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11 Exploring media psychophysiology: conceptual, theoretical, and methodological considerations

Abstract: This chapter provides an overview of the current theoretical and methodological issues in media psychophysiological research. Media psychologists interested in cognitive and emotional processing of media employ psychophysiological measures and their conceptual correlates as they explore, apply, and develop theory while also providing data to inform policy and practitioners. This chapter provides a basic foundation for the conceptual, validity, and analytic issues in the field. Specific psychophysiological measures discussed are electrodermal activity (EDA), electrocardiography (ECG), electromyography (EMG), and facial expression analysis (FEA). The chapter also includes a discussion about analyzing psychophysiological data over time and challenges and future directions.

Keywords: Media Psychophysiology, Cognitive and Emotional Processing of Media, Theoretical Perspectives, Psychophysiological Measurement

1 Introduction

Psychophysiology has been defined as the “study of the interrelationships between mind and body. Psychophysiolgists study primarily human subjects using non-invasive molar physiological responses . . . typical psychophysiological measures such as heart rate, skin conductance, and skeletal muscle activity as used to index long-lasting states such as arousal and emotion” (Schell and Dawson 2001: 12448). Potter and Bolls (2012: xvii) state that psychophysiological measures enable “(t)he observation of mental processes embodied in the brain that are engaged during media consumption”, and that media psychophysiology is “the application of psychophysiological measures in media research”. The brain is connected to all organs through a system of neurological, chemical, and muscular connections. Therefore, an assumption of psychophysiolgists is the belief that aspects of the mind can be assessed by measuring physiological signals in the body. The notion of the “embodied mind” is that the experienced mind is influenced by bodily signals and functions, as the body responds to aspects in its environment. As Clayton (2023: 60) explained, “mental expe-

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rience does not exist without the ongoing physical activity of the brain” and that “information travels from the brain to the periphery via the nervous system but is also received reciprocally from the periphery”. Hence, measuring physiological signals can indicate dynamic psychological processes undergone during exposure to media. This perspective has become more popular among media researchers over time.

Among the earliest examples of the use of psychophysiology (specifically electroencephalography; EEG) in communication research is work by Rothschild, Thorson, Reeves, and their colleagues in the mid-1980s (Reeves and Thorson 1986; Rothschild et al. 1986; Thorson, Reeves, and Schleuder 1987). In their work, Reeves, Thorson, and colleagues measured EEG during television commercials. They found that alpha-blocking – long considered an indicator of attention – occurred during specific cuts and edits in the commercials (Rothschild et al. 1986). These scholars, and particularly Annie Lang, were central in the proliferation of research labs that measure psychophysiological variables during exposure to media messages. Indeed, Lang established experimental communication labs at Washington State University and later at Indiana University, which spawned dozens of media psychology labs worldwide as her students embarked on their own research careers. Many of Reeves and Thorson’s students likewise created their own media psychophysiological research labs (Leshner 2017).

Another reason for the acceleration of established media psychophysiology labs is the advantages they afford for data collection. For instance, implicit measures of attention, arousal, and emotional valence via electrocardiography (ECG), electromyography (EMG), electrodermal activity (EDA), EEG, and eye-tracking (see Liu and Wang, Chapter 12, this volume), in conjunction with traditional self-report measures, provide greater opportunities for theoretical advancement than with self-reports alone (Clayton 2023). Implicit measures also help researchers to understand the so-called “black box” of the human mind as it processes media content (Geiger and Newhagen 1993; Potter and Bolls 2012).

Moreover, psychophysiological data significantly enrich communication science by illuminating the cognitive and emotional processing of media, especially when combined with relevant theories that inform individual media interactions. For example, collecting heart rate data in response to a media message becomes significantly more valuable when interpreted through psychological variables or states (Lang 1994). By establishing these conceptual connections, researchers can derive a deep understanding of how variations in physiological signals correlate with media processing, rather than merely noting whether a signal has increased or decreased in response to specific content.

This chapter provides an introduction and assessment of the overall theoretical and methodological issues of psychophysiological data in the context of media studies. We further restrict the discussion to peripheral forms of psychophysiological data, that is, data that are collected from the peripheral nervous systems (PNS). Psychophysiological data from the central nervous system (CNS) are presented elsewhere in this volume.

2 Conceptual issues

Potter and Bolls (2020) argue that a fundamental assumption of psychophysiology is that the mind is part of the human body. Information is sent from the brain to neurons, organs, muscles, etc. to all parts of the body. That information is also received by the brain as physiological signals are sent from distal parts of the body to the brain. “These measures are most useful for advancing communication when interpreted in light of how they correlate with psychological constructs such as attention, motivation, and emotion. When this happens, the enterprise is called psychophysiological research” (Potter and Bolls 2020: 266). For media scholars, a fundamental question is: are media special environmental stimuli somehow privileged over “real world” stimuli such that media are processed in the brain and somehow bypass mediating physiological systems? The perspective adopted by media psychophysiological theorists is that media are not special. Media engage physiological systems in the body that can impact how the brain formulates media experiences. From this perspective, we ask what are “media”?

