can be used to assess pathological Internet use [3]. The relationships among showing emotion, verbal expression of emotions, controlling negative physical reactions, coping, and anger management were examined, and emotion management skill was significant for IA levels. IA abusers exhibited bad emotion management skills [31]. IA and emotional intelligence tests was negatively correlated [32, 33]. Excessive Internet users expressed poorer intimacy, and had worse ability to express positive and negative emotions [34]. The withdrawal symptoms of Internet gaming

disorder (IGD) may indicate an immediate emotional reaction [35]. The possible reasons why people addicted to online game were coping with negative emotions and stress, having entertainment, empowerment, mastery, control, excitement, and challenge [36]. The psychological syndromes regarding emotion of IA are listed in **Table 2**.

Concerning the physiological syndrome of IA, the autonomic nervous responses of high-risk IA (HIA) abusers was studied. The blood volume pulse and respiratory response of HIA abusers would increase, but peripheral temperature and skin conductance would decrease [22]. Heart rate variability (HRV) is one index of autonomic nervous system (ANS) activity. The high frequency percentage acquired from HRV of HIA abusers was lower, but the low frequency percentage of HIA abusers was higher than that of LIA abusers [37]. The results showed that the sympathetic nervous activities of HIA abusers were stronger, and the parasympathetic nervous activities were weaker than that of LIA (low-risk IA) abusers.

Emotion conveys psychological (subjective) and physiological (objective) information, and can be observed and assessed through psychological methods such as self-reports, interviews, questionnaires, and through physiological reactions such as the heart rate, respiration, facial expression, and particularly ANS activities [38]. The ANS which contains the sympathetic nervous system and parasympathetic nervous system, which has antagonistic effects, plays an important role in regulation of physiological reactions and emotions. The emotion-related responses derived from ANS are cardiovascular responses, respiratory responses, and electrodermal responses. These responses usually cannot be manipulated consciously [38–41], and can be measured using noninvasive methods. For example, heart rate variability (HRV) and respiratory sinus arrhythmia (RSA) acquired from electrocardiography (ECG), a noninvasive physiological signal, was a widely adopted index of the regulation of ANS activities. HRV presents the regulation of sympathetic activity and parasympathetic activity, and RSA

| Author | Content |
|---|---|
| Peele (1991) in Young [3] | Emotion and feelings are the psychological hooks of addiction. |
| Young [3] | Emotion can be used to assess IA. |
| Oktan [31] | Emotion management skills were meaningful predictors of IA. |
| Parker et al. [32] | People with IA were reported bad scores on emotional intelligence tests. |
| Far et al. [33] | |
| Oktuğ [34] | Excessive internet users were indicated poorer intimacy, and worse ability to express positive and negative emotions than others. |
| Ko and Yen [35] | Withdrawal symptoms of internet gaming disorder (IGD) may indicate an immediate emotional reaction. |
| Petry et al. [21] | DSM-V: playing games to escape from or forget about real-life problems or relieve negative emotional states. |
| Brand et al. [14] | Urge for mood regulation is an important factor within the development of Internet-use disorders |

**Table 2.** Psychological syndrome (emotion) of IA.

presents the parasympathetic activity, the activity of the vagus nerve, and they were related to emotions [42–44]. Lower resting vagally mediated HRV was associated with greater difficulties in emotional regulation, particularly a lack of emotional clarity and impulse control [43]. RSA is rhythmic fluctuations in the heart rate that are associated with respiration and is related to complex emotion responses and social behavior [45, 46]. Therefore, RSA can be utilized to investigate the relationship between emotions and the parasympathetic activity by noninvasive means [27]. People with higher resting RSA expressed less but reported much negative emotion as those with lower resting RSA. People with higher resting RSA tend to express more positive emotions and to suppress negative emotional expressions [47, 48]. RSA values positively link to positive emotions and negatively correlated to negative emotions [27, 44, 49]. People with IA presented lower parasympathetic activity, lower RSA values [50], and People with IGD exhibited higher sympathetic activity than people without IGD [51]. Respiration is vital for mental and physical functions, and is the only autonomic nervous function which can be both automatically and consciously regulated. For example, abdominal breathing can assist people in relaxing and regulating negative emotions. Respiration can be not only the index for emotions, but also a type of biofeedback to regulate or to change emotions. It was noticed that respiratory response and cardiac response importantly affect regulatory functions, and may also be a regulation means to IA.

