UNIVERSITY OF ALBERTA

PSYCHOPHYSIOLOGICAL ASPECTS OF LACTATION

BY

WILMA M. MARSHALL ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

IN

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ABSTRACT

The primary objective of this study was to record peripheral and hormonal psychophysiological responses during breastfeeding in order to more accurately describe the physiological changes which occur. More specifically, this study investigated whether any consistency could be observed among a group of six successfully breastfeeding women in terms of their finger temperature (FT) and skin conductance response (SCR), and in terms of their oxytocin (OXT), luteinizing hormone (LH) and cortisol responses during a feeding. This study also constituted a preliminary methodological and measurement investigation, designed to develop procedures permitting the rapid simultaneous recording and subsequent analysis of peripheral and hormonal measures during a feeding. Data were recorded for five minutes prior to the initiation of a feeding, and at one-minute intervals for the following ten minutes. Relative to the initiation of feeding, significant increases ($p < 0.05$) in FT, relative to initiation, were recorded at minutes six through thirteen. When centered to the onset of Finger Temperature elevation, specific patterns of change were observed. SCR increases occurred prior to, and fell shortly after, a significant increase in finger temperature which remained elevated for the remainder of the recording period. By one minute after the onset of temperature rise there were increases in OXT, LH, and cortisol. OXT remained elevated relative to baseline with a clear second peak by minute eight. LH fell to baseline by minute three, and remained at or below baseline for the remainder of the sampling interval. Cortisol showed an intermittent pattern with an abrupt drop to baseline by minute eight. The broad context of this research has been to suggest a more integrative perspective for psychophysiolgy research in general, and for women's health issues in particular. The results suggest the need for more exploratory research and a series of focussed investigations considering female psychophysiology within a life history context.

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CHAPTER ONE

Introduction

A. Chapter Overview

Chapter One serves as an introduction to the study. Included are a chapter outline, an introduction to the study and its purposes, and a brief listing of the terms and abbreviations used.

B. Introduction

In recent years breastfeeding has seen a resurgence in popularity in western industrialized nations. More and more women are choosing to breastfeed their infants. Most successfully initiate breastfeeding, but many have difficulties maintaining lactation. In March 1981, 76.5% of all first-time mothers giving birth at three hospitals in Edmonton chose to breastfeed their babies. By the eighth week postpartum only 50% were still breastfeeding (Fieldhouse, 1984). Similar data have been reported for the rest of Canada (Ellis, 1986), for the United States (Feinstein, Berkelhamer, Gruska, Wong, & Carey, 1986; Martin, 1985; Martinez & Dodd, 1983), for Great Britain (Martin & Monk, 1982; Wright & Walker, 1983), and for Australia (Lumley, 1983; Palmer, 1984). Extending the duration of lactation is an objective promoted by the Canadian Pediatric Society (1978), and by Health and Welfare Canada which have recommended breastmilk as the principal source of nutrients for the first six months of life (Health and Welfare Canada 1979, 1986; Myres, Watson, & Harrison, 1981)

Concern, then, about the diminishing length of time infants are being breastfed postpartum has led public health agencies in several countries to initiate programs in support of lactation (Akre, 1991). Health and Welfare Canada has launched and is in the process of reviewing a national program to promote breastfeeding (Myers, 1985). One of the U.S. health goals for the year 2000 is to increase to 75% the proportion of mothers choosing to breastfeed their infants and to increase to 50% the proportion of mothers continuing to breastfeed until their infants are 6 months of age (U.S. Dept. of Health and Human Services, 1991). Several recent surveys, however, indicate a persistent decline in the percentage of mothers who breastfeed (Ryan et al., 1991).

Attributing these reductions to "practical difficulties and frustrations," Fieldhouse (1984, p. 132) emphasized the importance of continued support for the nursing mother. Support requires knowledge. The greater our knowledge of the typical sequences of lactation and of the physiological processes involved, the more able we will be to support and assist breastfeeding mothers in a variety of circumstances. Many aspects of breastfeeding have been researched in recent years, and various factors have been seen as contributing to difficulties in maintaining lactation. Most authorities have concluded that the milk ejection reflex is a key aspect of the breastfeeding process, in that it affects milk production, mother-infant interaction, and mutual satisfaction during feeding (Ellis, 1986; Isbister, 1954; Lawrence, 1985; Martin, 1985; Neifert, 1983; Neville, 1983; Newton & Newton, 1950; Post & Singer, 1983; Riordan, 1983; Woolridge, 1986).

To the casual observer, breastfeeding appears very similar to bottlefeeding. The infant sucks, and as a result of suckling obtains the milk. The breastfeeding sequence is, however, somewhat more complex than it appears. The baby sucks and gets that part of the milk stored in the lactiferous sinuses. The majority of the milk produced is unavailable to the baby or, in his absence, to the breast pump via simple suction alone. Most of the milk is high up in the alveoli where it is made and from which it must be actively excreted, or let-down, by the mother. Most mothers can produce the milk, but if they are unable to excrete it, subsequent milk production is suppressed (Lawrence, 1980; Underwood & Hofvander, 1982). The quantity of milk produced is related to how thoroughly the breast was emptied at the preceding feeding. Although milk synthesis is continuous, most occurs during nursing or immediately thereafter (Jacobs & Daughaday, 1974). Continued incomplete excretion leads to a decreasing volume of milk being produced. If the infant is unable to suckle well, or if the milk ejection reflex is not functioning adequately, incomplete milk removal results. Thus, the excretion of milk represents one of the critical aspects of the breastfeeding process. The mechanism of this excretion is the milk ejection, or let-down, reflex.

Successful lactation is thus dependent, in large part, on the appropriate regulation of the milk ejection reflex. Increased sympathetic arousal has traditionally been considered to be the mechanism inhibiting this neurohormonal reflex (Vorherr, 1971). The possibility of developing a behavioural intervention seemed tenable, given existing knowledge, if there were significant peripheral physiological changes which occurred during a feeding, and if these could be recorded. The purpose of this study was to increase understanding of the psychophysiological changes that occur in women during breastfeeding.

The first step in this research (Marshall, Cumming, & Fitzsimmons, 1992) documented a pattern of significant peripheral change during breastfeeding, and established both a method, and baseline data to support the current study. The pattern of peripheral change recorded during breastfeeding is uniquely different from that associated with increased sympathetic arousal. It closely parallels the pattern of peripheral change experienced by post-menopausal women experiencing a flush, and is different from the physiological response either to heating the subject or to initiating exercise. The menopausal flush is recognized as a hypothalamic event, and the similarity of the two patterns suggested that certain events may be in common.

The intent of the current study was to replicate the author's earlier study of the physiological responses to lactation, with the addition of hormone level monitoring. This included monitoring luteinizing hormone and cortisol which are known to increase with the menopausal hot flash, and oxytocin () which is known to increase during the milk ejection reflex.

Documentation of the hormonal and peripheral changes which occur provides useful information particularly for those specific situations in which direct assistance with the milk ejection reflex would be useful, for example, with those mothers attempting to provide milk for ill or premature newborns. Successful behavioural intervention could involve the alteration of complicated interactions among several levels of physiological subsystems. Documenting the pattern of change during a feeding will increase our understanding of some of these physiological subsystems, their interactions with one another, and may begin to suggest the manner in which the interactions might be modified.

This study may also suggest direction for subsequent research into the role of sympathetic arousal in lactation, and to validating and developing applications for psychophysiological measures. The data may extend our understanding of the hypothalamic events that occur during breastfeeding, and perhaps of the role lactation plays in the delay of postpartum ovulation.

Every study leads to specific procedures and specific terms and the present study is no exception. To assist reader understanding, some definitions are offered.

C. Definition of Terms and Abbreviations Used

The following definitions will be employed in an effort to clarify some of the terms used in this study:

Gonadotropins Pituitary hormones that regulate gonadal function.

Luteinizing Hormone (LH) An anterior pituitary hormone which stimulates ovulation and the growth of the corpus luteum in females and testicular production of androgens in males.

MER - The milk ejection reflex

micro*mho* (μ mho)- The electrical conductivity of the skin is measured in micromho, and is the reciprocal of skin resistance which is measured in ohms.

Oxytocin (OXT) A hormone of the posterior pituitary which strengthens uterine contractions and causes the ejection of milk.

Releasing Hormone One of a number of hormones produced by the hypothalamus that stimulate or inhibit the secretion of specific hormones by the anterior pituitary. Included in this group are GNRH (gonadotropin releasing hormone–influencing LH), and CRF (corticotropin releasing factor–influencing ACTH, adrenocorticotrophic hormone, which in turn influences cortisol).

Skin Conductance Level (SCL) A measure of the electrical conductivity of the skin with respect to a constant voltage applied to its surface, and refers to momentary, relatively rapid fluctuations which result from psychophysiological responses to discrete stimuli.

Skin Conductance Response (SCR) A measure which represents a positive linear relationship between conductance level and the level of sympathetic response.

CHAPTER TWO

Review of Related Literature

A. Chapter Overview

Chapter Two includes a chapter outline, an introduction, and an overview of the theoretical orientation and context which psychophysiology provides for this study. Also included are a review of the master's research which led to the current study, and a review of the literature related to the variables under investigation. The chapter concludes with a statement of the research problems posed by the literature.

B. Introduction

The general purpose of the current research project was to increase the understanding of psychophysiological changes which occur in women during breastfeeding by exploring the pattern of peripheral and hormonal responses during a feeding. In particular the study explored the relationships between stage of feeding and the peripheral and hormonal responses. The peripheral measures were temperature and skin conductance response. The hormonal measures were oxytocin, luteinizing hormone, and cortisol.

Reviewing techniques for data acquisition by psychologists doing field investigations of stress, Martin (1989) recommended that psychophysiological and biochemical measures be considered as dependent variables in psychological research: "the measurement [for example] of corticosteroids in the blood and urine [and, latterly, in saliva] can provide a sensitive and reliable index of the psychological and emotional states associated with stress" (p. 212). Addressing what they saw as common reservations about the use of these and similar measures, Baum, Grunberg, and Singer (1982) comment that "many [researchers] do not realize that the state of the art in biochemical assay techniques is such that endocrinological measurements can and should be added to the armamentarium of behavioural, psychological and physiological techniques already being used" (p. 218). As such, a brief review is included of the theoretical orientation and applied context provided by psychophysiology.

There are peripheral changes occurring at different stages of a feeding, and these may be related to hormonal changes which may also be occurring. The connection between feeding and these peripheral and hormonal changes will be examined by reviewing, first, my Master's thesis research which serves as the foundation for the proposed study, and second the literature related to (a) the peripheral vascular effects of oxytocin; (b) skin conductance response and peripheral temperature as recorded in different contexts; and (c) patterns of hormones used to infer underlying mechanisms.

C. Theoretical Orientation and Applied Context Provided by Psychophysiology

Research in applied psychophysiology, particularly in the counselling area of an educational psychology department, is remarkably similar to Dawson's (1990) description of psychophysiology in that it represents an interface between several disciplines, and, to use Dawson's analogy, is like being a pedestrian crossing a busy street who must be aware of the flow of traffic in more than one direction at the same time.

Physiological psychology defines itself as the study of the biology of psychological processes (Levitt, 1981). As such it begins with the nervous system of the organism, manipulates a physiological variable, and then observes the effects on behaviour. Physiological psychology typically aligns itself with neuroscience and neurobiology. In contrast, psychophysiology begins with an emotional, mental, or behavioural condition, manipulates this psychological variable, and observes the effects on physiological responses (Feuerstein, Labbe, & Kuczmierczyk, 1986). Psychophysiology typically aligns itselfwith health psychology and behavioural medicine. Porges and Coles (1976) further elaborated the distinction between these two subspecialties:

> Psychophysiologists are concerned with the effects of manipulating psychological variables on physiological responses that are generally detectable without intrusion into or violation of the physiological integrity of their subjects; [whereas,] physiological psychologists often manipulate the physiological status of their subjects while observing behavioral effects (p. 1).

The psychophysiology of emotion (Lang, Rice, & Sternbach, 1972), of sleep (Snyder, 1970), and of the detection of deception (Orne, Thackray, & Paskewitz, 1972) are among the various topics investigated using this perspective and methodology. Contributions have similarly been made to our understanding of intelligence and performance (Mulcahy, 1975), and to psychopathology (Alexander, 1972).

1. Theoretical Orientation

Psychophysiology attempts to explain a variety of behavioural processes by the interaction of their psychological and biological components. Questions of inferring psychological significance from physiological signals have a long history in psychology, two themes of which have particular relevance as context for the development of this study: general versus specific response and stimulus patterns, and homeostasis.

a. General versus specific responses and stimuli.

The first theme has roots dating back to William James' focus in his call for the physiological study of mental conditions: "no shade of emotion, however slight, should be without a bodily reverberation as unique, when taken in its totality, as is the mental mood itself." (1890, p. 450). Not only is James setting the grounds for the relation between psychology and physiology, but in emphasizing the uniqueness of the psychological and physiological patterns, he is also articulating the beginning of a long dialogue focused on general versus specific and unique responses and stimuli.

In the early 1900's the focus of psychophysiology research was on the effects of non-specific stress. Cannon's (1932) research suggested that if adaptive, defensive psychophysiological patterns are repeatedly invoked, or prolonged, they can produce stress, that is, illness or damage to the body. His papers on the physiological responses to emotions such as anger and fear initiated much of the research in this area. Cannon's "fight or flight" mechanism became one of the first models of psychophysiological responses, focused as it was on the neuroendocrine axis. The results of activation are identical with sympathetic innervation, but involve a delay of onset of twenty to thirty seconds for measurable effects, and maintain that effect for ten times longer (Usdin, Kretnansky, & Kopin, 1976) Cannon's model included the premise that the different nerves of the sympathetic nervous system all fire simultaneously, and with equal effect; thus, once activated the response was ungraded with reference to the stimulus, and was uniformly invoked throughout the body. Early statements like Cannon's were accepted as a basis for understanding which subsequent studies are now confronting, and which led at times to an overgeneralization of mechanisms and of intervention techniques.