Traditionally in media research, media have been defined by common and familiar industry functions, such as newspapers, magazines, television, radio, films, books, etc. The emphasis characterized media research as searching for *effects* media have on people (e.g., Payne Fund Studies; Petersen 2013). Searching for media effects was the dominant paradigm but began to shift in the 1980s to media *processing* (Chaffee 1980). Expanded histories of this shift are offered in Lang, Potter, and Bolls (2009) and Potter and Bolls (2012).

However, a media psychophysiological perspective defines media in terms of their psychological relevance, specifically how they would impact dynamic physiological systems, rather than by the typical industry-driven definitions. Reeves and Nass (1996) argue that attributes of media (e.g., text, pictures, sounds, movements) and the “boxes” they come in, form a different array of environmental stimuli that impact physiological responses, which then impact conscious and nonconscious experiences in the mind (Reeves and Thorson 1986). From a media psychology perspective, media are better defined in terms of the connections to psychological processes rather than in terms of industries. “[M]edia must be conceptualized as complex stimuli with multiple psychologically relevant variables continuously changing over time. The fluctuation of those variables will then initiate real-time interaction with the embodied brain, which means that media use is an interaction over time between two complex dynamic systems” (Lang, Potter, and Bolls 2009: 187). Since media can be considered a collection of environmental stimuli to which humans respond, psychophysiology provides useful tools to assess the multitude of impacts media can have on human cognitive and emotional processing of mediated content.

3 Theoretical perspectives on emotion, cognition, and psychophysiological measures

Although there is not a universally accepted definition, most theorists have considered “emotions” as internal mental states that represent evaluative and valenced reactions to events, agents, or objects that vary in intensity (Ortony and Turner 1990). Emotions have been examined from two dominant perspectives in the field of communication including the discrete perspective and the dimensional perspective (for a recent review, see Clayton 2023). Most often operating from a dimensional perspective (Cacioppo, Gardner, and Berntson 1997, 1999; Russell 1980), psychophysiologicalists have defined emotion as an affectively valenced response emerging from basic motivational processes in response to an evaluation of some object or stimulus (Bradley et al. 2001; Lang and Bradley 2008; Lang, Bradley, and Cuthbert 1997b).

The dimensional perspective of emotion is based on Russell’s (1980) circumplex model of affect. The dimensional perspective of emotions argues that specific, discrete emotions are highly intercorrelated; thus, discrete emotions can be organized on a two-dimensional circular space that is further divided into four quadrants (Russell 1980). One dimension varies on “arousal” which extends from “excited to calm” while the other dimension varies on affective valence which extends from “pleasure to displeasure” (Russell 1980).

In the early 1990s, Cacioppo and colleagues introduced the notion of ‘biological motivation’ within the dimensional perspective of emotion. The “evaluative space model” (ESM) was subsequently conceived and posits that two independent, evolutionary-based motivational systems are directly linked with the experience of emotional valence (Bradley et al. 2001; Cacioppo and Berntson 1994; Cacioppo and Gardner 1999; Cacioppo, Gardner, and Berntson 1999; Lang et al. 1997b). The appetitive (approach) motivational system is posited to activate in response to a positive stimulus, which results in an increase in positive emotional valence as well as approach tendencies such as increased attention to the stimulus (i.e., positivity offset). In contrast, the aversive (avoid) motivational system is posited to activate when a threat is perceived in the environment (i.e., negativity bias). Thus, this system has evolved over time to lead to fight-or-flight behaviors (i.e., protection) (Norris et al. 2010). As such, research has shown the activation of the aversive motivational system leads to greater negative emotional valence (Lang et al. 1997b; Norris et al. 2010). Further, research has shown that both motivational systems can activate simultaneously (i.e., coactivation) resulting in both positive and negative emotional valence, or activate reciprocally, uncoupled, or be inactive (i.e., when neither system is activated) (Cacioppo and Berntson 1994; Cacioppo, Gardner, and Berntson 1999; Lang et al. 1997b; Norris et al. 2010). Coactivation indicates that the appetitive and aversive motivational systems operate independently, and are better conceived as such, rather than as two directions of the same dimension.

4 Methodological considerations

In this section, the most common psychophysiological measures used in media psychology are reviewed, with a focus on data considerations. We also present some recent research to serve as examples of how these measures are typically used by media psychologists. The biology behind these measures is presented briefly, with directions to the readers for more in-depth treatment in comprehensive sources.