IA is a serious problem and is worthy to be studied; however, little attention has been paid to its physiological characters of emotion. Emotions were both a response and an influential factor on IA, and were mainly studied using physiological signals. People use the Internet for several online activities; however, different online activities may be variables to affect the physiological responses and the regulation to emotional stimulation. The general IA abusers and specific IA (IGD) abusers should be considered in the further study.

## 2. Emotional induction experiment

Emotional induction experiments using several emotional induction materials were conducted. The psychological characters were obtained using self-reports and questionnaires, and physiological signals were collected using respiratory belts and ECG. The relationship and differences in respiration between people with IA and people without IA, RSA, and HRV were tested, and the regulation of the parasympathetic activity in emotional states was discussed.

### 2.1. Emotional induction material and experimental instrument

Materials include emotional induction materials, emotional intensity questionnaire, IA scale (Chen Internet Addiction Scale), and physiological signal acquisition equipment. Emotional pictures selected from International Affective Picture System (IAPS) [52], and emotional film clips selected from Taiwan corpora of Chinese emotions and relevant psychophysiological data [53] were utilized for emotional induction materials. Emotional pictures (anger, disgust, fear, sadness, happiness, and surprise pictures), and emotional film clips (anger, fear, sadness, happiness, and fear films) were adopted. Anger, sadness, and fear are negative emotions, while happiness and surprise are positive emotions. Participants rated their emotional

intensity via questionnaire including happiness, sadness, disgust, surprise, fear, and anger, from 0 (lowest intensity) to 8 (highest intensity). DSM-5 IGD criteria and online game film clips as emotional induction materials were adopted for IGD experiment.

Internet addiction (IA) is usually evaluated using self-reported questionnaires, scales, or interviews. Chen Internet Addiction Scale (CIAS) [4], a well-developed and widely applied scale, was adopted. CIAS consists of 26 items and is a self-assessment scale including five dimensions of Internet-related symptoms and problems, namely symptoms of compulsive use, of withdrawal, and of tolerance, and problems in interpersonal relationship, and in health/time management. People can be classified into high-risk IA (HIA) or low-risk IA (LIA). The nine IGD criteria were used in IGD experiment. The cut-point was five, and people with the score over five were IGD.

Physiological signals including respiratory signals, ECG signals, and facial images were collected. Respiratory signals of thoracic movement (TM), abdominal movement (AM), and thoracoabdominal movement (TAM) were acquired using two respiratory belts with sampling rate at 1000 Hz (SS5LB, BIOPAC Systems, Inc., Goleta, USA). The belts were encircled at the level of armpit (TM, channel 1, C1) and navel (AM, channel 3, C3). Electrocardiography (ECG, with three disposable pregelled Ag/AgCl spot electrodes) was used with electrodes applied to the surface of a participant's skin. ECG signals were sampled at 1000 Hz and acquired using the DAQcard (USB 6218, National Instruments Corp., Austin, USA). Facial images were captured using a webcam (Logitech V-UBK45, USB 2.0, 10 fps, 640 × 480 resolution, Switzerland).

### 2.2. Experimental setup and procedure

Sixty-eight participants (12 females and 56 males) aged between 20 and of 29 years were recruited from one university in Taiwan for IA experiment. None of the participants had bipolar or related disorders, depressive disorders, anxiety disorders, or agoraphobia. Participants were randomly divided into two groups, group 1: the emotional picture trial group, 34 participants (6 females and 28 males) aged between 19 and 25 years, and group 2: the emotional film trial group, 34 participants (6 females and 28 males) aged between 19 and 27 years. All participants filled out the CIAS, and were divided into the HIA group (n = 15 of group 1, n = 19 of group 2) or the LIA group (n = 19 of group 1, n = 15 of group 2). This study was approved by the Institutional Review Board of the National Taiwan University Hospital Hsinchu Branch (Hsinchu, Taiwan) under the research Project Number 100IRB-32.