Cannon's focus on the catecholamine responses of the adrenal medulla was followed by Selye's work on the adrenocortical responses. One of the major assumptions in Selye's original theory (1936) was that the stimuli prompting the stress response were non-specific. In other words, a characteristic set of general body reactions can be triggered by a variety of stimuli whether pleasant or unpleasant (Selye, 1950). Although the response is relatively constant, regardless of the type of stimulus, the degree of response may vary as a function of the intensity of the demand for adaptation.

Mason's (1956, 1968) early research and reviews of the field documented that both the adrenal medulla and the adrenal cortex could be activated by psychological (internal) events. Mason's subsequent critiques (1975a/b) of Selye's theory marked a shift in emphasis in the field of psychophysiology as a whole. Instead of exclusively focusing on the sensitivity of these physiological systems to psychological stimuli, the role of emotional, and later cognitive, responses in mediating neuroendocrine responses took center stage. Researchers began to use neuroendocrine measures as indicators of an individual's underlying psychological state (Ader, 1979; Kakimoto et al., 1988). Difficulties and confusion arose, however, when not only increases in catecholamines or cortisol, but also the psychological state presumed to be mediating the response came to be referred to as the stress response (Lazarus, DeLongis, Folkman, & Gruen, 1985)

Latterly, as understanding of the various roles, functions and interactions of the endocrine and neuroendocrine axes has increased through research and through improved peripheral and biochemical measurement, the focus has shifted and been extended from non-specific responses and non-specific stimuli to the consideration of the specific and varying ways in which the same systems may function in response to different settings and stimuli.

At an intervention level this change in emphasis is reflected in the beginning of a shift from a focus on general relaxation to reduce autonomic arousal, to a focus on the regulation of the mechanisms related to a specific function or disordered function (symptom).

In the context of the initial study in this sequence (Marshall, 1987), for example, the traditional interpretation of an elevation in finger temperature as a reduction in autonomic arousal is difficult to assert in the context of a preceding or simultaneous rise in SCR. An increase in peripheral temperature, and by inference peripheral blood flow, should reflect a reduction in sympathetic arousal; but the increase in SCR infers an increase in the same arousal. When a parallel pattern of responses is documented in separate studies with populations including premenstrual syndrome (PMS) patients (Casper, Graves, & Reid, 1987), males with testicular dysfunction (DeFazio, Meldrum, Winer, & Judd, 1984; Feldman, Postlethwaite, & Glenn, 1976), and menopausal women (Sturdee, Wade-Evans, Paterson, Thom, & Studd, 1978; Tataryn, Lomax, Bajorek, Chesarek, Meldrum, & Judd, 1980), exploration of alternate explanations of the mechanisms underlying and related to peripheral temperature change would seem to be in order.

b. Homeostasis.

The second theme in psychophysiology relevant to the current study, is homeostasis, and dates back to the articulation by Claude Bernard (1850) of the *milieu interieur* , or internal environment of the body. He conceptualized this as a balance kept in equilibrium by a process of antagonistic innervation through which organs could respond to both stimulation and inhibition rather than to stimulation alone. Interestingly, what is less well remembered is Bernard's contribution to the extension of homeostasis to include mechanisms beyond direct innervation (1850).

Bernard demonstrated the principle that neural transmission was more than simple electricity, that there was a neurochemical component to the transmission. By showing that curare causes paralysis by blocking transmission across the neuromuscular junction of skeletal muscles, Bernard's study (1850) showed that a delay occurs between the arrival of an electric impulse at the end of a nerve on a muscle and the actual initiation of the muscle contraction. This delay was longer than could be explained in electric terms alone, thus suggesting the possibility of a chemical communication between neurons– later discovered to be the classic neurotransmitters.

Homeostasis has been defined in various ways and for various purposes. When the focus of research includes questions of regulation or adaptation, the most useful definition of homeostasis might involve its being a dynamic process involving the activity of multiple organs and systems, which requires the means to communicate to produce an "integrated function and biologically appropriate results." (Yen, 1986, p. 2)

Latterly, research has extended definition of these requisite communication systems to include neuropeptides (peptides produced by neurons), and the somewhat overlapping category of neurohormones (proteins, peptides, and steroid hormones) which alter brain activity in such a way as to emphasize particular patterns of behaviour.

Conceptualizing homeostasis in terms of the integration of multiple systems, in terms of biologically appropriate results, and in terms of the communication systems involved has implications for the ways in which both research in psychophysiology and its application are being defined and conceived.

The first implication would seem to be a broadening of focus beyond sympathetic arousal, to include an understanding of the neural, the neurohormonal, and the endocrine axes involved in regulation and homeostasis (Everly, 1987), and to include understanding of these communication systems, how they function and how they can perhaps be modulated for improved regulation and function. Regulatory processes in this context begin, thus, to be seen as subserving adaptive mechanisms. In the process of this expanding perspective women's health and stress-related issues may come to be considered in the context of their hormonal or endocrine profile, which, when generalized further, translates into an appreciation of neuroendocrine rhythms and fluctuations at various levels: from the ultradian (episodic variations termed ultradian because they occur at frequencies greater than one cycle per 24 hours), through the circadian (periodic variability synchronized with or determined by the sleep-wake and/or light/dark cycle), the menstrual cycle, and, indeed, the rhythm and sequence of the reproductive life-span (from pre-puberty to old age). There is a rhythm to each of these and related, biologically appropriate, functions.

Thus, the broad context here is to suggest, first, a more integrative perspective for stress research, for women's health issues, and indeed for psychology's perspective on psychophysiology: and second, to suggest, and then to explore a method consistent with this approach to research.

2. Applied Psychophysiology and Biofeedback Research

One of the principal criticisms of biofeedback is that there is "little evidence of its specific effectiveness, and there is little understanding of the mechanism by which it works" (Katkin & Hastrup, 1986, p. 246). This demand not only for controlled outcome studies, but also for research into relevant mechanisms of action needs to be addressed at a basic research level. Thus, this is not a biofeedback study per se, but it is intended as an investigation of the type of research which should precede biofeedback studies.

Before attempting to research the biological self-regulation upon which biofeedback is focussed, studies need to be initiated to determine the pattern of physiological responses present in normal rather than disordered function, and to identify potential intervening variables. One would, thus, begin by documenting variability, and then measuring specific relevant bodily reaction in the successful adaptive response. The physiological parameters recorded would then serve as a guide for subsequent research to develop interventions with disordered function.

Such basic research must be initiated with an understanding of the implications of the applied context for which it is intended. Unless such studies are undertaken by those familiar with the objectives and methods of applied or intervention focused psychology–a gap will continue to exist between the results of basic research and the needs of the clinician. Many clinicians are unfamiliar with the physiology research, and many basic researchers are unfamiliar with the intent and methods of the applied clinician. Both areas are changing, and the comfortable common ground of "psychosomatic" and "stress-related" definitions is disappearing.

3. Psychophysiology and Adaptive Responses

As Goldstein (1990) points out, the healthy adaptive organism does not respond in a stereotyped way to demands imposed on it. In contrast to the views of Cannon and Selye, the physiological responses of the body to various stressors are relatively specific and may vary in different neuroendocrine contexts. Therefore, knowledge of normal functioning in terms of psychophysiology theory, may come in part to be understood in terms of stimulus-response specificity. This refers to a given stimulus "consistently invoking the same pattern or hierarchy of physiological responses" (Roessler & Engel, 1977, p. 51) in most subjects. [Note: this is in contrast to individual response specificity in which an individual, or group of individuals, shows more response in one physiological system or organ in response to all stimuli. The tendency to overreact in any one physiological modality is often seen as the basis for the development of specific disorders.]

Successful behavioural intervention with a disordered physiological response involves the alteration of complicated interactions among several levels of physiological subsystems. Delineation of these subsystems, of their interactions with each other, and subsequently, of the manner in which their interactions may be modified by behavioural intervention becomes the task of the researcher in applied psychophysiology. In the context of this study, such knowledge about the physiological dynamics of breastfeeding may facilitate subsequent biofeedback intervention in support of mothers attempting to feed ill or premature newborns.

There has been an increasing demand from both biofeedback's theorists and its critics for improved basic research support. In 1977, Shapiro called for a shift in research emphasis from an exclusive focus on behavioural models and methods to an expanded concern about underlying psychophysiological mechanisms. King and Montgomery (1980), however, summarized the state of the field then, and to a large extent, now, when they wrote that "pleas for research on the psychophysiological mechanisms that may enhance peripheral temperature control have been virtually ignored" (p. 743).

One aspect of human behaviour not extensively researched to date, and yet which would appear to lend itself well to psychophysiology's research perspective and methods is lactation. Mason (1972) considers psychoendocrine mechanisms to be the physiological foundation of research in psychophysiology, and in this regard, one of the critical aspects of the physiology of lactation is a neurohormonal reflex. Meites (1974) has suggested the direction for research in this area:

> The knowledge gained in the past fifteen years of the neuroendocrine control of lactation has made it possible to apply some of this information to the treatment of problems in lactation. Several CNS-active drugs have been used to inhibit lactation in man and animals, but few attempts have been made to increase milk production by neuroendocrine means [or by employing non-pharmacological management techniques that utilize the knowledge gained] (p. 123).

4. Conclusion

In this study, a breastfeeding was considered as an adaptively significant stimulus (Herbert, 1989) to which women respond. In the context of the more integrative psychophysiology perspective suggested here, the pattern of peripheral and hormonal responses by a group of successfully feeding women was considered as a specific stimulus-response pattern, which may ultimately provide criterion levels for subsequent research into bio-behavioural interventions with women attempting to regulate the milk ejection reflex (Weichert, 1979). Because of parallels to the research into peripheral vasodilatation, the results are considered in the context of the menopausal flush literature.

D. The Master's Thesis Research

Successful lactation depends upon appropriate conditioning of the neurohumoral milk ejection reflex. Tactile stimulation from nipple and areola via an afferent neural pathway prompt synthesis of oxytocin in the paraventricular and supraoptic nuclei, its transport along neurosecretory axons, storage in, and release from the posterior pituitary (Dawood, Khan-Dawood, Wahi, & Fuchs, 1981; Verbalis & Robinson, 1985). Despite the importance of the MER in both establishing and maintaining lactation, the neuroendocrine sequence can and does operate below the level of awareness, and many mothers are not aware whether or not it has occurred.

OXT also has peripheral effects, notably dilatation of peripheral vascular beds without increased systemic arterial pressure (Nakano, 1973). Blood flow through the hand increases following injection of even small amounts of OXT into the brachial artery (Greenfield, 1962; Haigh, Kitchin, & Pickford, 1963). Therefore, since OXT is reported to be released during feeding, changes in finger temperature would be expected to occur, but to date this had not been investigated.

The initial study in this research sequence was therefore designed to investigate patterns of peripheral temperature and skin conductance change in breast feeding. Because there has been little research on lactation in an applied psychophysiology context, the first step involved developing a methodology to observe peripheral change during a feeding. To determine whether peripheral measures of skin temperature and skin conductance varied with behavioural sequences during a breastfeeding, the changes were investigated in twenty mothers with infants between 6 weeks and 6 months old. All of the infants were full term and healthy without current medication. Expected weight gain was occurring without solid food or supplemental formula. None of the mothers had resumed menstruation at the time of their participation in the study, suggesting they were not yet ovulating.

Based on the temporal relation of milk flow and oxytocin increases reported in the literature (Lucas, Lucas, & Baum, 1979; Dawood, Khan-Dawood, Wahi, & Fuchs, 1981), finger temperature, skin conductance response, and breast temperature were recorded prior to beginning breast feeding, at volition (the period when feeding is being initiated, but prior to actual suckling), and after two and five minutes of feeding. Recording of baseline readings began after a minimum 20 minute adaptation period during which the sensors were in place. Ambient room temperature was maintained at 21-22° C. throughout the experiment.

The data were collected using the Biocomp 2001 (Biofeedback Research Institute at Los Angeles, California) permitting simultaneous recording from three measures. One thermistor was attached to the outer surface of the middle phalange of the third finger of the hand holding the baby. [Note: the infant was supported or cradled by the forearm, but the hand was free and not in contact with the infant.] The sensors recording skin conductance response were placed on the fleshy area of the palm just below the base of the fingers on the same hand from which the temperature readings were being taken.

Data were analyzed with a one-way repeated measures ANOVA, and Scheffé tests were performed in order to contrast the mean values at different stages of feeding. Significant change ($p > .0001$) was recorded in each of the physiological measures relative to stage of feeding. Significant increases in breast temperature occurred relative to baseline at two minutes and five minutes. Mean breast temperature increased throughout the feeding, with one mother's breast temperature increasing to 37.09° C. –approximately normal core temperature–by five minutes. Significant increases in finger temperature occurred relative to baseline and volition at two minutes and five minutes. The greatest finger temperature changes, relative to baseline, which the mothers showed were 1.07° C. at volition, 2.76° C. at two minutes, and 3.32° C. at five minutes. Skin conductance response increased significantly between baseline and volition, and had decreased significantly compared to volition by five minutes.

The patterns of change observed appeared specific for each stage of feeding and suggest the possibility of systemic as well as local responses to breast feeding. Skin conductance increased and was followed shortly thereafter by increases in skin temperature of both finger and breast. The thermal changes occur at an approximate time when plasma oxytocin levels increase. Oxytocin is recognized as a peripheral vasodilator, but the relationship to the events observed here is not known. The pattern of change observed is, however, inconsistent with that attributed to sympathetic arousal, in that an increase in sympathetic tone, as inferred by the increase in skin conductance, should produce a decrease in peripheral blood flow, and skin temperature (Greenfield & Sternbach, 1972; Guyton, 1986) and is different from the physiological response to simply heating the individual or initiating exercise.