4.1 Electrodermal activity (EDA)

Media psychology researchers are often interested in how people respond to emotionally arousing media. Electrodermal activity (EDA) is a response to such stimuli. EDA – also referred to in the literature as galvanic skin response (GSR), electrodermal response (EDR), and skin conductance (SC) – is a relatively easy measure of autonomic sympathetic arousal. EDA originates from the autonomic activation of sweat glands in the skin. The sweating on hands and feet is triggered by emotional stimulation. Our body has about three million sweat glands. The density of sweat glands varies markedly across the body, the highest being on the forehead and cheeks, the palms and fingers as well as on the soles of the feet.

Whenever sweat glands are triggered and become more active, they secrete moisture through pores toward the skin surface. By changing the balance of positive and negative ions in the secretion, electrical current flows more readily, resulting in measurable changes in skin conductance. Although the primary purpose of sweat emission is thermoregulation, sweating on hands and feet is also triggered whenever we are emotionally aroused.

The appearance of so-called “flop sweat” is not necessary in order to see differences in EDA as the sweating does not need to be visible to the naked eye. With EDA you can tap into unconscious message processing that is not under conscious cognitive control. EDA is solely modulated by autonomic sympathetic activity that drives bodily processes, cognitive and emotional states as well as cognition on a subconscious level. EDA activity is typically measured in micro-Siemens (μS).

EDA is recorded non-invasively using electrodes placed on the skin and requires minimal preparation time. Generally, EDA sensors have a 1 cm^2 measurement site made of Ag/AgCl (silver/silver chloride) and are placed with either reusable snap-on Velcro straps or with an adhesive collar, the latter of which requires the use of conductive gel. The method of physical measurement will depend on the recording system.

The EDA signal is comprised of two main components: a slowly varying tonic or baseline level, known as skin conductivity level (SCL) and a phasic component, known as skin conductance responses (SCRs), which include reactions to specific eliciting stimuli (SCR peaks) and non-specific skin conductance responses (NS-SCRs). NS-

SCRs are SCRs that are unrelated to any eliciting stimulus and occur spontaneously in the body at a typical rate of one to three per minute. SCRs are of interest in emotional quantification, as they provide a measure of the level of arousal and engagement of an individual in response to a known stimulus (typically a message feature of interest; Shimmer 2015). Individual SCRs are often characterized by metrics such as their latency, amplitude, rise time, and recovery time (Kreibig 2010). Between SCL and SCR in media psychology research, SCL is the more common metric.

SCL is a tonic analysis that aggregates sampled data (often in one-second increments). The researcher then computes change scores from a baseline for data analysis. SCL can show increases and decreases in autonomic arousal across the range of message exposure. An example of a typical SCL analysis is Wise et al. (2009). They had participants read four news stories that contained health threats – two from “high-proximity” and two from “low-proximity conditions”. They collected ten seconds of baseline prior to exposure for each story, and then calculated change scores for each second of SCL during message exposure. They found that skin conductivity was higher for the high-proximity stories than the low-proximity stories, and this difference appeared to grow larger over time.

However, others have examined key points of interest within a message that required a different analysis. An example is Gangadharbatla, Bradley, and Wise (2013). In their study, participants played a video game, in which they passed under a billboard advertisement. Gangadharbatla, Bradley, and Wise sought to examine the points at which each participant passed beneath a product billboard. The researchers placed markers four seconds prior to and six seconds following passage beneath each billboard. They surmised that an increase in skin conductivity of passing under the billboard would be detected approximately three to four seconds after the billboard. Their data supported their hypothesis, such that skin conductivity increased in relation to passing under the billboard in the video game.

Analyzing SCRs requires a different process. SCRs are the number of EDA “peaks” observed during message exposure. Each SCR is quantified by detecting peaks within the EDA data, which provides a count of how many such peaks occur during an experimental condition. To detect “peaks”, often the recording system software will provide algorithms and procedures that allow for automatic detection. Typically, this requires the researcher to find the maximum SCR value (the maximum peak) within each pair of onsets and offsets. The peak amplitude is the amplitude at the peak minus the amplitude at the onset. Peaks can be counted for each message and/or they can occur shortly after a message feature of interest.

A relatively early example in media psychology that measured SCRs is Detenber, Simons, and Bennett (1998), in which the researchers found that moving pictures elicit greater arousal (measured with SCRs) than still pictures, and this occurred across a range of content (i.e., whether the pictures were positive or negative). Dillman Carpentier and Potter (2007) reported both SCL and SCRs. They were interested in metronome beats per minute as auditory structural features, with increased tempo leading

to greater skin conductance. They found that SCR frequency was greater during music processing than during no music (silence). They also revealed that SCL showed that fast-paced music elicited greater activation than lower-paced music. Interestingly, they also found that music genre interacted with tempo on SCR frequency, with faster tempo increasing SCRs for classical music and decreasing it for rock music.