Fifty participants (14 females and 36 males) aged between 20 and 36 years were recruited from two universities in Taiwan for IGD experiment. The participants were divided into IGD & HIA group (n = 19, 4 females and 15 males, aged between 20 and 36) and non-IGD & LIA group (n = 21, 9 females and 12 males, aged between 20 and 28) using both CIAS and DSM-5 criteria. This study was approved by Research Ethics Committee for Human Subject Protection of National Chiao Tung University (Hsinchu, Taiwan) under the Project Number NCTU-REC-102-009.

The experimental procedure consisted of three phases. First, in phase 0, participants were seated in a comfortable chair and introduced to the experimental purpose and procedure, and then signed an informed consent form. Second, in phase 1, the physiological baseline including respiratory signals (TAM), ECG signals, and facial images of participants was measured

and recorded [54]. Third, in phase 2, emotional induction experiment was conducted, and participants were elicited by emotional induction materials [50, 51]. All physiological signals during the whole experimental period were acquired and recorded. These data acquired during the psychophysiological signal baseline was the stage of before emotional induction, and during the recording of the emotional induction was the stage of after emotional induction.

### 2.3. Data analysis and result

Data analysis method included statistics, such as correlation coefficient, T-test, and factorial ANOVA, and signal processing method for ECG and respiratory signals. ECG signals were processed and analyzed using an R-peak detection method. The RR intervals were transformed into an auto power spectrum, and the obtained HRV contained three frequency bands—high frequency (HF, 0.15–0.4 Hz), low frequency (LF, 0.04–0.15 Hz), and very low frequency (VLF, <0.04 Hz, excluding 0.00 HZ). Usually, HF indicates a parasympathetic nervous response and LF indicates a sympathetic nervous response. The RSA value was calculated as HF/((HF + LF)). Complementary Ensemble Empirical Mode Decomposition (CEEMD) which has been validated to be suitable for respiratory signals was applied to decompose respiratory signals [55]. CEEMD can acquire high frequency (HF, muscle contraction frequency), dominant frequency (DF, main respiratory frequency), and power of each respiratory signal. We are curious about the responses or reaction intensity (normalized power difference value) to several emotional stimuli from different time scale materials of IA abusers. The value of normalized power difference upon before and after the emotional inductions indicated the respiratory amplitude (emotional intensity), and the trend of difference implied the positive and negative respiratory responses. The differences in TAM, ECG (RSA) between HIA and LIA were examined.

### 2.4. Result

No statistical difference in age and gender existed whether in IA experiment or in IGD experiment. The consistency of CIAS scoring, IGD scoring, and emotional intensity among participants was tested, and results (Cronbach's alpha values) were acceptable [56]. Regarding the results of respiratory signals, the normalized power differences of high frequency (HF) and dominant frequency (DF) varied along different emotions. The HIA and the LIA groups also exhibited different normalized power differences among some emotions. Respiratory amplitude and frequency implied the emotional intensity of physiological reaction. In the HIA group, the power differences of DF in positive and negative emotional states were less consistent than those in the LIA group, and the trends of difference were almost opposite. The emotional effects on respiratory amplitude almost positively affected the HIA group but negatively affected the LIA group. The results of trends of respiratory power difference suggested that when HIA group in whether negative or positive emotional states, their thoracic movement was mainly responsible for respiratory regulation, whereas LIA group mainly used abdominal movement to regulate respiration [30]. Concerning the autonomic nervous response, the results of RSA and HRV indicated that the RSA base of the HIA group was lower than that of the LIA group. Hence, the HIA group did not tend to express positive emotions. They may express negative emotions rather than positive emotions, and did not suppress negative

emotions [47, 48]. The RSA reactivity to positive emotions was not varied that much as that of negative emotions. The results of RSA reactivity of before and after emotional inductions were shown in **Table 3**. The summary result of emotional intensity, TAM and RSA reactivity in IA experiment was shown in **Table 4**.