Significant increases in finger temperature were recorded at those times which other research suggested that an oxytocin increase was likely to occur. Thus this first step established that a peripheral temperature increase occurs in relation to the initiation of a feeding. The pattern of SCR and peripheral temperature change suggest that there may be a characteristic peripheral manifestation of the MER which is different from a thermoregulatory change. The initial study also served to establish both the methodology, and the baseline data to support subsequent research.

E. The Related Literature

1. Peripheral Vascular Effects of Oxytocin

Anecdotal evidence for the peripheral vascular effects of OXT has come from women who describe warm hands and an upper body flush of warmth concurrent with the sensation of the MER.

Reviewing the cardiovascular actions of OXT, Nakano (1973) felt that the principal circulatory effects of OXT occurred in the peripheral blood vessels. The vessels of the skin were very sensitive to OXT's vasodilatory action. The vasodilatory effects of OXT have been demonstrated when the hormone has been experimentally injected. Kitchin, Lloyd, and Pickford (1959) found that OXT had a vasodilatory action to which the hand was more responsive than the forearm. Injection of 500 units intravenously, or 50 units injected into the brachial artery, caused blood flow through the hand to double, although the response diminishes with repeated doses via either route (Greenfield, 1972). Intra-arterial injection of even small amounts of OXT have increased the blood flow in the hand on the side of the injection (Haigh, Kitchin, & Pickford, 1963).

Clarifying the relationship between temperature increases and OXT may permit the subsequent identification of finger temperature increases as an objective marker of the MER. Some preliminary research has been done on the possibility of a relationship between vasodilation and lactation. Abolins (1954) measured the temperature of mammary skin before and after feeding and found that there was a strong positive correlation between milk volume and a rising or stationary high temperature. Using infrared thermography, Lind, Vuorenkoski, and Wasz-Hockert (1972) documented a significant increase in breast warmth when the MER occurred in response to the sound of a crying baby. Jelliffe and Jelliffe (1978) felt that the temperature increases reported by Lind et al., were the result of increased blood flow to the skin covering the breast. With the exception, however, of a single case study employing informal temperature recording (Walker, 1981), and the initial study in this sequence, there appear to have been no other attempts to document temperature change during a feeding.

2. Skin Conductance Response and Peripheral Temperature Patterns as Recorded in Different Contexts

The psychophysiological rationale for choosing peripheral temperature and skin conductance as indicators of sympathetic arousal is of particular relevance to the current study. Skin conductance is a measure of electrodermal activity, in large part reflecting activity in the eccrine sweat glands. Vasomotor activity represents the variable distribution of blood to different parts of the body as blood vessels constrict and dilate. Vasomotor constriction occurs in response to sympathetic arousal. One measure of vasomotor activity is skin temperature. Since sweat glands and peripheral blood vessels are considered to be exclusively or predominantly innervated by the sympathetic division of the autonomic nervous system (Greenfield & Sternbach, 1972; Guyton, 1986; Katkin & Hastrup, 1986), a response pattern suggesting an increase in sympathetic tone would involve an increase in SCR accompanied by a decrease in skin temperature.

The increase in skin conductance observed in the first study during feedings, may reflect a sudden increase in sympathetic arousal, but in the traditional model such an increase should produce a decrease in peripheral blood flow. Instead, contrary to what sympathetic arousal theory would predict, the greater SCR was accompanied by a marked and persistent increase in skin temperature at both finger and breast.

This intriguing pattern has also been reported in three other contexts, all considered pathological or dysfunctional: as part of the pattern of the menopausal hot flush, as part of flush-like episodes reported in pre-menopausal women with premenstrual syndrome (Casper, Graves, & Reid, 1987), and has also been reported in males, following testicular failure or bilateral orchiectomy, a pattern of hot flushes ensues paralleling that of the menopausal flush (Eaton & McGuire, 1983; Ginsburg & O'Reilly, 1983). A rapid increase in skin conductance is a characteristic feature of this response, and is sometimes characterized as the impending sign of a menopausal flush (Sturdee et al., 1978; Tataryn et al., 1980).

Interestingly, however, the pattern of SCR and peripheral temperature increase during the menopausal hot flush has involved the SCR being recorded at the sternum only, and the temperature at the finger. Rickles and Day (1969) found the sternum to be an "inactive site" for recording skin conductance. Freedman (1989) found no sternal SCR change in premenopausal women either in response to artificial heating in the lab, nor during daytime ambulatory monitoring of their normal activities.

In contrast, large sternal skin conductance changes have been reported during menopausal flushes, both under resting lab conditions (Tataryn et al., 1980), and during both heat induced lab and ambulatory circumstances (Freedman, 1989).

The contrast between menopausal and non-menopausal women in terms of sternal SCR has previously been explained as an alteration in thermoregulatory function during the menopausal flush. Since there are similarities in the response pattern between the menopausal flush and breastfeeding, replicating the first study in this sequence and additionally recording sternal SCR in the non-pathological context of a breastfeeding may extend our understanding of possible underlying mechanisms.

3. Patterns of Hormone Change

The menopausal hot flush is recognized as a hypothalamic event and the similarity to the flush of the initiation stage of a feeding suggests there may be certain hypothalamic events in common. The hot flush is associated with increases in LH as a spontaneous pulse, and with a more prolonged increase in cortisol. Since there are striking similarities between the peripheral response patterns during lactation and the menopausal flush, recording the levels, exploring the relationship of hormonal to thermal changes may clarify the processes involved and begin to define the similarity or difference of these two phenomena.

a. Luteinizing hormone.

The menopausal flush has been described as a specific thermoregulatory disorder (Tataryn, 1980), characterized as a sudden downward setting of the central thermostats with heat loss mechanisms activated to bring core temperature down to the new level. LH pulses have been recorded as occurring with the menopausal flush. Pulses were not always accompanied by flushes, but a flush was never seen in the absence of an LH pulse (Casper, Yen, & Wilkes, 1979). Subsequently, however, it was concluded that the two events may not be directly connected: when the LH pulse was stopped with an LHRH (luteinizing hormone releasing hormone) analogue, menopausal flushing continued (Casper & Yen, 1981; DeFazio et al., 1983; Lightman et al., 1982). The question than becomes, is there a mechanism common to both flushing and gonadotropin secretion?

In the context of postpartum anovulation, LH levels are presumably low, but the research relative to lactation seems not yet clear. Amico, Richardson, and Winters (1989) found that OXT does not suppress LH levels, although the animal research suggests (Lu et al., 1976; Schallenberger et al., 1981) that in rhesus macaques and rats, suckling, itself, may have a direct inhibitory effect on the hypothalamic secretion of gonadotopins. Recording LH and OXT levels during a feeding, relative to peripheral temperature change, may suggest a higher order or common factor that controls both.

b. Cortisol.

Increases in plasma (and saliva) cortisol have long been used as evidence of changed hypothalamic-pituitary-adrenocortical (HPAC) activity. An increase in serum cortisol has been used as a biological marker for major depressive disorders (MDD) [from Carrol et al. (1981) to, for example, Stokes et al., 1984)]. Increased HPAC activity has been recorded in a variety of other disorders, including stress states (Kirshbaum et al., 1989; Machak et al., 1987). As Asnis and Lemus (1987) point out, however, the literature on the function of the HPAC axis has frequently focussed on MDD, neglecting normal as well as additional pathological controls. They further suggest that assessment of cortisol secretion as a laboratory aid in diagnosing depression is much less important than using it to identify biochemical and/or clinical correlates of specific stimulus contexts, and of homogeneous groups or sub-groups. In treatment contexts, there are scattered reports of this measure being used to find such correlates (post partum depression, Ehlert et al., 1990; post-traumatic stress disorder, Mason et al., 1986; essential hypertension, McGrady et al., 1987 a/b).

Elevated plasma cortisol and adrenocorticotropic hormone (ACTH) levels have been reported as a component of the menopausal flush (Meldrum et al., 1979). Genazzani et al., (1984) reported plasma levels of cortisol were elevated during menopausal flush episodes. The timing of the cortisol rise was similar to and concurrent with the LH pulse, but the magnitude of the increase of cortisol was greater. This measure may help to clarify possible hypothalamic similarities between the flush and breastfeeding should a similar pattern be recorded in this study. Alternatively the cortisol rise during the flush may represent a secondary response to the stimulus of the flush itself. Kakimoto et al., (1988) used the plasma-free portion of the cortisol measure as a measure of acute cortisol response to varying stimuli.

In man and the other, non-human, primates, serum cortisol has a daily (circadian) rhythm which must be taken into account. At its highest during the early part of the daily light cycle, cortisol levels falls during the day to reach their lowest level in the evening and early part of the dark phase, before beginning to rise again during the later part of the night to a morning crest (Herbert, 1989).Within this rhythm, the 1-4 p.m. level generally considered a comprehensive measure since it correlates well with the mean 24 hour cortisol level in a wide range of subject populations (Halbreich, Zumoff, Kream,

& Fukushima, 1982; Halbreich, Asnis, Zumoff, Nathan, & Shindledecker, 1984; Halbreich, Asnis, Shindledecker, Zumoff, & Nathan, 1985; Asnis & Lemus, 1987).

F. Conclusion and Research Problems

The preceding literature review has examined four areas of importance relative to the research proposed here: the first study in this sequence; the peripheral vascular effects of OXT; the pattern of SCR and peripheral temperature change in different contexts; and potential patterns of associated hormone change.

The basic research question of this study is, then, what changes occur in peripheral and hormonal measures during breastfeeding? More specifically, the literature poses three problems:

1. There is pharmacological, but not physiological, evidence of a relationship between OXT and peripheral temperature change. If documented, during feeding, this may provide a rationale for subsequent research into temperature change during breastfeeding as an objective marker of an OXT release, and/or of the MER.
2. Despite current theory that an increase in sympathetic tone, as measured by SCR, should produce a decrease in peripheral blood flow, as measured by finger temperature change, there are reports of temperature increase preceded by an SCR increase. Recording these during breastfeeding, and in the context of the concurrent hormone changes, may begin to clarify the processes involved.
3. The pattern of hormone changes occurring during breastfeeding needs to be investigated, particularly the patterns of OXT, LH, and cortisol changes in relation to the peripheral temperature and skin conductance events. Knowledge of the physiological changes associated should provide valuable information for subsequent research into the underlying mechanisms.

CHAPTER THREE

Methods

A. Chapter Overview

Chapter Three, Methods, includes a chapter outline and a review of this study's sample criteria, research design and data analysis. Also reviewed are the procedure, instrumentation, and data collection techniques employed.

B. Sample

The subjects of this study were selected from responses to a request for volunteers that was made to the Greater Edmonton Birth and Parent Education Centre, the La Leche League, and several church groups in the greater Edmonton area. Six women who were breastfeeding infants were selected from those who volunteered for this study on the basis of their meeting the following criteria. Subjects were breastfeeding without the use of solids or supplementary milk, and were between six weeks and six months postpartum. They were not yet menstruating. All of the infants were full term (37+ weeks) with a weight gain of at least 4 to 6 ounces per week since birth. None were smokers, and all had had post-partum examinations with no reported concerns. These criteria were confirmed during an initial interview with each mother.

C. Research Design and Analysis

The research was conducted as a non-factorial single group design involving no randomization nor comparison between groups. No cause and effect relations were hypothesized, but rather a descriptive baseline would be established among those variables identified as potentially relevant for subsequent research.

Data were analyzed, first, with a single-factor repeated-measures ANOVA (Jaccard, 1983) in order to replicate (FT and SCR by Stages of Feeding) the original study. A second analysis of variance was completed to incorporate the results of direct hormonal sampling (FT and SCR by 1 minute Time Periods during Feeding). A third, exploratory analysis of the data involved centering the results of each measure to the onset of finger temperature elevation in each subject. (Levey, 1980).

By using the onset of the temperature rise as a reference point, a relatively precise picture of the physiological changes and the temporal relationships was obtained. Since the temperature increase documented in this study occurred at different times after the initiation of feeding for different subjects, the number of samples at the beginning and end of the experiment was necessarily not uniform. In this second analysis, means were calculated only for those time points for which samples were obtained from all subjects.

Several precedents for this approach to normalizing the data to a significant physiological event exist in the psychophysiology literature (e.g., Hoff, Quigley, & Yen, 1983; Maschak, Kletsky, & Artal, 1984). Levey (1980) provides a rationale for the use of this sort of transformation in order to "describe functional relationships in such a way that the transformation may aid in identifying the nature of the underlying processes." (p. 600)

Levey further notes that in psychophysiology studies transformations should be based, ideally, on known physiology. In this context, the vasodilatory properties of OXT and the observed significant temperature increases during breastfeeding provide a model or rationale for temperature increase as the temporal reference point around which to explore the physiological changes during a feeding.

D. Procedure

The method used in this study, as in the preceding one, was developed in an attempt to take into consideration possible confounding variables suggested in the psychophysiological and biofeedback literature. Broder (1979) stressed the importance of achieving a baseline period long enough to permit responses to stabilize once the sensors have been attached. Yates (1980) suggested a similar adaptation period in order to adjust from outside temperatures and/or varying levels of activity prior to the recording session. Control of ambient temperature in the recording setting is recommended by several researchers (e.g., King & Montgomery, 1980), with Broder (1979) specifying a range of 70° - 72° F, or 20° C.

Subjects were invited to arrive at the McKenzie Health Sciences Centre at approximately 2:00 p.m. and to anticipate spending three hours in the research setting. The time was selected as the period in the day when levels of cortisol are relatively low and flat. The first hour consisted of an adaptation period during which, shortly after arrival, temperature and skin conductance sensors were attached, and an IV needle was inserted; the following 45 minute period thus permitted adaptation to the presence of these devices and to the ambient temperature of the room.