Potter and Bolls (2020: 267–268) provide a table of recent communication research that used PNS measures, including indicators of SCLs and SCRs. Clayton (2023) and Bolls et al. (2020) provide a more historical overview of the measurement of EDA, including best practices for EDA measurement. Although EDA is an ideal measure to track emotional arousal, it is not able to reveal the valence of the emotional response. As with other PNS measures, it is best to interpret EDA in conjunction with other PNS measures and with self-report data.

4.2 Electrocardiography (ECG)

Cardiac activity is a common measure used in media psychophysiology and is most often measured with an electrocardiograph (ECG). ECG is a non-expensive, noninvasive, and completely passive recording technique. ECG data also has excellent millisecond time resolution, making it an ideal research tool for studying the precise timing of emotional and physiological processing. Both standard and advanced analytical methods provide deep and credible insight into human behavior processes.

Measuring ECG involves placing sensors on a combination of extremities (e.g., arms, ankles) – the precise placements are dependent on the ECG data collection system being used. Often, sensor placement involves one sensor on each forearm, slightly below the elbow, and one or two on the wrist to provide a ground. ECG systems use gelled electrodes attached to the skin to pick up electric potentials generated by the heartbeat. Specifically, ECG records the electrical activity generated by heart muscle depolarizations, which propagate pulsating electrical waves toward the skin. Although the electricity amount is in fact very small, it can be picked up reliably with ECG electrodes (in microvolts, or μV).

Among the metrics recorded by ECG is heart rate (HR). HR reflects the frequency of a complete heartbeat from its generation to the beginning of the next beat within a specific time window. It is typically expressed as beats per minute (BPM). HR can be extracted using ECG and PPG (photoplethysmography) sensors. Interbeat interval (IBI) is the time interval between individual beats of the heart, generally measured in units of milliseconds (ms). Typically, the time between R-spikes (RR-interval) is used for the analysis. R-spikes are upward peaks in an electrocardiogram that represent the moment of ventricular depolarization – the point when the ventricles contract. IBI and HR are statically related (Potter and Bolls 2012: 78).

Importantly, HR acceleration and deceleration can inform the researcher of the psychological meaning of the extent to which cognitive resources are allocated to en-

coding information into working memory or whether defensive processes are engaged. According to Potter and Bolls (2012: 76), HR deceleration during media exposure indicates an increase in cognitive resource allocation whereas HR acceleration indicates a “rejection of environmental stimuli in support of other processes involved in responding and adapting to one’s environment”.

Clayton et al. (2020a) expand on the psychological meaning of HR acceleration and deceleration. They state that greater heart deceleration via parasympathetic nervous system activation is a valid and reliable indicator of greater cognitive resources allocated to encoding message content (Berntson, Cacioppo, and Fieldstone 1996; Lacey and Lacey 2007; Lang 1994; Wetzel et al. 2006), whereas HR acceleration is an indicator of fewer cognitive resources allocated to encoding content (Bartholow and Bolls 2013; Clayton et al. 2019; Lang 1994, 2006, 2009, 2017; Thorson and Lang 1992). However, research has demonstrated that the allocation of resources to *internal* processing (e.g., counterarguing, visualization, defensive processing) results in HR acceleration (Bolls 2002; Clayton et al. 2019; Clayton et al. 2023a; Wang et al. 2012). This conceptualization has proven quite useful to researchers studying media psychology as cardiac deceleration and acceleration have been studied at both phasic and tonic levels.

4.2.1 Analyzing HR

Since a person’s HR can be influenced by many things, it is important for the researcher to highly control the environment in which participants experience media. HR is especially susceptible to movement artifacts, meaning that participant movements may create changes in HR that are independent of the stimuli under study.

Actually, it is generally not the raw BPM that researchers analyze, but rather the change scores from the baseline. Each person has their own resting HR, which could vary by more than 40 BPM. It is not unusual for one participant to have a resting HR of 60 BPM, while another has a resting HR of 90 BPM or higher. The possibly large variations across individuals’ resting HR make it untenable to analyze raw BPM data. Also, having multiple stimuli (and other tasks such as completing self-report questions) may influence a person’s HR, which may then impact their HR upon the next stimulus exposure. In order to minimize these impacts, researchers typically have the participants remain still prior to the next message exposure for a period of time (often ten seconds but baseline recording times vary widely) while not being exposed to anything of consequence (e.g., a black screen). This allows for the participant’s HR to stabilize to the resting baseline. When HR data are analyzed, the researcher subtracts the baseline HR from the HR collected during message exposure and creates change scores in BPM. Each change score could be a negative, positive, or 0, which would indicate the change in HR, deceleration, acceleration, or no change, during message exposure. Since change scores are relative to a participant’s own resting HR,

it is the change score that can provide an accurate indication of HR acceleration and/or deceleration when computed across participants.