| | **RSA reactivity** | | |
|---|---|---|---|
| **Emotion** | 1: Before emotional induction | 2: Emotional state | Difference (2–1) |
| **Negative** | HIA < LIA | HIA < LIA | HIA(0.029, ↑) > LIA (0.000, −) |
| Anger | | | HIA(−0.031, ↓) > LIA (−0.010, ↓) |
| Fear | | | HIA(0.107**, ↑) > LIA (−0.004, ↓) |
| Sadness | | | HIA(0.017, ↑) = LIA (0.017, ↑) |
| **Positive** | HIA < LIA | HIA < LIA | HIA(0.125**, ↑) > LIA (0.016, ↑) |
| Happiness | | | HIA(0.126*, ↑) > LIA (0.080, ↑) |
| Surprise | | HIA > LIA | HIA(0.124*↑) > LIA (−0.053, ↓) |

HIA: high-risk IA; LIA: low-risk IA; ↑: increase; ↓: decrease; −: no difference; *p < 0.05; **p < 0.01.

**Table 3.** RSA reactivity before and after emotional inductions.

| **Group** | **1** | | **2** | |
|---|---|---|---|---|
| Stimulation | Picture (static stimulation) | | Film (dynamic stimulation) | |
| Emotion intensity | HIA > LIA (questionnaire) | | HIA < LIA (questionnaire) | |
| Emotional type | Positive | Negative | Positive | Negative |
| TAM (power difference) | HIA | | HIA | |
| | TM (−0.34, ↓) AM (−1.32, ↑) | TM (0.21, ↑) AM (−0.87, ↑) | TM (−0.19, ↓) AM (−2.22, ↓) | TM (0.20, ↑) AM (0.63, ↑) |
| | LIA | | LIA | |
| | TM (0.11, ↑) AM (0.44, ↑) | TM (−1.44, ↑) AM (0.27, ↑) | TM (−4.33, ↓) AM (−1.42, ↑) | TM (−2.70, ↓) AM (−4.26, ↑) |
| | HIA: TM, LIA:AM<br>TM: breathing frequency changed faster<br>AM: breathing frequency changed slower (parasympathetic) | | | |
| RSA reactivity | | | RSA↑ (except surprise) (HIA*↑ < LIA↑) | RSA↓ (except sadness) (HIA*↑ < LIA↓) |

HIA: high-risk IA; LIA: low-risk IA; TAM: thoracoabdominal movement; TM: thoracic movement; AM: abdominal movement; RSA: respiratory sinus arrhythmia; ↑: increase; r: decrease; *p < 0.05.

**Table 4.** Summary table of emotional intensity, TAM, and RSA reactivity in IA experiment.

http://dx.doi.org/10.5772/intechopen.73692

The experimental result of IGD experiment indicated that the IGD & HIA group felt more positive emotion for online game films than the non-IGD & LIA group, and the IGD & HIA group exhibited weaker physiological activity to online game films than the non-IGD & LIA group. It was interesting that IGD abusers have positive emotion to online game films, but they self-rated not much physiological activity (arousal) than people without IGD. The results of HRV index (LF/HF) in the IGD & HIA group also implied that the IGD abusers exhibited stronger sympathetic nervous activity or weaker parasympathetic nervous activity. The parasympathetic activity of the IGD & HIA group to regulate negative emotions was weaker than the non-IGD & LIA group, which consisted with the RSA results of IA experiment.