The majority of oxytocin-lactation studies have been hospital-based early post-partum observations. These would appear to be potentially confounded by the separation of mother and baby in most hospital settings. When separated from the baby, the mother is more apt to respond to crying or to sounds of the baby coming from the nursery--and this anticipation is considered in part responsible for preliminary OXT release (McNeilly, Robinson, Houston, & Howie, 1983). An attempt was made to control for this by using the adaptation period as a time when mother and baby were calmly together, thus establishing the baseline readings in a calm non-feeding, but not separated, situation.

The experimental room was furnished for a non-clinical appearance, with pictures, plants, rug, etc. Ambient room temperature remained 20° C throughout the experiment. Subjects were seated in a comfortable chair with arms. Subjects were invited to dress in short sleeved, loose fitting tops which would permit easy placement of the recording thermistors, and which made it possible to fasten the various wires out of the way of both mother and infant.

After seating, one thermistor was attached to the outer surface of the middle phalange of the third finger of the hand on the same side as the feeding. This hand was chosen because of its accessibility during feeding, and because for most mothers, this is the less active hand during feeding.

The thermistor measuring ear canal temperature was placed at the mother's comfort in the right ear canal. The thermistor was held in place by a temporary hearing aid form, with the wires taped in place behind the subject's ear. The skin conductance sensors were placed on the thenar and hypothenar eminences of the left palm, and on the upper sternum.

Insert Illustration 1 about here

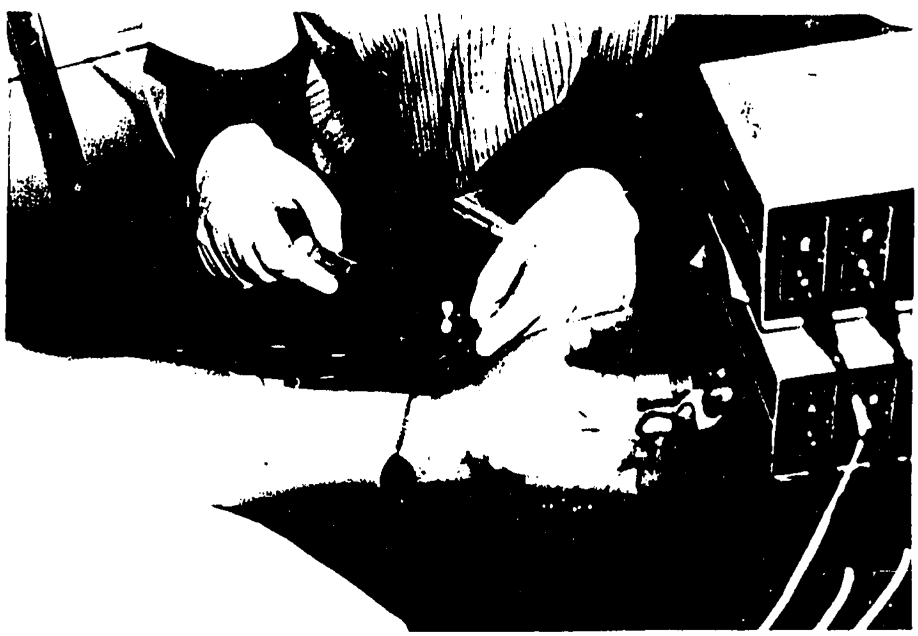


PLATE 1 Illustration of the Placement of Data Collection Devices

The sensors were held in place with electrode patches, and interference from the wires attached to the sensors was minimized by having them pass between the fingers and over her shoulder, respectively. An intravenous cannula was inserted into an arm vein of the mother and an IV line was kept open with normal saline. Blood samples were withdrawn through a series of two 3-way stopcocks which permitted the removal of the excess saline into a syringe prior to removal of the blood sample.

After the IV and the sensors were in place, and while the mother was adapting to their presence and to ambient room temperature, background information was obtained in a conversational format. Approximately 45 minutes later, an initial blood sample was taken. Fifteen minutes later, and five minutes before the initiation of the feeding, simultaneous recording of baseline levels was begun by initiating computer recording, timed to coincide with the subsequent blood draws. After five minutes of baseline recording the mother was invited to initiate the feeding, and sampling of both peripheral and blood measures proceeded at one minute intervals for the following 15 minutes. Particular note was made of the point two minutes after the initiation of feeding, since this is the time by which most researchers have reported the milk-ejection reflex to have occurred (Janbu, 1985; Dawood, 1981).

Feeding was accomplished with the mother seated and the infant lying across her lap on a pillow (See Illustration 2). Assistance was provided, as needed, in helping attach the infant to the breast. The sampling procedure did not appear to interfere with the feeding, nor did the feeding appear to interfere with the sampling.

Insert Illustration 2 about here

PLATE 2 Illustration of Data Collection During Feeding

Additional recordings were not made during feeding at the second breast since not all infants were willing to feed again on the second side, and because research data suggests that a second reflex does not always occur during sucking at the second breast (Janbu, 1985).

E. Instrumentation

The measures of temperature and skin conductance were recorded using the Unicomp computerized biofeedback system. Continuous monitoring of four modalities was made using this system and was recorded on the computer using an analog to digital conversion. The Unicomp was set up to record at one minute intervals throughout the baseline and feeding period. Each of these data points reflects the averaged value of the three readings per second made during the preceding 60 second period. The Unicomp program was used to guide an IBM-style 286-AT computer, functioning with 16MHz clock time, and 1 megabyte RAM.

F. Data Collection

Baseline recording of temperature and SCR were made during an adaptation period permitting the subject to habituate to the equipment and setting. Skin conductance measurement conformed to publication standards of the Society for Psychophysiological Research in terms of placement, the use of silver-silver chloride electrodes, and of an electrode paste consisting of one part physiological saline and two parts Parke-Davis Unibase (Fowles et al., 1981; Venables & Christie, 1980).

Two baseline samples of blood were withdrawn through the cannula at 15 and 5 minutes before the initiation of breast feeding. After initiation, samples were taken at 1 minute intervals until the end of a fifteen minute feed. Each sample consisted of six cc of 15 blood. The total blood taken during each study was therefore be less than 150 cc (22 samples of 6 cc).

Each sample was immediately divided into two, and kept on ice until the end of the session. Three cc were placed in a heparinized tube on ice, and were centrifuged to separate plasma as quickly as possible. The remaining 3 cc were allowed to clot and the serum was separated. Both serum and plasma were stored at -20° C.

The plasma samples were assayed using the established (Amico, 1981; Amico & Robinson, 1985; Amico, 1986) radioimmunoassay for OXT in Dr. Amico's laboratory (Division of Endocrinology and Metabolism, School of Medicine, University of Pittsburgh). Serum samples were assayed for LH and cortisol by commercially available kits in the Department of Laboratory Medicine, University of Alberta Hospital. Plasma samples were assayed for LH on an ACS: 180 (Ciba-Corning) chemiluminescence analyzer, and for cortisol using the Department of Laboratory. Medicine's established ELISA, or enzyme immunoassay.

CHAPTER FOUR

Results

A. Chapter Overview

Chapter 4 includes an overview of the chapter contents and the results of the analyses of the data. The first of these includes a summary statement of the results of the first study–the replication of which was one of the purposes here–and a description and analysis of the findings of the present study (Finger Temperature & palmar SCR by Stage of Feeding) as they relate to the earlier results.

The second includes a description and analysis of Finger Temperature and palmar SCR data (by Time Periods during Feeding). The third and final analysis includes a description of the data for each of the additional variables (OXT, LH, cortisol, and sternal SCR), and concludes with an analysis of the data performed to investigate the temporal relationship of the variables to the beginning of the increase in peripheral temperature.

B. Description and Analysis for Relication (FT & SCR by Stages of Feedings)

Before analyzing the data, a summary of the values at each Stage of Feeding will be provided for each measure. As in the first study, the Initiation of feeding (described originally as Volition) served as the base (time zero) in this analysis of the physiological changes which occur during feeding. Baseline was calculated as the mean of the five minute period preceding the beginning of the feeding. Volition was defined as pre-suckling behaviour by the mother to begin the feeding. The Feeding Stages of Volition, Two minutes, and Five minutes were identified in the first study from reports in the literature of OXT release by five minutes.

1. Baseline Data

Table 1 shows the means and standard deviations of the baseline scores for FT and SCR in the current study, together with their minimum values, maximum values and range. It can be observed that the group's mean baseline finger temperature (± S.E.) was 32.84 ± 0.398° C, and ranged from 31.59 to 34.13° C. Baseline Palm SCR ranged from 4.09 to 11.45 micromho (μ mho), with a mean value (± S.E.) of 7.11 ± 1.25 μmho. Table 1a shows the baseline finger temperature and SCR for the subjects in the first (1987) study.

Table 1
Summary of Baseline Data
N = 6

MEASURE	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
Finger Temp (°C)	32.838	.976	31.59	34.13	2.539
Palm SCR (μmho)	7.11	3.063	4.09	11.45	7.36

Table 1a
Summary of Baseline Data (Marshall, 1987)
N = 20

MEASURE	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
Finger Temp (°C)	31.96	1.53	27.76	34.09	6.327
SCR (μmho)	15.51	6.65	3.14	25.47	22.33

2. Finger Temperature Data

Table 2 provides the mean value, standard deviation, maximum and minimum values, and range at each Stage of Feeding for Finger Temperature. Mean finger temperature (± S.E.) changed from a Baseline reading of 32.84 ± 0.398° C to 32.42 ± 4.26° C at Initiation, to 32.83 ± 0.437° C at Two minutes, and 33.18 ± 0.405° C at Five minutes. The mean difference relative to baseline was 0.421° C at volition, 0.007° C at two minutes, and - 0.345° C at five minutes.

Table 2
Mean Finger Temperature (° C) at each Stage of Feeding
N = 6

STAGE OF FEEDING	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
Baseline (T1)	32.838	.976	31.59	34.128	2.539
Volition (T2)	32.417	1.044	31.464	33.721	2.257
Two Minutes (T3)	32.831	1.07	31.597	34.439	2.841
Five Minutes (T5)	33.[illegible]83	.992	32.165	34.984	2.819

Table 3 presents the summary table for the analysis of variance performed relating Stage of Feeding and Finger Temperature. The observed F ratio (F obs=17.858) was statistically significant (F critical = 4.25, p< .0001). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 83% of the variability in Finger Temperature was associated with Stage of Feeding. Given the significance of the F ratio, Scheffé tests were performed in order to contrast the mean values at different stages of feeding when these were paired for comparison purposes. The results of the Scheffé tests are presented in Table 4, and illustrate that Finger Temperature was found to be significantly ($p < .05$) higher than T2 (Initiation of feeding) at the Five Minute ($F = 4.344$) Stage of Feeding.

Table 3

Analysis of Variance: Finger Temperature by Stage of Feeding

N = 6

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
BETWEEN SUBJECTS	18.835	5	3.767	17.858
WITHIN SUBJECTS	3.797	18	.211	
treatments	1.769	3	.59	4.362
residuals	2.028	15	.135	
TOTAL	22.632	23		

Table 4

Summary of Differences between Paired Stage of Feeding Means: Finger Temperature

N = 6

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Baseline vs Volition	.421	1.31
Baseline vs Two Minutes	.007	3.478
Baseline vs Five Minutes	-.345	.882
Volition vs Two Minutes	-.414	1.269
Volition vs Five Minutes	-.766	4.344*
Two Minutes vs Five Minutes	-.352	.917

Significant at 95%

3. Palmar SCR Data

Table 5 shows the mean value, standard deviation, maximum and minimum values, and range at each Stage of Feeding for palmar SCR. Mean SCR changed from a baseline reading of 7.107 µmho to 7.515 µmho at Initiation, to 6.287 µmho at Two Minutes, and to 5.543 µmho at Five Minutes. The mean diferences relative to Baseline were -0.408 µmho at Initiation, 0.82 µmho at Two Minutes, and -1.563 µmho at Five Minutes.

Table 5

Mean palmar SCR (μ mho) at each Stage of Feeding

N = 6

STAGE OF FEEDING	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
Baseline (T1)	7.107	3.063	4.09	11.45	7.36
Volition (T2)	7.515	3.642	3.84	13.34	9.5
Two Minutes (T3)	6.287	3.563	2.81	12.16	9.35
Five Minutes (T5)	5.543	3.68	1.41	11.43	10.02

Table 6 presents the summary table for the analysis of variance performed relating Stage of Feeding and palmar SCR. The observed F ratio (F obs = 45.909) was statistically significant (F critical = 4.25, $p < .0001$).The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 95% of the variability in palm SCR was associated with stage of feeding. Given the significance of the F ratio, Scheffé tests were performed in order to contrast the mean values at different stages of feeding when these were paired for comparison purposes. Table 7 illustrates that after Scheffé tests were performed, significant differences ($p<.05$) were found between Baseline and Five Minutes, and between Initiation and both the Two Minute and Five Minute Stages of Feeding.

Table 6

Analysis of Variance: palmar SCR by Stage of Feeding

N = 6

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
BETWEEN SUBJECTS	239.457	5	47.891	45.909
WITHIN SUBJECTS	18.777	18	1.043	
treatments	13.848	3	4.616	14.047
residuals	4.929	15	.329	
TOTAL	258.234	23		

Table 7

Summary of Differences Between Paired Stage of Feeding Means: Palmar SCR

N = 6

COMPARISON	MEAN DIFFERENCE	SCHEFFÉ
Baseline vs. Volition .	-.408	.507
Baseline vs. Two Minutes	.82	2.046
Baseline vs. Five Minutes	1.563	7.437*
Volition vs. Two Minutes	1.228	4.591*
Volition vs. Five Minutes	1.972	11.83*
Two Minutes vs. Five Minutes	.743	1.681

Significant at 95%

4. Conclusion

In the original study Finger Temperature was found to be significantly ($p < .05$) higher than Baseline at Two Minutes ($F = 19.74$), and at Five Minutes ($F = 22.15$), and was significantly higher than Volition at Two Minutes ($F = 8.91$) and at Five Minutes (F

= 10.55). There were no significant differences in Finger Temperature between Baseline and Volition, nor between Two Minutes and Five Minutes.