The researcher can conduct both phasic (short-term, orienting response) and tonic (long-term, cognitive effort) analyses on HR, depending on the question of interest. Phasic analyses may show momentary changes in cardiac activity evoked by specific message events, such as the onset of a disgusting image in a fear appeal (Leshner, Bolls, and Thomas 2009). Tonic analyses examine longer-term HR variation across exposure to larger portions of media stimuli (e.g., entire advertisements, news stories, video games).

In addition to measuring BPM via IBIs (Keene et al. 2017; Potter and Bolls 2012), researchers can also collect and measure heart rate variability (HRV). HRV simply put is the variance in time between successive IBIs (Allen, Chambers, and Towers 2007). Although not widely used in communication research (Lang, Potter, and Bolls 2009), HRV allows the researcher to distinguish how variation in both parasympathetic and sympathetic activation influences HR output (Koruth et al. 2015; Ravaja 2004). For instance, Koruth et al. (2015) provided a secondary analysis of HR wherein the initial analysis of BPM revealed slower HR during exposure to negative radio advertisements compared to positive radio advertisements. Hence, with these results, one might conclude that the parasympathetic nervous system – which slows down HR and reflects greater attention – is naturally what resulted in slower HR for the negative radio advertisements relative to the positive radio advertisements. However, the HRV analysis showed that sympathetic nervous activation was significantly greater during positive radio advertisements whereas the parasympathetic indicators showed no significant differences between the two types of radio advertisements (Koruth et al. 2015). Hence, Koruth et al. demonstrated that the difference between the two types of radio advertisements was not due to slower HR via parasympathetic nervous system activation for the negative radio advertisements but rather faster HR via sympathetic nervous system activation for the positive radio advertisements (Koruth et al. 2015). This study is a clear example of how HRV can be used to untangle the underlying activation of both nervous systems for any given cardiac cycle measured during media exposure. For a more practical overview of HRV in media research, we recommend Ravaja (2004) and Koruth et al. (2015).

4.3 Electromyography (EMG)

Electromyography (EMG) measures the electrical activity produced when muscles contract (iMotions 2024). This action begins with an electrical potential traveling from the brain, moving down the spinal cord to motor neurons, which then releases acetylcholine at the neuromuscular junction (Winter 1984). This sequence leads to a calcium influx that causes the motor filaments actin and myosin to slide over each other, which results in muscle contraction. This activity can be observed by placing electro-

des on the skin above the muscle fibers, which provide data on when and how strongly a muscle is activated (Picard and Strick 1996; Winter 1984). EMG activity, which is quantified in microvolts, exhibits a linear relationship with both the strength of muscle contractions and the number of muscles engaged. This implies that the stronger the contraction and the greater the number of muscles involved, the higher the recorded voltage amplitude (iMotions 2024).

In addition, EMG can detect muscle activity even when overt actions are not apparent or when specific behaviors are suppressed, thereby providing a unique insight into cognitive-behavioral processes that are not visible through observation alone. Previous research supports a significant link between muscular EMG and motor cortex EEG, particularly noting substantial correlations in signal attributes such as frequency, power, and phase within the 12–25 Hz beta band (Churchland et al. 2010; Churchland, Santhanam, and Shenoy 2006; Hashimoto et al. 2010). These findings emphasize the effectiveness of EMG in monitoring the interactions between cortical and motor systems. Furthermore, facial electromyography (fEMG), which specifically records from facial muscles, extends the utility of EMG by providing detailed data on facial expressions, an aspect critical for understanding emotional and communicative cues.

Facial electromyography serves as a reliable physiological indicator of emotional responses to media content. Facial EMG measures the bioelectrical activity of specific facial muscles, although these responses often occur without any physical observation; hence, fEMG measurement is extremely sensitive to bioelectrical activity that may occur automatically and without awareness. It provides a reliable objective assessment of the emotional valence (both positive and negative) elicited by media and communication messages. The primary muscles analyzed as correlates of emotional valence included in media psychology are:

Corrugator supercilii (CS). Located above the eyebrow toward the nose, activation or furrowing of this muscle, is associated with negative emotional valence. Activation of CS is inhibited during exposure to positive information or message content (Ekman and Friesen 1978). Notably, the frowning response has also been found to be associated with increases in concentration (Schwartz et al. 1976). Most often, however, media scholars have recorded this muscle as an indicator of a negative emotional experience during media exposure. For instance, Leshner, Bolls, and Wise (2011) utilized the CS not only to study negative valence but also to examine defensive processing in response to televised anti-tobacco ads. Their findings suggested that activation of this muscle was associated with dampened emotional response and correlated with accelerated HR and diminished recognition memory.