It is noticed that the effect of induction material, film and picture, was different. Emotional films induced a single targeted emotion, whereas some emotional pictures (anger and fear) induced multiple emotions. The stimulation type and time interval may cause such difference [57]. For temporal character, picture is a kind of static stimulation which displayed lasting for 12 s, and one frame is regarded as one stimulus. The emotional film clip is a kind of dynamic stimulation which displayed lasting 180 s (1/30 s/frame), and it is total 5400 stimuli for 180 s. Nevertheless, the display time of induction material was different from film and picture, and that may affect the emotional induction effect. For cognitive feature, films convey complex cognitive feature and can catch people's attention [57]. The emotional complexity was observed from the emotional picture trial but the film trial. In the real world, people usually receive dynamic stimulation rather than static stimulation, and therefore, the emotional film inductions are more close to the real world stimulation. In addition, the negative emotional materials induced multiple negative emotions. The stimulation type and property were shown in **Table 5**.

| **Property** | | | **Film** | **Picture** |
|---|---|---|---|---|
| Substantial [57] | Temporal | Display time | 1/30 s/frame | ∞ s/frame |
| | | Stimulation period | 180 s | 12 s |
| | Spatial | Resolution | 1180 × 800 | 1024 × 768 |
| | Feature | | 1. Complex cognitive feature | |
| | | | 2. Catch attention | |
| Emotional | Type | | Positive/negative | Positive/negative |
| | Complexity | | | 1. Fear overlaps surprise |
| | | | | 2. Anger overlaps surprise and fear |
| Stimulation | | | 1. Real world stimulation | Static stimulation |
| | | | 2. More pure emotional induction | |
| | | | 3. Dynamic stimulation | |
| | | | 4. Dynamic physiological regulation | |

**Table 5.** Stimulation properties of film and picture induction materials.

## 3. Conclusion

IA is a hot and serious issue worldwide, and psychophysiological relationship between emotion and IA using physiological signals was studied. This study was not only a hypothesis testing research, but also a hypothesis generating research. Emotion and physiological signals play important roles in (dynamic) expression and regulation of emotional responses to IA. Emotional induction experiments were conducted to acquire respiratory signals (thoracoabdominal movements), ECG signals, facial images, and self-assessed emotional intensity of IA abusers and IGD abusers. Complementary Ensemble Empirical Mode Decomposition (CEEMD) was also adopted as a feature extraction method for respiratory signals without phase loose or distortion. The power values, respiratory amplitude, of dominant frequency from thoracic movement and the abdominal movement in HIA and LIA groups were analyzed. The HIA group and the LIA group expressed different respiratory response upon positive and negative emotional inductions. The induction effects of emotional picture and film stimulation were also different. The autonomic nervous responses were also considered. RSA and HRV index computed from the ECG signals, reflected autonomic nervous system (ANS) activity, and particularly vagus nerve regulation (RSA reactivity). The results revealed that the HIA group had a lower RSA level than the LIA group. IA abusers (HIA) exhibited stronger RSA reactivity following negative emotion, but exhibited weaker RSA reactivity following positive emotion. The emotional responses of IGD abusers were also examined. IGD abusers had stronger happiness feelings to positive emotional online game films, and felt multiple negative emotions to negative emotional online game films. IGD abusers have more positive emotion, and stronger sympathetic activity, but weaker physiological activity to the online game films than those of people without IGD. This study provides results of respiration, HRV index, and RSA reactivity, the ANS and vagus nerve activity of IA abusers, and assists further study of the emotion regulation of the ANS for IA abusers.

## Acknowledgements

This work was fully supported by the Taiwan Ministry of Science and Technology under Grant Numbers MOST 103-2221-E-009-139, MOST 105-2221-E-009-159, and MOST 105-2634-E-009-003. This work was also supported in part by the "Aim for the Top University Plan" of the National Chiao Tung University and Ministry of Education, Taiwan, R.O.C. This study was approved by the Institutional Review Board of the National Taiwan University Hospital Hsinchu Branch (Hsinchu, Taiwan), under the research project: A study of interactions between cognition, emotion and physiology (Contract No: 100IRB-32), and was approved by the Research Ethics Committee for Human Subject Protection of National Chiao Tung University (Hsinchu, Taiwan), Contract No: NCTU-REC-102-009-e. Thanks team members, Hong-Ming Ji, Shang-Chun Hsieh, Yi-Hua Huang, and Yao-Ming Wu, for assisting this study.

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