In the present study there were significant differences in Finger Temperature between Initiation and Five Minutes. There were no significant differences between Baseline and any of the three subsequent Stages of Feeding, as originally defined. As such, this analysis fails to confirm the Finger Temperature results of the initial study.

In the original study palmar SCR increased significantly ($p < .05$) between Baseline and Volition ($F = 4.24$), and decreased significantly, relative to Volition by Five Minutes ($F = 3.48$). In the present study there were significant differences in palmar SCR, relative to the initiation of feeding, by minute five, and again from minutes nine through eleven. There were, however, no significant differences between Baseline and any of the three subsequent Stages of Feeding, as originally defined. As such this analysis fails to confirm the SCR results of the initial study.

C. Description and Analysis (FT & SCR by Time Periods)

When the ANOVA and Scheffé tests were extended farther into the feeding period and included the data from each one minute Time Period throughout the feeding, additional results were obtained. Initiation of feeding (described originally as Volition) served as the base (time zero) in this analysis of the physiological changes which occur during feeding. Baseline was calculated as the mean of the five minute period preceding the beginning of the feeding. Initiation was defined as the beginning of feeding, with the baby's suckling.

1. Finger Temperature Data

Figure 1 displays the mean values for Finger Temperature for Baseline and for each one minute Time Period during feeding. Finger Temperature increased steadily after the Initiation of feeding, and remained elevated throughout the feeding period, exceeding mean Baseline (32.84°C) by three minutes and reaching maximum (33.53°C) by nine minutes.

Insert Figure 1 about here

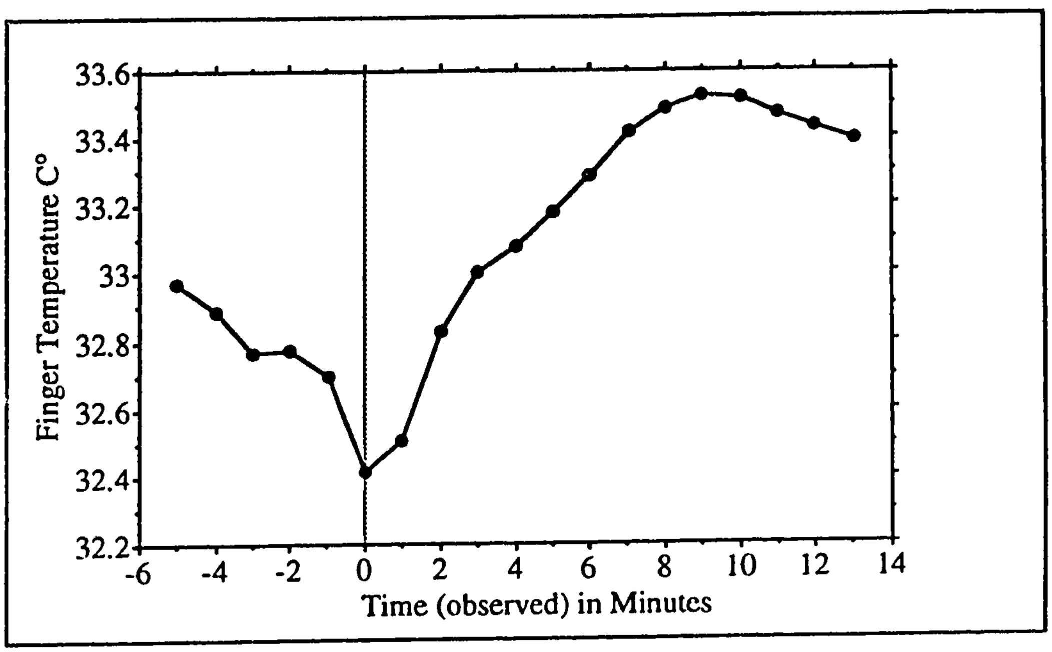


FIGURE 1: Mean Finger Temperature by (one Minute) Time Periods

Table 8 presents the summary table for the analysis of variance relating the Time Periods during feeding and Finger Temperature. The observed F-ratio (F obs = 65.687) was statistically significant (F critical = 3.25, $p < .0001$). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 80% of the variability in finger temperature was associated with the Time Period of the feeding. Given the significance of the F ratio, Scheffé tests were performed in order to contrast the mean values at the one-minute Time Periods of the feeding when these were paired with each other and with the baseline value for comparison purposes. The significant results of the Scheffé tests are presented in Table 9.

Table 8
Analysis of Variance: Finger Temperature by Time Periods (One Minute) during Feeding
N = 6

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
BETWEEN SUBJECTS	66.748	5	13.35	65.687
WITHIN SUBJECTS	17.072	84	.203	
treatments	11.378	14	.813	9.993
residuals	5.693	70	.081	
TOTAL	83.82	89		

Table 9 illustrates that in this study Scheffé tests of paired means indicated that Finger Temperature was found to be significantly higher ($p<.05$) than the Initiation of feeding by the six minute time point (F = 1.978) into the feeding, and continued to be significantly higher from that point through the thirteen minute time point (F = 2.533). Finger Temperature was also significantly higher than the first minute Time Period from the seventh (F = 2.186)through thirteenth minutes (F = 2.076) of the feeding. There were no significant differences between any of the other paired means.

Table 9

Summary of the Significant Differences Between
Paired Time Period (One Minute) Means: Finger Temperature
N = 6

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Initiation vs. Minute Six	-.866	1.978*
Initiation vs. Minute Seven	-1.004	2.654*
Initiation vs. Minute Eight	-1.068	3.008*
Initiation vs. Minute Nine	-1.11	3.247*
Initiation vs. Minute Ten	-1.103	3.204*
Initiation vs. Minute Eleven	-1.054	2.925*
Initiation vs. Minute Twelve	-1.013	2.703*
Initiation vs. Minute Thirteen	-.98	2.533*
One Minute vs. Minute Seven	-.911	2.703*
One Minute vs. Minute Eight	-.976	2.509*
One Minute vs. Minute Nine	-1.017	2.728*
One Minute vs. Minute Ten	-1.01	2.688*
One Minute vs. Minute Eleven	-.961	2.433*
One Minute vs. Minute Twelve	-.92	2.231*
One Minute vs. Minute Thirteen	-.888	2.076*

Significant at 95%

2. Palmar SCR by Time Periods (One Minute) during Feeding

Figure 2 displays the mean values for palmar SCR for Baseline and each one minute Time Period during feeding. Table 10 presents the summary table for the Analysis of Variance relating Time Periods during feeding and palmar SCR. The observed F-ratio (F obs = 294.156) was statistically significant (F critical = 3.25, $p < .0001$). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 80% of the variability in finger temperature was associated with the Time Period of the feeding. Given the significance of the F ratio, Scheffé tests were performed in order to contrast the mean values at the one-minute Time Periods of the feeding when these were paired with each other and with the baseline value for comparison purposes.

Insert Figure 2 about here

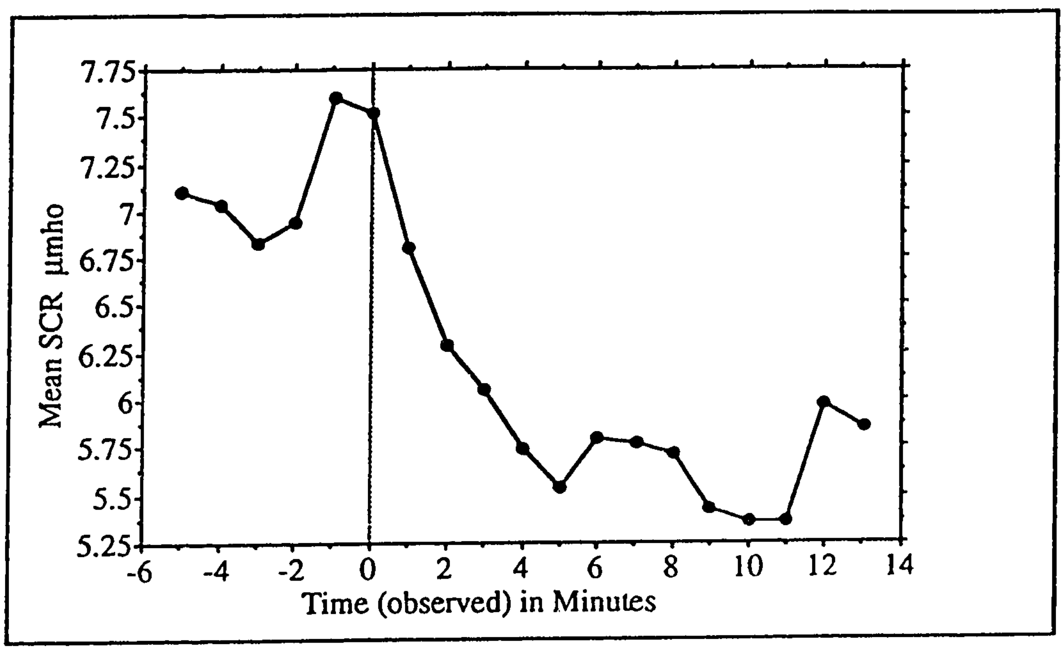


FIGURE 2: Mean palmar SCR by (one Minute) Time Periods

Table 10

Analysis of Variance: palmar SCR by Time Periods (One Minute) during Feeding

N=6

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
BETWEEN SUBJECTS	1080.848	5	216.17	294.156
WITHIN SUBJECTS	61.73	84	.735	
treatments	33.907	14	2.422.	6.093
residuals	27.823	70	.397	
TOTAL	1142.578	89		

Table 11 illustrates that in this study Scheffé test of paired means indicated significant change in palmar SCR between Initiation and the Minute Five (F = 2.096), and again from Minutes Nine through Eleven. There were no significant differences between any of the other paired means.

Table 11

Summary of the significant Differences Between

Paired Time Period (One Minute) Means: Palmar SCR

N = 6

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Initiation vs Minute Five	1.972	2.096*
Initiation vs Minute Nine	2.092	2.359*
Initiation vs Minute Ten	2.155	2.504*
Initiation vs Minute Eleven	1.952	2.054*

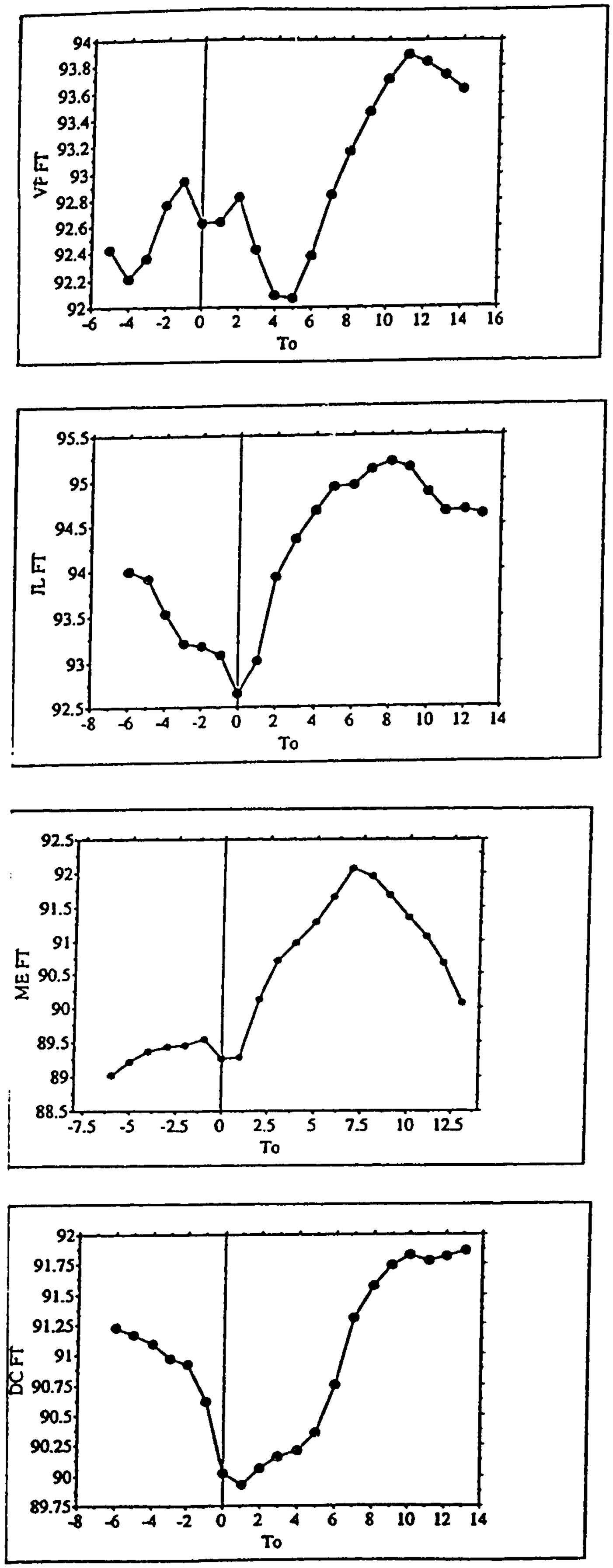
Significant at 95%

3. Conclusion

Results of this analysis confirmed that signficant finger temperature increase were occurring during feeding, but not within the Stages of Feeding as originally defined in the first study. Analysis of Variance and Scheffé tests of paired means indicated that significant mean Finger Temperature increases were occurring relative to the Initiation of feeding, but not until minutes six through thirteen. Examination of the data files of the individual subjects indicated that in all cases substantial Finger Temperature increases were occurring, but at different times for each individual. Figure 3 displays several individual Finger Temperature records. This observation suggested the approach taken in the third analysis.