Zygomaticus major (ZM). Located on the cheek, positioned even with the base of the nose and extending to the outer edge of the eye, the ZM is primarily activated during smiling and therefore is associated with positive emotional valence.

Orbicularis oculi (OO). Located on the lower, outer corner of the eyelid just below the pupil, OO is primarily activated during the experience of positive emotional va-

lence. It should be noted here, however, that scholars may use OO as an indicator of negative emotional valence via the startle eyeblink response (Lang, Bradley, and Cuthbert 1990). However, media scholars have recorded this muscle as a correlate of a positive emotional experience during media exposure.

Moreover, psychophysiolgists argue the most reliable measurement of positive emotional responses is to measure both OO and ZM (Clayton 2023), which comprise the Duchenne smile or “authentic smile” (Frank, Ekman, and Friesen 1993). The historical context of fEMG in media studies further reinforces its validity. Research has highlighted the effectiveness of fEMG in avoiding the biases of self-report methods (Bolls et al. 2020; Clayton 2023; Hazlett and Hazlett 1999). Recent studies have extended these applications by demonstrating how narrative coherence in television influences emotional responses, with lower cohesion leading to increased CS activation, indicative of negative emotions (Sukalla, Shoenberger, and Bolls 2016). Furthermore, the capability of fEMG to measure subtle muscle activations that are not overt, or visible through webcam analysis, has been demonstrated, even when respondents are instructed to suppress their expressions (Cacioppo, Bush, and Tassinari 1992).

Measuring fEMG involves recording the electrical activity of facial muscles to assess emotional responses, using surface electromyography electrodes, often pre-gelled for ease of use and single-use (i.e., disposable) to maintain hygiene (Bolls, Lang, and Potter 2001). These recordings are typically measured in microvolts (μV) and undergo several processing steps including amplification, filtering, and rectification to clean the data from noise and prepare them for analysis (see Clayton 2023). To analyze changes in muscle activity, researchers calculate change scores from a baseline measurement, establishing a baseline under neutral conditions and then measuring during stimulus exposure. The difference in muscle activity indicates the emotional response (Fridlund and Cacioppo 1986). fEMG data are analyzed for both phasic activity, which shows rapid changes in response to stimuli, and tonic activity, which reflects sustained muscle activity, and provides immediate and general emotional states (Hess and Kleck 1990). The adaptability of fEMG is further demonstrated in studies that explore phasic responses to dynamic media content.

For instance, Read, van Driel, and Potter (2018) linked the intensity of CS activation to implicit attitudes toward homosexuality in advertisements by showing how media can subtly influence societal views through emotional engagement. The technique has also been adapted to measure startle responses (Lang and Bradley 2010) and is utilized to understand reactions to humor or sexual content in advertisements (Sparks and Lang 2015). Clayton (2022) recorded CS muscle activation as a correlate of aversive motivational activation associated with the experience of psychological reactance during exposure to freedom-threatening anti-vaping messages. Conversely, ZY and OO have been used to assess positive emotional responses during self-transcendent media (Clayton et al. 2021; Clayton et al. 2023b). Philipp, Storrs, and Vanman (2012) used ZY and CS in immersive virtual environments. They found that participants’ ZY and CS responded to

the immersive virtual environment in the same manner as their non-mediated environment (Philipp, Storrs, and Vanman 2012).

fEMG falls short of identifying discrete emotions. Although fEMG provides insights into the general positivity or negativity of a reaction by capturing facial muscle activity, it does not delineate between specific emotional states like joy, anger, or fear (Tassinari, Cacioppo, and Vanman 2007). Larsen, Norris, and Cacioppo (2003) further elucidate that while fEMG can indicate arousal levels associated with emotional responses, it cannot pinpoint the exact nature of the emotion without additional contextual, self-report data, or facial expression analysis. Such combinations allow for a deeper interpretation of how messages are emotionally processed by individuals (Barrett et al. 2007; Mauss and Robinson 2010; van Boxtel 2010).

Technological advancements have significantly enhanced applications of fEMG, particularly through the development of wireless and mobile EMG systems that allow for more naturalistic studies in real-world settings. Innovations like high-resolution surface electromyography (HR-sEMG) and the use of Flexible Noninvasive Electrodes (FNEs) have improved the precision and comfort of measurements by making EMG an even more powerful tool in physiological research (Cheng et al. 2023; Guntinas-Lichius et al. 2023). Combining fEMG with physiological measures like heart rate or galvanic skin response can enrich our understanding of an individual's emotional and cognitive states in response to media stimuli.