Insert Figure 3 about here

FIGURE 3: Samples of Individual FT data records



D. Data Centered on Onset of Peripheral Temperature Rise

To explore the dynamics of the hormonal and peripheral physiological changes which occur during a feeding, the onset of the Finger Temperature rise was used as a reference point in the data to explore the temporal relationship of the different variables to the onset of the peripheral temperature elevation.

To accomplish this all variables were centered around (or normalized to) the onset, following the initiation of feeding, of each individual's Finger Temperature increase. For this third analysis, and to permit comparison to other studies, temperature recordings were analyzed according to the following criteria (Meldrum et al, 1979, p. 714):

(1) A temperature elevation was considered significant if it exceeded 1° C; (2) the baseline was defined as the temperature immediately preceding a significant elevation; (3) the peak temperature was defined as the maximum temperature achieved during an elevation; (4) the magnitude of the elevation was measured from the baseline to the peak.

The time point immediately preceding the onset of the temperature rise served as the base (time zero) for this temporal analysis of the circulating hormone and peripheral measures.

1. Finger Temperature

Figure 4 illustrates the mean values for Finger Temperature when centered around onset of temperature elevation. During the 15 minutes of recording after the initiation of the feeding, a significant (> 1° C) finger temperature elevation was recorded in all subjects by (mean ± S.E.) 4.8 ± 0.8 minutes after the commencement of the elevation. The mean (± S.E.) rise was 1.236 ± 0.1° C, with peak temperature reached 7.3 ± 0.6 minutes after the commencement of the elevation. Finger temperature remained elevated for the duration of the recording period.

Insert Figure 4 about here

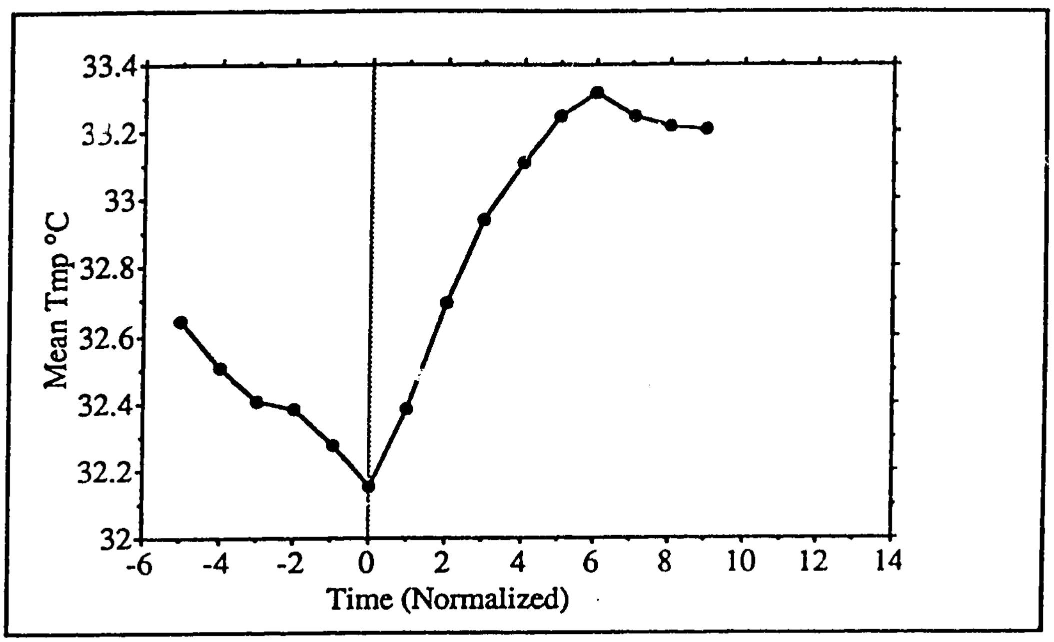


FIGURE 4: Mean Finger Temperature Centered to Onset of Temperature Elevation

2. Palmar SCR (pSCR)

When centered on the onset of Finger Temperature elevation, mean baseline pSCR (±S.E.) was 5.68 ± .91 µmho. Palm SCR increasedto 7.26 ± 1.5 µmho prior to the onset of the Finger Temperature elevation returning to baseline or below within the first minute. A second brief rise (to 5.82 ± 1.85 µmho) occurred at minute 7. Figure 5 displays the mean pSCR values.

Insert Figure 5 about here

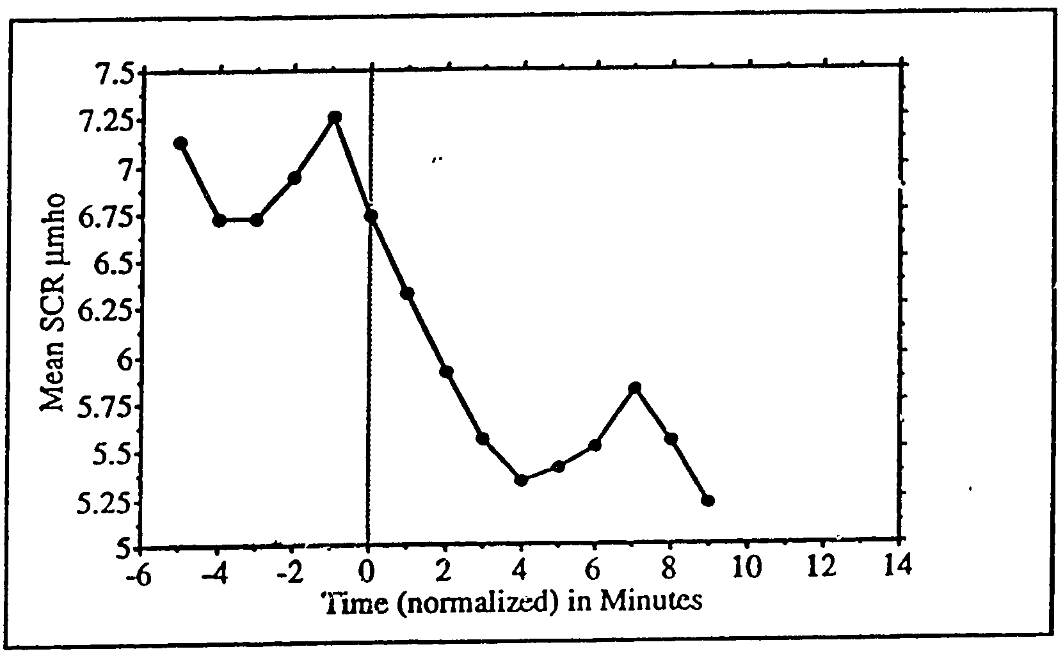


FIGURE 5: Mean palmar SCR Centered to Onset of Temperature Elevation

3. Sternal SCR (sSCR)

Figure 6 displays the mean sternal SCR values when normalized to onset of Finger Temperature elevation. It is interesting to note the contrasting direction and amplitude of these changes when contrasted to the simultaneously recorded palmar SCR.

Insert Figures 6 and 6a about here

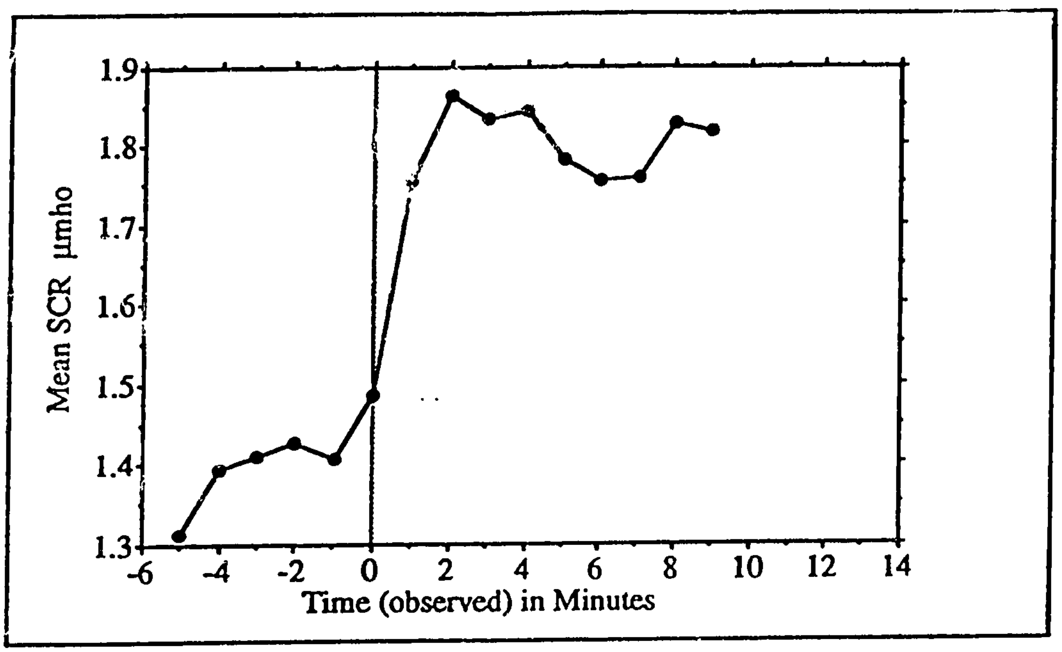


FIGURE 6: Mean sternal SCR Centered to Onset of Temperature Elevation

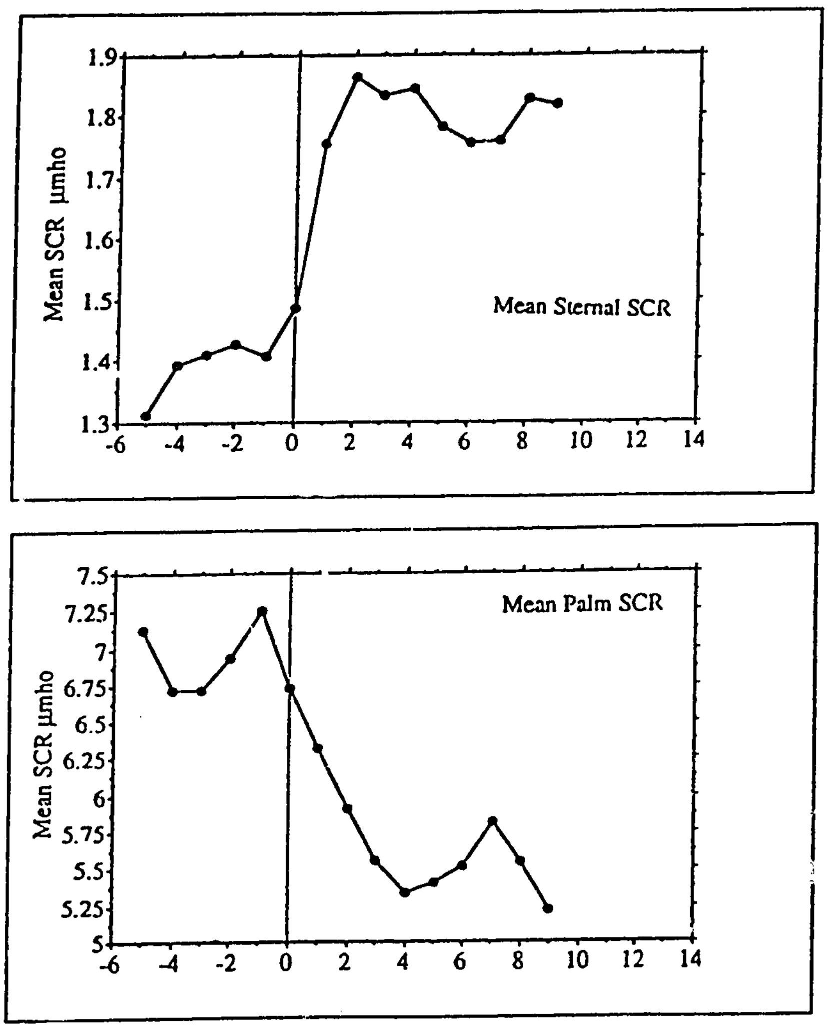


FIGURE 6a: Simultaneous Recordings of sternal and palmar SCR Measures

<u>4. Oxytocin (OXT)</u>

Figure 7 illustrates the changes in circulating concentrations of OXT in relation to Finger Temperature elevation. Pre-stimulus basal values for the sample group were (± S.E.) 8.76 ± 2.24 picogram per millilitre (pg/ml) 15 minutes prior to the initiation of feeding, and 8.32 ± 1.75 pg/ml 5 minutes prior to initiation. The mean of the individual peak stimulated level was 18.54 ± 3.127, and was reached by 6.2 ± 1.4 minutes after the commencement of that individual's OXT increase.

Mean basal OXT (defined as the value immediately before the onset of the temperature elevation) among the subjects was 4.78 ± 0.86 pg/ml. Mean OXT concentration approximatley doubled by the first minute, reaching values of 9.93 ± 3.77 pg/ml. The pattern of release reflects an initial increase for 2 minutes followed by a larger increase by the eighth minute, reaching values of 12.01 ± 3.25 pg/ml.

Relative to the elevation of Finger Temperature, OXT concentrations remained elevated relative to basal values during the balance of the recording period. In 4 out of 6 subjects, significant temperature (> 1° C) increase occurred within ± 1 minute of an OXT pulse. In five out of six subjects peak temperature elevation occurred within ± 1 minute of maximum OXT levels.