4.4 Facial expression analysis (FEA)

The idea that emotions are universal, and therefore humans can accurately classify emotions based on recognizing faces, comes from Darwin's universality hypothesis. Facial expressions are movements of the numerous muscles supplied by the facial nerve that are attached to and move facial skin. Almost all facial muscles are triggered by the facial nerve (except the upper eyelid). Ekman and Friesen (1976, 1978) and Ekman, Friesen, and Hager (2002) developed the Facial Action Code (FAC). The FAC was derived from analyses of facial movements and can describe any facial movement in terms of anatomically based action units (AUs) and serves as the basis for the facial action coding system (FACS). Research by Strack, Martin, and Stepper (1988), among others, supports the notion that facial expressions and emotions are closely intertwined.

Using a webcam and software that creates algorithms, FEA has moved from human facial expression coding to reliable automatic classification. This makes FEA an easy way to assess emotional response – both discrete (i.e., specific emotions such as fear or joy) and dimensional (i.e., positive or negative valence) classifications of emotions.

Automatic FEA algorithms are based on FACS, developed by Ekman and Friesen (1976), with facial expressions based on combinations of AUs. Each AU corresponds to

an individual face muscle or muscle group. Human scoring of FACS requires a lot of time and a lot of training. With the adoption of computer vision and machine learning algorithms and the collection of high-quality databases of facial expressions, automatic facial coding procedures have been developed. These procedures instantaneously detect faces, code facial expressions, and recognize emotional states. The translation from face features into metrics is calculated by numerically comparing the actual appearance of the face and the configuration of the features in the database provided by the facial expression engines.

Depending on the software used, automated FEA can detect head orientation (yaw, pitch, roll), facial landmarks, six or seven discrete emotions, and emotional valence. Different software can also vary depending on the number of AUs they collect, and the threshold methods they use. Careful attention must be paid to the particular software one uses as well as the methods for computing facial expressions. For example, some software provides raw data from the facial coding algorithm that represents a “confidence score”, which indicates how sure the algorithm is at a specific moment regarding the detection of a particular facial expression. One benefit of these data is that they permit the analysis of variations in a particular emotional response during the course of message exposure. The strength of confidence can be filtered so that the system counts only those scores that the algorithm shows are above a certain confidence threshold.

Researchers have employed an array of software to provide automatic FEA. In one of the earlier studies on computer-based FEA, Ahn et al. (2010) used the Neven vision library (which automatically detects the x and y coordinates of 22 points along with eyes and mouth openness levels and head movements such as yaw, pitch, and roll for each frame of video) and the OKAO visual library developed by OMRON Corporation (automatically detects and tracks 37 points on the face, end movements such as pitch, yaw, and roll, as well as eye and mouth openness levels) as their vision tracking points on their participant’s faces. They then developed machine learning classifiers to assess the rate at which they were able to successfully classify emotional expressions. This paper provided evidence for their prediction, which was subsequently shown to be accurate, that the advances in computer vision and machine learning algorithms would successfully automate FEA.

Other recent research using FEA in human communication research includes Joo, Bucy, and Seidel (2019); Leshner et al. (2021a); Shen, Dillard, and Peng (2022); Pokharel et al. (2023); Parvanta et al. (2022); and Namba et al. (2017).

5 Analyzing psychophysiological data over time

Assuming the researcher is interested in HR or other psychophysiological activity over time (during message exposure) the most common analytic type is to run repeated-measures ANOVA (rANOVA) on the change scores (baseline subtracted from

the particular physiological signal at all moments of time), where time is the within-subjects factor (Potter and Bolls 2012). The researcher can examine linear and or polynomial HR trends on a second-by-second basis (or whichever time unit the researcher wants) to see if HR accelerates and/or decelerates in conjunction with a media attribute. However, psychophysiological measures (e.g., ECG, EDA) collected and analyzed over time nearly always violate the sphericity assumption of rANOVA since such repeated measures are correlated. Sphericity is tested with Mauchly's test and when significant Huynh-Feldt (Huynh and Feldt 1976) or Greenhouse-Geisser (Greenhouse and Geisser 1959) adjustments to degrees of freedom are required.

In recent years, however, multilevel linear models (MLM) have been recommended as an alternative to rANOVA (Page-Gould 2017; Volpert-Esmond, Page-Gould, and Bartholow 2021). The issues regarding these two analytic methods are discussed elsewhere in this volume.

6 Challenges and future directions

One growing area in the field of media psychophysiological research has focused on examining individual differences in the cognitive and emotional processing of media. Lang and colleagues (Lang, Shin, and Lee 2005; Lang et al. 2007) were pioneers in examining how individual differences, specifically differences in motivational reactivity, influence audiences' processing of media. Using the self-report motivation activation measure (MAM) (Bradley et al. 2001; Lang, Bradley, and Cuthbert 1997a), which has been linked to personality types such as sensation-seeking (Gerra et al. 1999), Lang and colleagues (Lang, Shin, and Lee 2005; Lang et al. 2007) found that individuals have a very stable tendency to approach or avoid different types of mediated information. Further, this individual difference is strongly correlated with psychophysiological measures indicative of approach and avoidance responses (Lang et al. 2007). Additionally, in their study, the MAM data also mapped with indicators of cognitive processing of media including secondary task reaction times (STRTs) and HR deceleration (Lang et al. 2007). In another study, Clayton et al. (2019) found that individual differences in motivation activation predicted which audience members were likely to approach to contest (i.e., counterargue) highly aversive anti-tobacco PSAs, and which audiences were likely to avoid the highly aversive anti-tobacco PSAs (i.e., fight-or-flight responses).