Insert Figure 7 about here

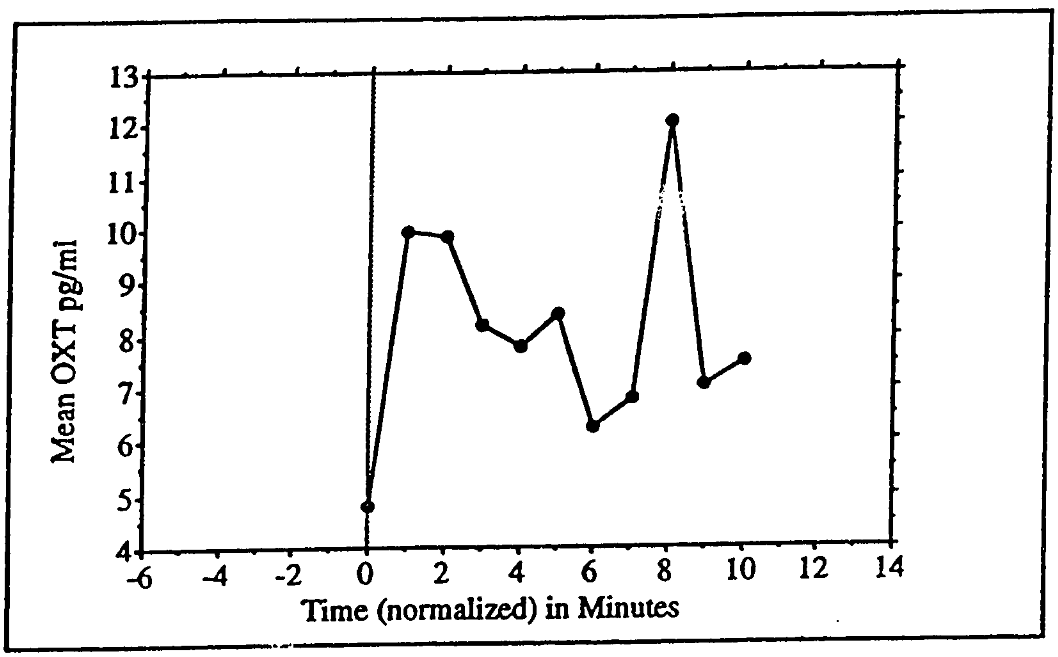


FIGURE 7:
Mean Oxytocin Concentrations Centered to Onset of Temperature Elevation

5. Luteinizing Hormone (LH)

Figure 8 illustrates the changes in circulating concentration of LH when centered on the onset of peripheral temperature elevation. Basal values for the sample group were (± S.E.) 3.73 ± 1.05 International Units per Litre (IU/L 15) minutes prior to the initiation of feeding, and 3.15 ± 1.75 IU/L 5 minutes prior to initiation.

Mean basal LH (defined as the value right before the onset of the temperature elevation) among the subjects was 3.33 ± 0.95 IU/L. Relative to the elevation of Finger Temperature, mean LH concentration increased briefly by the first minute, returning to basal values, however, by minute 3, and remaining at or below basal values for the balance of the recording period.

Insert Figure 8 about here

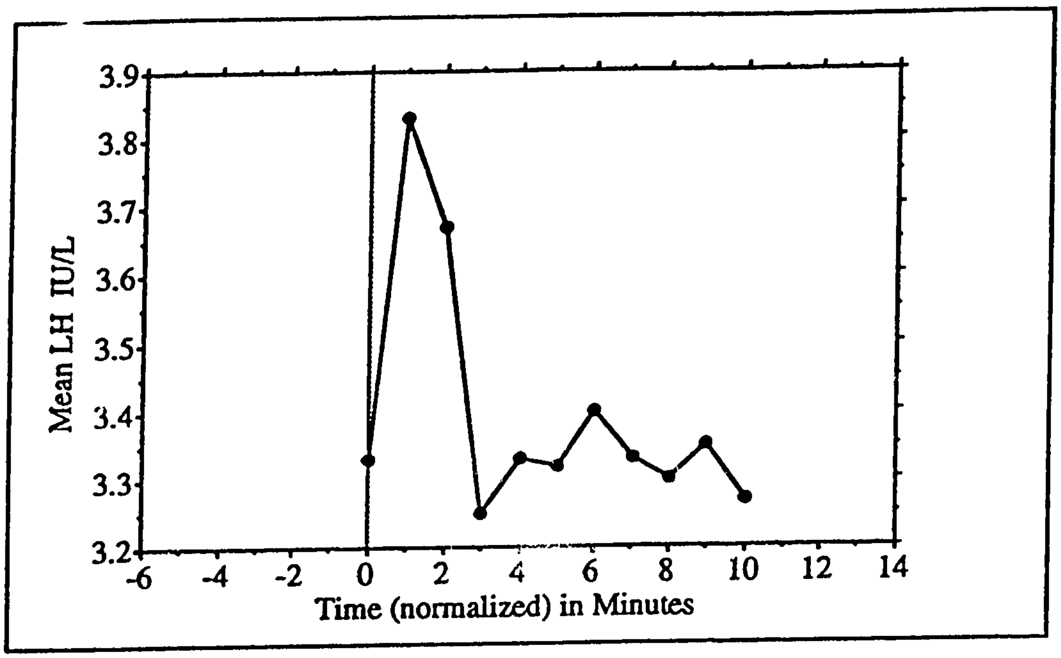


FIGURE 8: Mean LH Concentrations Centered to Onset of Temperature Elevation

<u>5. Cortisol</u>

Figure 9 illustrates the changes in the circulating concentration of cortisol when centered on the onset of peripheral temperature elevation. Basal values for the sample group were (±S.E.) 170.67 ± 15.5 nMol/L 15 minutes prior to the initiation of feeding, and 157 ± 12.75 nMol/L 5 minutes prior to initiation.

Mean basal cortisol (defined as the value right before the onset of the temperature elevation) among the subjects was 155.67 ± 28.05 nMol/L. Relative to the elevation of Finger Temperature, mean cortisol concentration increased briefly by the fir ute, showing an intermittent pattern of short term pulse increments, returning to below basal values, however, by minute 8.

Insert Figure 9 about Here

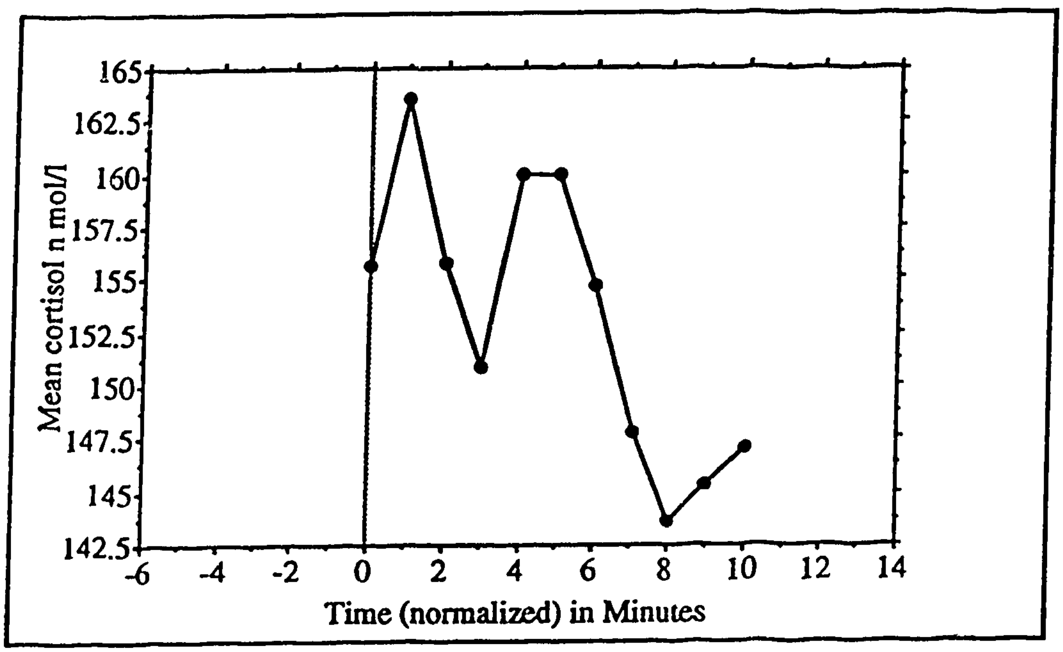


FIGURE 9: Mean Cortisol Concentrations Centered to Onset of Temperature Elevation

E. Dynamics of the Physiological Sequence During Breastfeeding

Figure 10 is a composite display of the sequence of events which occur during breastfeeding when these are centred around the onset of Finger Temperature elevation (Time zero).

When centered to the onset of Finger Temperature elevation, specific patterns of change were observed. PSCR increases occurred prior to, and fell shortly after, a significant increase in finger temperature ($p < 0.05$) which remained elevated throughout the remainder of the recording period. By one minute after the onset of temperature rise there were increases in OXT, LH, and cortisol. OXT remained elevated relative to baseline with a clear second peak by minute eight. LH fell to baseline by minute three, and remained at or below baseline for the remainder of the sampling interval. Cortisol showed an intermitent patttern with an abrupt drop to baseline by minute eight.

Insert Figure 10 about Here

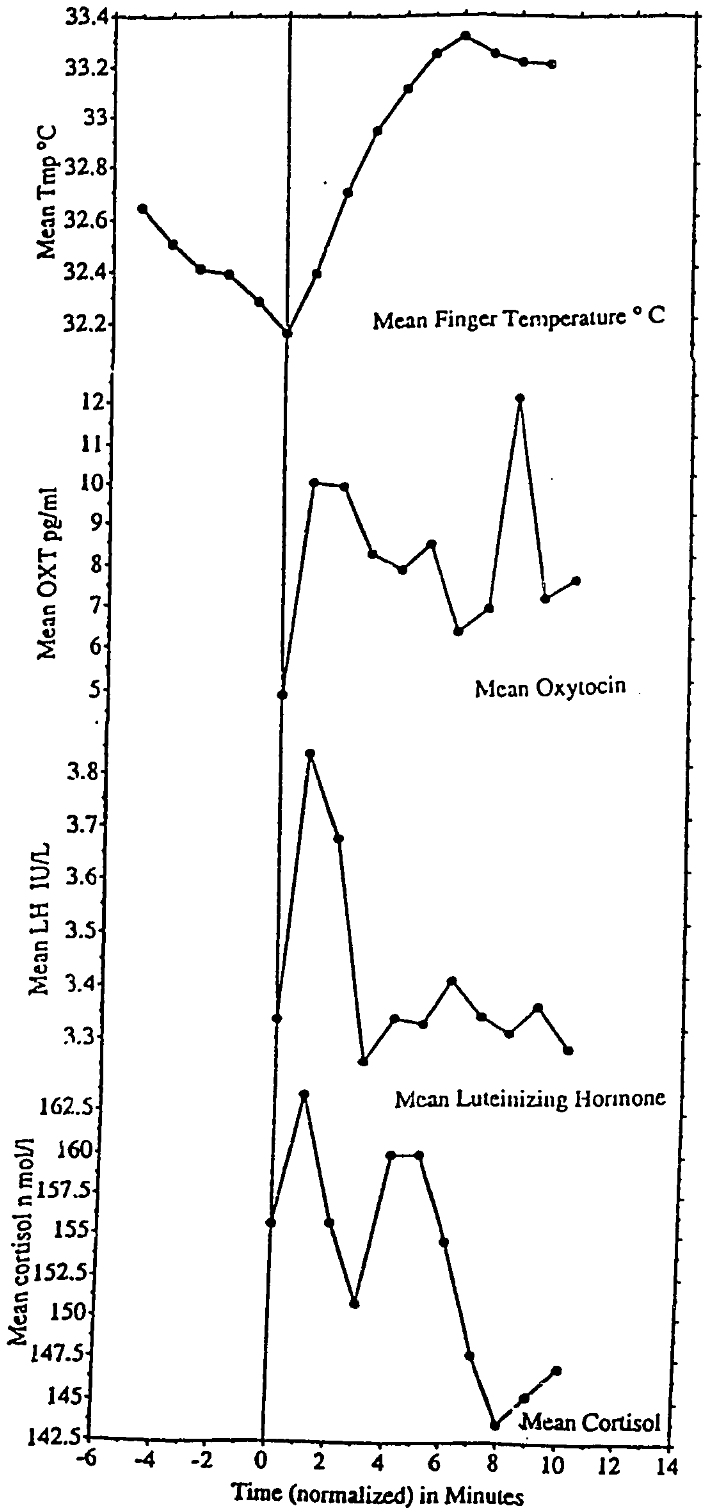


FIGURE 10:

Composite of Events Occurring During Breastfeeding when Centered to Onset of Temperature Elevation

CHAPTER FIVE

Discussion

A. Chapter Overview

The primary objective of this study was to record peripheral and hormonal psychophysiological responses during breastfeeding in order to more accurately describe the physiological changes which occur. More specifically, this study represented an investigation as to whether any consistency could be observed among a group of successfully breastfeeding women in terms of their finger temperature and skin conductance response, and in terms of their OXT, LH, and cortisol responses during a feeding. This study also constituted a preliminary methodological and measurement investigation, designed to develop procedures permitting the rapid simultaneous recording and subsequent analysis of peripheral and hormonal measures during a feeding. In Chapter 5 a discussion is offered of the results in relation to the objectives of this study and also in terms of some of the implications for subsequent theoretical and applied research.

B. Research Question and the Problems Rising from the Literature

The design of this study was developed to answer one research question and to address three problems rising from the literature.

1. What Changes Occur in Peripheral and Hormonal Measures during Breastfeeding?

Changes in peripheral temperature, SCR, and hormonal levels were recorded prior to and during breastfeeding. When centered around the onset of Finger Temperature elevation, specific patterns of change were observed. Palmar SCR increases occurred prior to, and fell shortly after, a significant increase in finger temperature ($p < 0.05$) which remained elevated throughout the remainder of the recording period. By one minute after the onset of temperature rise there were increases in OXT, LH, and cortisol. OXT remains elevated relative to baseline, with a clear second peak at eight minutes. LH fell to baseline by minute three, and remained at or below basal level for the rest of the recording period. Cortisol showed an intermittent pattern with an abrupt drop to baseline by minute eight.