Other media psychophysiological research has examined how individual differences in substance use behavior influence the cognitive and emotional processing of anti-substance messages. In one study, Clayton et al. (2020a) found significant differences between smokers and non-smokers in their cognitive and emotional processing of anti-tobacco messages via psychophysiological measurement. Specifically, smokers were more defensive in their second-by-second cognitive and emotional processing of

anti-tobacco messages via their psychophysiological responses than non-smokers (Clayton et al. 2020a). In another study, Sanders-Jackson et al. (2019) found differences in psychophysiological responses to smoking cues in anti-vaping messages based on the audiences' prior level of e-cigarette use. In this study, e-cigarette users and dual users of e-cigarettes and combustible cigarettes had greater appetitive/approach responses (fEMG and HR deceleration) to smoking cues depicted in the anti-vaping messages than anti-vaping messages without smoking cues (Sanders-Jackson et al. 2019). Likewise, Clayton (2022) using HR, SCL, and fEMG found significant differences in cognitive and emotional processing of anti-vaping messages that varied in dogmatic or suggestive language between e-cigarette users and non-e-cigarette users (Clayton 2022), and when comparing non-e-cigarette users with ever-vapers (Clayton et al. 2020b). Leshner et al. (2021b) recently found differences between cannabis users and non-users in their cognitive and emotional processing of anti-cannabis messages, particularly messages that focused on driving risks compared to cognitive ability and health harm messages.

There are, of course, other communication domains that have examined individual differences in cognitive and emotional processing of media content via psychophysiological measurement. This includes political communication or "biopolitics" (see, e.g., Bucy and Bradley 2014; Bucy and Holbert 2011), video game research (see Krcmar et al. 2015; Ravaja et al. 2006), and environmental communication studies (e.g., Schmälzle, Wilcox, and Grall 2021). We contend that future media psychophysiological studies should continue to consider individual differences in message processing studies, as such differences continue to be important moderators in how audiences interact with and respond to various media content.

Finally, the ability for communication scholars to collect psychophysiological data continues to be a practical endeavor given the decreasing costs of the necessary equipment for data collection. Moreover, new opportunities for data collection continue to be promising. For example, the field of psychology has demonstrated the feasibility of collecting real-time psychophysiological data outside of research laboratories (in the field) via ambulatory assessments (AA) (see, e.g., Ebner-Priemer and Kubiak 2007; Trull and Ebner-Priemer 2013). The AA approach aims to collect psychological, behavioral, and psychophysiological data using in-field data acquisition systems (Ebner-Priemer and Kubiak 2007). Yeykelis, Cummings, and Reeves (2014) measured sympathetic arousal (skin conductance) with a wrist sensor in relationship to multitasking, which was defined as switches between content on a personal computer during the course of a day. They found that arousal was highest at the point of a switch, followed by reduced arousal after the switch. Indeed, devices, technology, and software have now made physiological data collection more obtainable from participants' environments, which can lead to greater ecological validity (Trull and Ebner-Priemer 2013), which is often a limitation of in-lab data collection studies (Clayton 2023). Thus, the ability to collect psychophysiological data in person or in the field has become more attainable for communication scholars, and those alike.

7 Conclusion

There has been a substantial growth of psychophysiological laboratories across communication and media programs, and we surmise that the growth will continue. In this chapter, we attempted to provide an overview of the current theoretical and methodological issues in media psychophysiological research. Media psychologists who are interested in the cognitive and emotional processing of media employ physiological measures and their conceptual correlates as they explore, apply, and develop theory. The context in which this research activity occurs is broad and includes many content fields in which other media researchers engage. We hope this chapter provides a basic foundation for the conceptual, validity, and analytic issues in the field.

Media psychophysiology affords a versatile lens through which to examine the interplay between media exposure and psychological states, especially as they occur during media exposure. By addressing conceptual, theoretical, and methodological challenges, researchers can explore the underlying mechanisms of media processes and effects more precisely than typically available through self-reports. The benefits are two-fold. First, media researchers, through understanding media processing, can inform practical applications such as informed interventions, and ethical media practices. Second, media psychologists, through psychophysiology, can strive for a deeper understanding of how people cognitively and emotionally process media in the digital age.

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