2. Problems Rising from the Literature

a. Oxytocin and peripheral temperature need to be recorded in the context of breastfeeding.

This study recorded significant peripheral temperature elevation during breastfeeding. By using the onset of the temperature increase as a reference point, this elevation was found to be associated after the initiation of feeding with an OXT increase

b. SCR and finger temperature need to be recorded together in the context of breastfeeding.

An SCR increase followed by an increase in finger temperature was demonstrated by this data.

c. The pattern of hormone change needs to be investigated.

This preliminary investigation has shown that one minute sampling can be done both during a feeding and concurrently with computer collection of peripheral and physiological data. The pattern of hormone changes in relation to peripheral temperature and SCR has been recorded, and can be referred to for further investigation of these relationships.

C. Discussion of the Major Findings

The results of this study confirm those of the earlier study in this research sequence in that physiological changes can be recorded during a feeding. This study also confirms a consistency in the patterns of women's responses during feeding and strengthens the suggested viability of psychophysiological approachs in lactation research.

Previous research suggested that peripheral temperature might increase during feeding. The first study in this sequence documented a significant increase in peripheral temperature, and that result has been replicated here. OXT theory suggested that these temperature changes might be temporally related to an OXT response during feeding. This study synchronized the recording of hormonal and peripheral physiological responses, and captured data describing a neurophysiological event that is difficult to observe. The relationship between OXT and peripheral temperature increase recorded during a feeding needs to be explored further, but from this preliminary work they appear to have a temporal relationship.

1. Finger Temperature

In the first data analysis reported in Chapter Four several differences from the first study were rapidly apparent. Although analysis of variance and Scheffé paired comparisons did show significant increases in this study between the initiation of the feeding and the point five minutes later (Volition and V+5), the results as a whole were dramatically different from those of the first study. The contrast at T2 (Volition plus 2 Minutes) was even more dramatic: In this study there was an increase of 0.84° C; whereas, in the first study the mean increase over baseline had been 2.19° C. Part of the difference could be attributed to higher baseline values in the second study sample: 32.77° C, here, as compared to 31.39° C in the first group. Yet when the data were examined for peak temperature increase over baseline, the subjects in this study did show a mean peak increase over baseline exceeding 1° C. These peak increases were not, however, being caught by the T1 through T4 Stages of Feeding established in the first study.

These finger temperature differences may reflect differences in the two sample groups. There is a narrower range in the sample of the second study as evidenced by the baseline measures, resulting, particularly in terms of finger temperature, in a narrower range of change, given ceiling effects in peripheral temperature measures. Similarly, significant temperature rise does not occur until 7 minutes in the second study, which, again, may reflect the narrower baseline range, and particularly its higher levels.

The contrasting results may, however, also reflect differences in the behavioural or psychological variables involved here. The rationale for the Stage of Feeding approach in the first study was to infer from a composite of hormonal studies those points at which OXT was likely to have increased. In the present study the concurrent hormone data has been recorded, and yet the first study did find a pattern of significant change in peripheral temperature during feeding. To resolve this apparent contradiction, a reconsideration of the behavioural observations led to several speculations.

Cacioppo and Tassinary (1990) make the point that apparently unreliable relations between psychological and physiological events may be attributable to physiological recording and interpretation questions, but that "imprecision during signal acquisition on the psychological side of the equation " (p. 18) may also be at issue.

Observing a naturally occurring spontaneous event versus recording an event which is prompted (and to some degree driven) by the demands of the coordination of the data recording may lead to rather different results. In the first study, Volition was defined as pre-suckling activity by the mother to initiate the feeding, and was recorded by marking its occurrence within an ongoing stream of data collection. In contrast, Initiation in the current study was defined as the beginning of the feeding, and was cued, or prompted, to begin in time with the joint demands of the blood draws, of computer recording, and of synchronizing the two.

In subsequent studies it would be interesting to incorporate a subjective event marker into an already [illegible] stream of data collection subsequent studies, perhaps asking the subject to indicate with a raised finger when she is aware of the MER.

If the MER sequence being observed and recorded is seen as a stimulus-response association, then it is necessary and sufficient for the subject to simply be "aware of the beginning of the feeding" --and much of the animal literature reports this in this way. If, however, this sequence is considered in terms of potential regulation by the mother of the MER, then the volitional aspect becomes much more important.

Although there are numerous studies concerning the relationship between OXT and breastfeeding, and concerning the vasodilatatory properties of OXT, the relationship between vasodilation, OXT and breastfeeding has not been established. This is in part due to the fact that there have been few studies, but also that the temperature rise appears to occur at diferent times in different individuals. This fact was not readily apparent in the results of the first study because of the emphasis in the data collection strategy of observing a spontaneously occurring event (volition) within an ongoing stream of data collection. The contrast between the two sets of data may, thus, reflect differences in conceptualizing volition and initiation in the two studies.

2. Skin Conductance Response

The SCR is currently undergoing rapid changes in models of its physiological mechanisms, its interpretation and application, and its collection methods.

There have been substantial changes in current basic research regarding the anatomical and physiological model of what is seen to be the mechanism underlying the changing levels recorded by the SCR. Thus, the SCR is now interpreted by some researchers (Dawson & Filion, 1991) as a reflection of the skin's electrical properties in terms of the fluctuating height of fluid in the sweat ducts, rather than as an indicator of fluid on the surface of the skin increasing surface conductance. This shift in the interpretaion of the physiology will influence inferences about regulatory processes, in terms of both the central mechanisms and peripheral receptor functioning which subserve them.

In addition to changes in the physiology models of the SCR, there have been recent changes in the interpretation and application of the electrodermal data. Measures of SCR, like finger temperature, are being used today not merely as an indicator of fluctuations in sympathetic tone, but as the objective markers of entire physiological events. Thus the presence or absence of a menopausal flush is now being coded by one research group (Freedman, 1989) on the basis of a four μmho, over 30 seconds, increase in sternal SCR.

Finally, the collection methods for the SCR are in the midst of substantial revision. When Rickles and Day (1968) reported non-palmar electrodermal sites, they were reporting results from data collected according to Edelberg and Burch's (1962) standard for electrode paste, and utilizing acetone and shaving preparation for sites of electrodermal activity on the body. Neither of these instrumentation approachs is currently in wide use, yet their study continues to stand, without allowance for these differences, as the standard reference point for active and silent SCR sites. It is also interesting to note that for comparison purposes to the current study, their sample was entirely male.

Because of these recent changes SCR measures become something of a moving target for comparison between research groups and individual studies. Questions of surface area from which the recordings are being drawn, different electrode creams designed to reflect different interpretations of what the physiology is doing–all of these lead to the conclusion in this methodological investigation, that subsequent research needs to carefully explore, and to be more thoroughly reported, if the results of this measure are to be interpreted and replicated.

In this study several factors influenced replication. In an attempt to improve the precision and quality of recording, the original protocol was changed to reflect the publication standard of the American Psychophysiological Society (Fowles et al., 1981). In retrospect, to have used, at least at a pilot level, the placement, gel, and sampling rate of the first study would have been the better choice for replication purposes.

The largest difference in the two sets of SCR results, however, is probably not due to instrumentation questions, but to the recording of a spontaneous rather than initiated event Even more than in the context of finger temperature, incorporating subjective event markers would seem particularly useful with SCR measures which have traditionally been related to the perception of and response to stimulus events.

In this study, simultaneous recording of SCR at the two sites used by the menopausal research groups (Tataryn et al., 1981 using the palmar measure, and Freedman, 1989 the sternal) resulted in an interesting observation. Simultaneous recording of the same measure, by the same computer, with the same electrode cream and sensors, consistently produced in all subjects data which not only differed considerably in amplitude (with the palmar changes being much greater), but which showed change in opposite directions. Further research to confirm that this is not artifact or instrumentation problem, followed by exploration of this anomaly should be initiated.

3. Oxytocin, Luteinizing Hormone, and Cortisol

These results demonstrate a consistent pattern of OXT response related to the onset of the peripheral temperature elevation. A small but distinct increase occurs in LH immediately after the onset of the temperature rise; thereafter, the levels drop, are essentially flat and remain low. Similarly, there is a small but apparent rise in cortisol, but the levels are generally low. These results suggest a temporal synchrony in these events. Further exploration of these relationships may depend first on increased sampling rates and recording of temperature and SCR variability in order to keep pace with the hormonal patterns caught by the one minute blood samples, and, second, on resolution of the demands of the data recording as they influence spontaneous volition in a feeding.

D. LIMITATIONS

The findings of the present study may have been limited by the following factors:

1. The reliability and accuracy of measurement and recording instruments
2. The reliability of the data catch from sensor contacts
3. Fluctuation in the temperature of the room
4. Inconsistency of the period of time elapsed since previous feeding
5. Measurement artifacts, particularly with older and more active babies
6. Recording of spontaneously occurring versus prompted behaviour, that is, questions of volition versus initiation

E. DELIMITATIONS

The findings of the present study were delimited by the following factors:

1. The subject sample was limited to six mothers between the ages of 26 and 32
2. The sample was comprised of mothers selected from among the women who volunteered for the study. No attempt was made at random or representative sampling by age, or breastfeeding experience, and all mothers were from the greater Edmonton area.

F. IMPLICATIONS

The broad context of this research has been to suggest a more integrative perspective for psychophysiology research in general and for women's health issues in particular. To consider a pattern of changes which occurs in the menopausal flush, in the context of pms, in the context of lactation, may in fact lead to consideration of variability in vasomotor function in a series of reproductive contexts.

As indicated in Chapter One, most mothers can produce milk, but if they are unable to excrete it, subsequent milk production is suppressed. With an adequately sucking baby and good technique, the MER functions "synergistically" (Woolridge, 1986) with the baby's suckling to effect milk transfer and to maintain lactation. Some mothers, however, are striving to establish or maintain a milk supply when they are separated from their infants (Stewart & Gaiser, 1978), and others are attempting to feed infants who are unable to suck vigorously due to illness (Bose, D'Ercole, Lester, Hunter, & Barrett, 1981; Osorio, Ferrari, Acland Ferrari, Suna, & Gerpe, 1981; Lawrence 1985), prematurity (Ruis, Rolland, Doesburg, Broeders, & Corbey, 1981), Down's syndrome (Aumonier & Cunningham, 1983), cleft lip or palate (Lawrence, 1985). Each of these groups of women are attempting lactation with only minimal neural stimulation to initiate the sequence of milk-ejection.

For most women, milk-ejection has stabilized by approximately six weeks post-partum. However, the effectiveness and functioning of this reflex vary considerably. Although, ideally, the let-down response becomes conditioned to the baby's sucking, by six weeks some mothers are identified as having difficulties, which are partly attributable to an insufficient let-down.

What may not be apparent to the external observer is that despite the importance of the MER to the maintenance of lactation many mothers are not aware whether or not the let-down has occurred. This neurohormonal sequence can and does operate beneath the level of awareness. It can, however, be brought into a woman's awareness. Mothers appear to learn to recognize the sensation of the let-down, that is, to discriminate it amidst the variety of incoming stimuli. Isbister (1953) reported that primiparous mothers did not feel the let-down until 3 weeks postpartum. That experiencing the sensation of the let-down is not dependent on the milk supply being established is suggested by multiparous mothers, who had nursed before, experiencing/reporting the MER's sensations much sooner.

External indicators of the let-down have for many years been used to help mothers notice/become aware of the let-down: in the early stages of lactation, dripping milk on the side from which the infant is not feeding; changes in the sucking/breathing pattern of the infant; increases in vaginal flow in the immediate postpartum period. Similarly, women have often been encouraged to try to relate the external indicators to subjective sensations: a feeling of fullness in the breast; a prickling or pins and needles sensation; sh."

The problem with these informal approaches is that they are not experienced by all mothers in all circumstances: not every mother experiences leaking milk after the first weeks; if the milk supply is low these sensations are less likely to be experienced; not everyone feels sensations like those someone else has experienced and can describe. The difficulty of articulating subjective sensations is akin to that of accurately describing the sensation of riding a bicycle so that someone else can learn how to balance. Thus an external indicator would have value, particularly for the mother for whom things are not going well.

If information about temperature change could help foster awareness of subjective sensations, and thus assist the mother in facilitating, or at least, not inhibiting the MER, then the first step was to document that temperature change occurs.

The fact that many women learn to not permit the MER under all circumstances is evidenced that after the first few weeks the majority of mothers do not leak or spontaneously let down their milk except when they are about to feed their babies. Exceptions to this occur: when the breasts are extremely full and there is sufficient back-pressure to force milk from the lactiferous sinuses, and when women are orgasmic.

If not inhibiting the response, the mother would get feedback from the temperature increase that would tell her when even very tentative efforts were heading in the right direction. If the MER were functioning below the awareness of the mother, initial fingertip temperature shifts might give her feedback so that she could do more of whatever is working, or attend to whatever internal/external stimuli seemed related.

Assessment of breastfeeding adequacy and subsequent recommendations concerning supplemental feedings should consider the research that equates supplementation with shortened duration of lactation, and consider intervention approaches that involve fostering the MER. One approach to the recovery or improvement of the MER is pharmacological, as suggested by Weichert (1979). Non-pharmacological approaches used by themselves, or as adjuncts to other interventions might use the results of the research reported here.

Given the possibility that finger temperature increases might function as an objective indicator of the MER, one possible application of these results would be research into a biofeedback intervention using finger temperature.

The study of the life history of human females helps make a frame or context for this research perspective used in this study. To consider lactation within a life history context, permits comparison with the menopause.To consider female physiology across the life cycle, and to consider what is biologically appropriate, is to look for common patterns at different stages, rather than seek to study each of several events as separate and distinct. In doing the latter, we lose the pattern that might make each more clear, and, in the context of each other, more related to female variability within the human pattern.

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